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An Analysis of the Impact of ASEAN's Logistics Performance on Trade Flows Using Linear and Non-linear methods in an Augmented Gravity Model

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ABSTRACT

Logistics in trade has a pivotal role in the economic development and in the competitiveness of countries. This study aims to provide a strong empirical evidence in linking logistics performance with trade flows in the ASEAN region using panel data methods in an augmented gravity model. The Logistics Performance Index (LPI) collected by World Bank is the metric used for logistics performance whose impact on ASEAN's aggregate and sectoral trade using the priority sectors from 2007 to 2016 is explored. For sectoral trade, the data is zero-inflated with a strong evidence of heteroscedasticity. Hence, non-linear methods were used, namely, Poisson Pseudo Maximum Likelihood method, Feasible Generalized Least Squares method, and the Heckman Two-step procedure, while for overall trade, the usual panel estimation methods were used. The results showed that logistics performance has a strong positive association with trade value, both for aggregate trade and for trade in each of the priority sectors. The outputs of the LPI framework, particularly, timeliness, tracking and tracing, and ease of arranging international shipments are relatively more important indicators of logistics performance in increasing trade value.

KEYWORDS: gravity model · ASEAN trade · logistics · panel data

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1. INTRODUCTION

While there is a strong evidence that openness to trade is good for economic growth, globalization brings several supply chain challenges, which include advanced logistics. Logistics is generally defined as part of the supply chain process that involves the flow of goods, services and materials from a point of origin to the end-use destination in order to meet customer demand. [44] The efficiency of firms' logistics provides a competitive edge against rivals in the market. Hence, logistics is a vital part of any business model.

Well-functioning logistics, both domestically and internationally, is essential for a country seeking to promote national competitiveness. [5] The level of efficiency by which countries import and export goods defines how they can grow regionally and compete in the global economy. Countries with efficient transport and logistics system can easily connect with firms in the domestic and international markets. It can also provide inter-sectoral connections such as in agriculture, manufacturing, tourism and other industry sectors within the local economy. In addition, efficient logistics services facilitate the mobility of products by ensuring their safety and speed of delivery and by reducing trade-related costs. The quality of logistics services together with the infrastructure have a strong effect over the facilitation of transport of goods between countries. Countries with inefficient logistics face high costs – both in terms of time and money in international trade and global supply chains – adversely affecting countries and companies and reducing turnover. [33]

Logistics problems and issues usually include inefficient custom procedures, poor quality of infrastructure, and the unpredictability and unreliability of supply chain. Marti et al argued that trade facilitation measures are not fully developed in most emerging countries due to weak infrastructure, complex customs procedures, and excessive bureaucracy between government agencies. In addition to the previously mentioned, increasing trade costs also

hinder the efficient movement of goods across borders. [47]

Arvis et al proposed that logistics has two main facets: the inputs and outputs of the supply chain. [3,4,5] The inputs refer to areas for policy regulation while the outputs are the supply chain or service delivery performance outcomes. The Logistics Performance Index (LPI) reported by World Bank is a commonly used metric of a country's logistics performance since it covers vital aspects of logistics. This is further discussed in the research framework section of the paper.

Most related studies focused on the impact of certain variables on overall trade, i.e., trade value aggregated from different areas and classifications of goods. Moreover, analyses of such kinds of data are performed using linear models since statistical issues of having zero-inflation in the data or having non-homogeneity do not usually arise for aggregated data. As an extension, this paper will add to the literature an empirical evidence on the link between logistics performance and the trade value of different sectors in international trade, particularly the priority good sectors of ASEAN. Data on trade for each sector are usually either zero-inflated or non-homogeneous making the linear assumption in the model to be inappropriate and suboptimal. Hence, this paper will use novel non-linear regression methods in order to obtain better estimates and to correctly interpret the relationships of the variables in the model. A more appropriate statistical model with better estimates will translate to better decisions especially to our policy makers. Also, since there is no single statistical model that works best for all problems, i.e. there is no single method which will outperform any other method, the performance and the actual estimates from applying different non-linear regression methods will also be compared.

This study uses the augmented gravity model in analysing the impact of logistics performance on the overall and sectoral trade value of priority goods in the ASEAN. Thus, this paper has two primary objectives. Firstly, this paper will primarily aim to offer new empirical estimates on the relationship between logistics and bilateral trade flows specific in the ASEAN region using both linear and nonlinear methods while controlling for other determinants of trade. Moreover, this study aims to dig deeper and provide a better understanding of the sectoral level by analysing the priority good sectors of the ASEAN which includes the following: agro-based products, fisheries, rubber-based products, wood-based products, textiles and apparel, automotive, electronics, ICT, and healthcare products. Identifying the determinants of trade is important in order to better understand the trade patterns of ASEAN member states which will then be used in formulating appropriate general policy measures, as allowed within the scope of this research, for overall trade flows as well as for each the priority-good sectors.

ASEAN's long-term and sustainable growth would depend on the ability of its member countries to link up, such as through trade, with one another and with the rest of the world. Identifying the most important components of logistics with strong impacts on the level of trade will facilitate in designing a comprehensive reform program to address such barriers to achieve a healthier and more competitive trading in the region. The findings of this study will provide rational support for government and private institutions that have direct and indirect influence over logistics performance to focus attention on specific aspects of logistics in order to further enhance the region's competitiveness in global value chains.

2. THEORETICAL AND CONCEPTUAL FRAMEWORK

This section explains the framework of this research. Section 2.1 discusses the importance of logistics and its role in international trade. Section 2.2 discusses the logistics performance index (LPI) which is one of the most commonly used metrics for logistics performance of countries. The structure and approaches used in coming up with the index and its indicators are discussed. This study uses the LPI as the metric for logistics performance of countries. Since this study will look into the link between logistics performance and trade value of the priority sectors of ASEAN, section 2.3 discusses a short background on how the ASEAN came up with its priority goods sectors.

2.1. Logistics and Trade

The Transport Division of the Economic and Social Commission for Asia and the Pacific provides a summary of different definitions of logistics by different organizations. [19] Some of these definitions are as follows. According to the United Nations Conference on Trade and Development, the services provided by logistics companies include the "management of customs procedures, setting up of assembly and manufacturing plants; groupage; warehousing; information logistics services; and transportation with a selection of carriers and negotiation of tariffs." [29] Moreover, quoting the Council of Supply Chain Management Professionals, logistics is the "process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the requirements." [61] The Singapore Logistics Association defines logistics as "the process of planning, implementing and controlling the flow, storage, distribution and supply chain of goods; related information flow; and financial flow from point of origin to point of consumption, which includes inbound, outbound, internal, and external movements." These varying definitions and services

offered related to logistics operations is summarized into five main groups: assembly, supply chain, quality control, financial services, and customer services. [19, 62]

Logistics play an important role in national and regional economies in two ways. First, logistics is one of the largest expenditures for businesses, and hence, is affecting and being affected by day-to-day economic activities. Second, logistics supports the movements of many economic transactions. [27] Efficient logistics system is an important factor for sustainable economic growth. [32]

Logistics, which encompasses freight transportation, warehousing, border clearance, payment systems, and many other functions, is regarded as the backbone of international trade. [5] World trade is moved between countries by a global network of logistics service providers. [3] However, the ease with which countries can take advantage of this network in order to gain international market access depends on each country's trade procedures, transport and telecommunication, and the domestic market for support services. In fact, different government stakeholders have been working on a comprehensive policy framework for logistics in order to achieve efficiency and efficacy in the services provided. For instance, China implemented the so-called Five-Year Plan to promote the link between logistics and other industries in order to facilitate the flow of exports. [19] The focus has been on strengthening infrastructure such as ports, freight stations, and logistics parks. Moreover, in Indonesia, they implemented the so-called Indonesian National Logistics Blueprint in order to enhance the logistics competitiveness of the country and to prepare them for the ASEAN economic integration. Malaysia implemented the so-called Third Industrial Plan for 2006-2020, which includes the logistics sector as a priority sector. [19] The plan aims to increase the total merchandise trade through an efficient logistics industry, an improvement in the infrastructure, and the use of ICT technology, among others. Thailand implemented the Logistics Development Strategy for 2007-2011 in order to improve business logistics, to optimize transport and logistics network, to internationalize logistics services, to enhance trade facilitation, and to achieve capacity building. Efforts to improve the logistics sector are being done to improve import and export processes such as the reduction of costs and time of transporting import and export goods. [19]

2.2. Logistics Performance Index and Indicators

To measure the logistic performance of the countries, this research will use the Logistics Performance Index (LPI). The LPI is an extensive and comprehensive index which was created to aid countries in identifying the challenges and opportunities they may face in their trade based on their logistics performance. [3,4,5] LPI has provided valuable information for policy makers, traders, and other stakeholders, as well as researchers and academics, on the important role of logistics for economic growth. Most importantly, the index is a rich source of information in crafting policies necessary to support logistics in areas such as infrastructure planning, service provision, and cross-border trade and transport facilitation.

The index provides the most comprehensive data on county logistics. The index is constructed using six components which were chosen based on theoretical and empirical research on logistics. [3,4,5] Of the six components, three are considered as input indicators and the other three as output indicators. The inputs are viewed as areas for policy regulations while the outputs are service delivery performance outcomes in terms of time, cost, and reliability. The input indicators are the following: customs, infrastructure, and quality of services. The output indicators are the following: timeliness, ease of arranging international shipments, and tracking and tracing. We may view the inputs as specific policy areas and stimuli to achieve the desired outcomes of logistics performance.

Infrastructure development is considered a prerequisite for the development of any nation. [63] The contribution of infrastructure to the economy has received attention from both policymakers and researchers. It has been generally recognized that a sufficient supply of infrastructure services is an essential factor for productivity and growth. Poor transport infrastructure or inefficient transport services leads to higher direct transport costs, longer time of delivery, and negative economic consequences, while more developed transport systems have lower transport costs because they are more reliable and can handle more movements. [56] Improvements in transport infrastructure such as the road density network, air transport, railways, ports, and logistics have led to increased trade flows and therefore plays an important role for trade facilitation. [40]

With the extent of globalization, border control authorities also play a vital role in trade facilitation and the circulation of goods and people across countries and at the same time in protecting borders and national security. [13] Customs is defined as the principal enforcer of trade policy, responsible for administering differential tariffs, quantitative restrictions, rules of origin, anti-dumping measures, and trade embargoes. [25] It plays an important role in export promotion through the administration of duty drawback schemes and other incentives. Costly and cumbersome border procedures and standards raise transaction costs and extend delays to clearance of export, imports, and transit cargoes which hinder countries' international trade competitiveness. In order to simplify customs and border management procedures, bilateral and regional trading agreements must be made among countries. [14]

As global supply chains become more complex, ensuring on-time delivery of inbound and outbound shipments also become even more challenging. Country's ability to export on time is a comparative advantage that is as important as the factors of production in international trade. It has been shown that a 1% decrease in the processing time of a container at the exporter is associated with a 0.4% increase in bilateral trade, while 1% less variability in shipping times can lead to up to 0.2% increase in bilateral trade. [37, 55] Also, it was shown that every additional day in ocean travel for a shipment to arrive reduces the probability of outsourcing manufacturers by 1%. [38]

The demand for tracking and tracing has been widely recognized by different industries particularly the manufacturing firms. Today's global industries are facing problems coming from tracking and tracing in their logistics networks that have resulted in huge coordination problems in the overall product development sites. [64] Real-time tracking and tracing are important in managing integrated logistics networks and in providing better customer service. [58] It is an important element of customer service and it is often considered as an industry norm rather than just a potential competitive advantage for logistics service providers. [15] In the context of international trade, tracking is defined as monitoring the movement of finished goods through the supply chain, which is also a way to ensure that all regulatory requirements are met, i.e., the payment of taxes. [18] Tracing, on the other hand, is a powerful aid to determine the point at which any out-of-normal event occurred, i.e., to establish were a product was diverted out of the legitimate supply chain. [17]

Quality of logistics services is an important aspect in business and supply chains since it is a key component for customer satisfaction and loyalty. [11, 24, 65] The following are the traditional dimensions of quality of logistics services: personnel contact quality, ordering procedure, order release quantity, information quality, order accuracy, order condition, order quality, timeliness, and order discrepancy handling. [26] In the current online environments, the following additional indicators of quality of logistical services are identified in addition to the traditional indicators: customer service, ease of use, hedonic aspect, website design, flexibility, information quality, merchandising, order value, assurance/trust, and system availability/reliability. [26]

The ability to arrange international shipments at competitive prices is an important indicator for national competitiveness. [55] Usually, high income countries score low on this aspect because of expensive logistics services and the lack of flexibility in arranging low-priced shipments. [55, 4] This aspect of logistics performance is usually more determined by interventions from the private sector which are sensitive to market conditions. Nonetheless, government and public policy has a significant impact on the economic and market conditions to facility and ease activities in the freight transportation sector. Government policies should cover issues on safety, competitions in the market, environmental aspects, and the economic performance of the sector. [55]

2.3. ASEAN Priority Sectors

In pursuing its regional economic integration agenda and prior to the adoption of the ASEAN Economic Community (AEC) Blueprint, the ASEAN started focusing its efforts on deepening and accelerating integration in priority sectors in 2004, complementing the efforts under the ASEAN Free Trade Area and ASEAN Framework Agreement on Services.

With the ASEAN's decision in 2003 to create by 2020 a competitive single market and production base called the AEC, it would be crucial to identify which sectors experience higher efficiency from intra-regional trade or which sectors are likely to exhibit trade creation, in other words. This information would be important as a means to formulate the appropriate policies to enhance efficiency and create comparative advantage for the relevant sectors. [53] Increasing the efficiency of these key sectors will allow the ASEAN community to compete for capital, and retain value-added economic activity and employment within the region. [6] While it is advantageous for the ASEAN to integrate across the whole range of economic sectors, the region has initially focused its resources on integrating few priority sectors considering the magnitude of the challenge integrating all sectors would pose. [6] Also, ASEAN countries were not ready to harmonize tariffs and to have a common external tariff policy. Hence, the members agreed to a sectoral approach to economic integration. The task involves the identification of sector-specific projects or initiatives, which would result from regular dialogue or consultation with stakeholders, particularly, the private sector.

The Framework Agreement for the Integration of Priority Sectors and its Integration Protocols for the eleven priority sectors were signed in November 2004. The 11 identified priority sectors are agro-based products, fisheries, rubber-based products, wood-based products, textiles and apparel, automotive, electronics, e-ASEAN, air transport, healthcare and tourism. These sectors were chosen based on the comparative advantage in natural resource endowments, labor skills and cost competitiveness, and value-added contribution to the region's economy. In 2005, in addition to the 11 priority sectors identified in 2003, the ASEAN Economic Ministers Meeting held in Lao PDR added logistics service as the 12th priority sector in the ASEAN. These priority sectors, once integrated, were expected to serve as a catalyst for overall ASEAN economic integration. [6]

3. METHODOLOGY

This section discusses the methodological aspect of the paper. Sections 3.1 and 3.2 discuss the gravity model for trade and the augment gravity model. The theoretical underpinnings of the gravity model will be discussed as well as its viability in doing research on international trade. Sections 3.3 and 3.4 discuss the actual model formulation and the research hypothesis that will be tested. The operational framework is also discussed in section 3.3. This study makes use of official statistics and primary data from government and non-government institutions whose methodologies and reports are well-documented and are readily available. This is further discussed in section 3.5. The details on the model fitting and procedures for estimation and hypothesis testing, which include both linear and non-linear methods, of the gravity model for trade is discussed in Section 3.6. This section discusses the statistical models, which include the assumptions, the estimation procedures, some properties, and their appropriateness. The research uses model-based techniques in testing the research hypotheses and in answering the research questions.

3.1. Gravity Model

The fundamental model considered for the analysis is the gravity model by Tinbergen which hypothesizes that geographic distance is inversely related to trade and that market size measured in terms of GDP is positively related with trade. [66] Equation (1) below shows the relationship:

$$Trade_{I,J} \propto \frac{(GDP_I)^{\alpha}(GDP_J)^{\beta}}{(Distance_{I,J})^{\theta}} \quad (1)$$

, where α, β and θ are approximately equal to 1. The gravity model bears a very close resemblance and can be attributed to the Newtonian law of gravity in physics. Getting the natural logarithm of both sides of equation (1) will give

$$\ln(Trade_{I,J}) = \alpha\ln(GDP_I) + \beta ln(GDP_J) - \theta\ln(Distance_{I,J}). \quad (2)$$

Equation (2) above shows that countries with big market size, measured in terms of GDP, tend to trade more; while countries which are far apart in terms of geographic distance tend to trade less than countries close to each other. Chaney mentioned that the gravity model has been applicable for different samples of countries, different years, and different methodologies. [12]

Anderson acknowledged the gravity model as a realistic and sound representation of trade flows. [2] It has been successful empirically and provided a good fit for different goods, different regions, and under different circumstances. He also provided a theoretical basis of the gravity equation model applied to commodities using properties of expenditure systems with the assumption that preferences for a country's goods are homothetic across importing countries. [2] Deardorff laid down a survey on theoretical foundations of different trade models, discussed the empirical tests, and laid down the problems in testing the trade theories. [16] Bergstrand laid down mathematical foundations and empirical evidence for the gravity model in international trade. [10] He derived a generalized gravity model from a general equilibrium world trade model after imposing certain assumptions. Several other works tackled the theoretical underpinnings of the gravity model. [11, 17, 35, 43, 46]

3.2. Augmented Gravity Model for Bilateral Trade

In the literature, various variables were added to the gravity model to better capture bilateral trade flows. Some of these variables may be viewed as controlling variables, or may be policy variables. The new equation, with the addition of controlling variables on the gravity equation model, is called an *augmented gravity model* or *extended gravity model.* The augmented gravity model is widely recognized in the empirical trade literature as a useful multivariate approach for examining and identifying determinants for bilateral trade flows. Bergstrand in their proposed empirical model of the generalized gravity equation added variables on adjacency or contiguity of two countries, exchange rate, and membership of some economic cooperation zone or trade agreements. [10] Jakab et al studied improvements in trade integration in three Central and Eastern European countries covering the period up to the second half of the 1990s. [41] Other than the GDP of the countries and distance, they also included GDP deflator, exchange rate, export price, import price, dummy variables on language, dummy variables on border or adjacency, and membership to trade agreements, and economic zones. These were similar variables that Trung and Nguyen used in their paper which examined trade potential of climate smart goods of Vietnam and that of Felipe and Kumar who studied the role of trade facilitation in Central Asia. [67, 22] Ekanayake et al investigated the effects of regional trade agreements in Asia on intra-regional trade using an annual data from 1980-2009 using the gravity model. [20] The additional variables included were relative factor endowment between the countries, a similarity index as described in Equation (3) below, dummy variable on having a common border, dummy variable on having a common language, dummy variable if the two countries share a common colonial linkage or if one country is a former colony of the other country, dummy variable if the two countries are members of the same regional trading agreement, dummy variable if the two countries have a bilateral agreement, and other dummy variables on membership on regional cooperation such as the Association of Southeast Asian

Nations, Bangkok Agreement, Economic Cooperation Organization, and South Asia Association for Regional Cooperation. The similarity index used by Ekanayake et al is shown below:

$$SIM_{ij} = \ln[1 - \left(\frac{GDP_i}{GDP_i + GDP_j}\right)^2 - \left(\frac{GDP_j}{GDP_i + GDP_j}\right)^2]. \quad (3)$$

Marti et al studied the impact of logistics performance for years 2007 and 2014 for countries grouped into 5 major regions: Africa, South America, Far East, Middle East, and Eastern Europe. [43] They included variables on the population, and dummy variables on sharing of borders, having a common official language or second language, and having a common colonizer.

The gravity model is extensively used in the literature to determine how trade facilitation measures can affect trade activities in Southeast Asia. [60] Moreover, the gravity model was used to analyse the impact of the establishment of more liberal air transport policies on bilateral trade, particularly of APEC member countries. [30] It was also to measure the bilateral trade flows and trade potential between South Asian Association for Regional Cooperation (SAARC) economies. It specifically aims to study the benefits of the South Asia Free Trade Agreement (SAFTA) to member countries in terms of the increase in trade potential, increase in trade volume, increase in trade competitiveness, and trade creation with the member countries and non-member countries. [1]

3.3. Operational Framework of the Research

The mathematical representation of the relationship between bilateral trade and the logistics performance index, and others, is given in equation (4) below:

$$\ln(Y_{ijt}) = \beta_1 ln(GDP_{it}) + \beta_2 ln(GDP_{jt}) + \beta_3 (Distance_{ij}) + \beta_4 L_{it} + \beta_5 L_{jt} + \boldsymbol{Z} + \varepsilon_{ijt} \quad (4)$$

, where Y_{ijt} is defined as the trade value (in USD), from country i to country j at time t; GDP_{it} is the GDP of country i at time t; GDP_{jt} is the GDP of country j at time t; L_{it} is the Logistics performance index score of country i at time t; L_{jt} is the Logistics performance index score of country j at time t; $Distance_{ij}$ is the bilateral distance between country i and country j; $\boldsymbol{Z}$ contains the controlling variables in the model; and, ε_{ijt} is the error term which captures all the other determinants of the response variable not included in the linear model. The form of $\boldsymbol{Z}$ is given in equation (5) below:

$$Z = \theta_1 \ln(Pop_{it}) + \theta_2 \ln(Pop_{jt}) + \theta_3 RFE_{ijt} + \theta_4 SIM_{ijt} + \theta_5 CB_{ij} + \theta_6 CL_{ij} + \theta_7 CC_{ij} + \theta_8 ER_{it} + \theta_9 ER_{jt} + \theta_{18} GDPpercapita_{it} + \theta_{19} GDPpercapita_{jt} \quad (5)$$

, where Pop_{it} is the population of country i at time t; Pop_{jt} is the population of country j at time t; RFE_{ijt} is the relative factor endowment and is a measure of the difference of the level of development and is computed as the absolute difference of the natural logarithm of per capita GDP of country i at time t and country j at time t; SIM_{ijt} is the similarity index of country i and country j at time t shown in equation (3); CB_{ij} is a dummy variable on whether countries i and j have a common border or are contiguous. CL_{ij} is a dummy variable on whether countries i and j have a common official language. A slight modification of CL_{ij} is whether the two countries have a common language spoken by at least 9% of the population. CC_{ij} is a dummy variable on whether countries i and j have ever had a colonial link. Some modifications of CC_{ij} are the following: whether the two countries have had a common colonizer after 1945, whether the two countries are currently in a colonial relationship, whether the two countries have had a colonial relationship after 1945. Another related variable is if the two countries were/are the same country. ER_{it} is the real effective exchange rate country i at time t; ER_{jt} is the real effective exchange rate country j at time t, and is a proxy for relative prices. Lastly, $GDPpercapita_{it}$ and $GDPpercapita_{jt}$ are the GDP per capita for country i and country j, respectively, at time t. Note that other variants of GDP may also be used as controlling variables.

This study investigates the overall and individual effects of the components of Logistics on trade flows. Since the components of LPI are highly correlated, putting all the components of logistics performance index in one model would lead to the problem of multicollinearity. To avoid the problem of multicollinearity, separate regression models are estimated to assess each of the component of Logistics. Hence, there are 6 additional regression models for each of the 6 components of LPI as shown in Equations (6) to (11) below:

$$\ln(Y_{ijt}) = \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 (Distance_{ij}) + \beta_4 Customs_{it} + \beta_5 Customs_{jt} + \boldsymbol{Z} + \varepsilon_{ijt} \quad (6)$$

$$\ln(Y_{ijt}) = \beta_1 ln(GDP_{it}) + \beta_2 ln(GDP_{jt}) + \beta_3 (Distance_{ij}) + \beta_4 Infra_{it} + \beta_5 Infra_{jt} + \boldsymbol{Z} + \varepsilon_{ijt} \quad (7)$$

$$\ln(Y_{ijt}) = \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 (Distance_{ij}) + \beta_4 LogQC_{it} + \beta_5 LogQC_{jt} + \boldsymbol{Z} + \varepsilon_{ijt} \quad (8)$$

$$\ln(Y_{ijt}) = \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 (Distance_{ij}) + \beta_4 IntShip_{it} + \beta_5 IntShip_{jt} + \boldsymbol{Z} + \varepsilon_{ijt} \quad (9)$$

$$\ln(Y_{ijt}) = \beta_1 ln(GDP_{it}) + \beta_2 ln(GDP_{jt}) + \beta_3 (Distance_{ij}) + \beta_4 Trac_{it} + \beta_5 Trac_{jt} + \boldsymbol{Z} + \varepsilon_{ijt} \quad (10)$$

$$\ln(Y_{ijt}) = \beta_1 ln(GDP_{it}) + \beta_2 ln(GDP_{jt}) + \beta_3 (Distance_{ij}) + \beta_4 Time_{it} + \beta_5 Time_{jt} + \boldsymbol{Z} + \varepsilon_{ijt} \quad (11)$$

, where $Customs_{it}$ and $Customs_{jt}$ are the scores on the efficiency of customs and border clearance processes at time t for countries i and j, respectively; $Infra_{it}$ and $Infra_{jt}$ are the scores on the quality of trade and

transport-related infrastructures at time t for countries i and j, respectively; $IntShip_{it}$ and $IntShip_{jt}$ are the scores on the ease of arranging international shipments at competitive prices at time t for countries i and j, respectively; $LogQC_{it}$ and $LogQC_{jt}$ are the scores on the quality and competence of logistical services at time t for countries i and j, respectively; $Trac_{it}$ and $Trac_{jt}$ are the scores on the efficiency of tracking and tracing at time t for countries i and j, respectively; and lastly, $Time_{it}$ and $Time_{jt}$ are the scores on the timeliness of shipments at time t for countries i and j, respectively.

In summary, figure 1 shows the operational framework in studying the relationship between bilateral trade flows and logistics performance. The first set of independent variables are the variables in the classical Tinbergen gravity model for trade. The next set of variables are the six indicators of logistics performance. The last set of variables are the other important factors or determinants of bilateral trade in the augmented gravity model.

3.4. Research Hypotheses

The main research hypotheses are the following:

a. **The overall LPI index is positively related with trade, both overall and sectoral, in the ASEAN.**
The LPI index is an indicator of the competitiveness of a country in terms of logistics performance. Hence, the expected sign of the relationship is positive and should be statistically significant. This should be true for both the linear and non-linear models and both for overall and sectoral trade.

b. **The six indicators of the LPI is positively related with trade, both overall and sectoral, in the ASEAN.**
The six indicators are customs, infrastructure, quality of logistics services, ease of arranging international shipments, tracking and tracing, and timeliness. In the development of the index, the six indicators were identified as the primary drivers and positive outcomes or results of good logistics performance. Hence, these six indicators should be positively related with trade, both for overall and sectoral trade.

3.5. Data Sources

The Logistics Performance Index (LPI) survey was designed and is conducted every two years by the World Bank International Trade and Transport Departments, in collaboration with academic and international institutions and private companies involved in international logistics. The first LPI report was published in 2007. The computation of the LPI scores is based on an online survey of professionals involved in logistical operations. The following six core components of logistics performance are individually rated: customs, infrastructure, ease of arranging international shipments, quality of services, tracking and tracing, and timeliness. The principal component analysis (PCA) method, a standard statistical technique used to reduce the dimensionality of a dataset, is applied on the data to arrive at the LPI scores.

Data on bilateral trade is available from the UN Commodity Trade Statistics (UN Comtrade). For data on the trade value of priority goods sector in ASEAN, the Standard International Trade Classification (SITC) Revision 3 is used.

Data on bilateral distance metrics, and the dummy variables (if two countries are contiguous or not, if they share a common language, if they have ever had a colonial link, if they were/are the same country) are available from CEPII, a French research center in international economics. It was founded in 1978 by the French government to study the effect of globalization

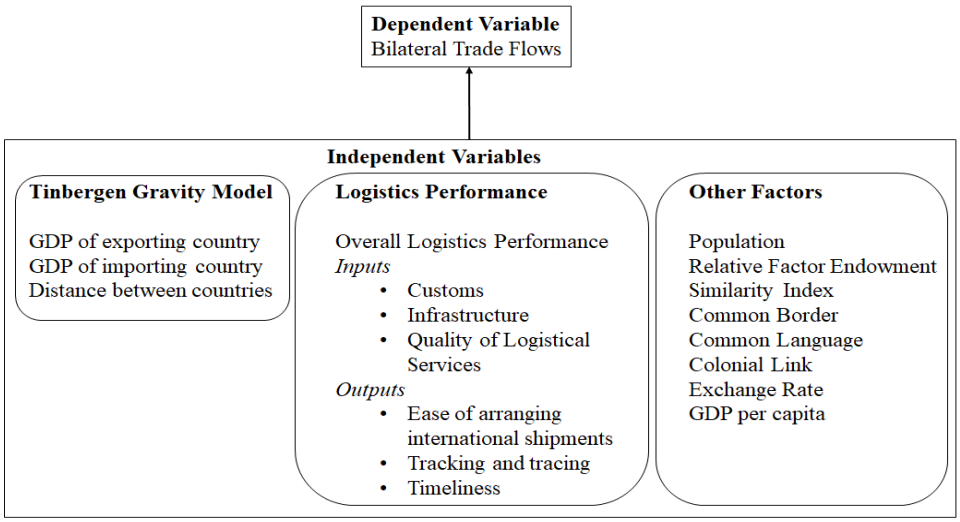

Figure 1. Operational Framework for Bilateral Trade and Logistics Performance

on the economic administration of the country. Data on population, GDP, GDP per capita, GDP growth rates, GDP per capita growth rates, and other economic indicators are available from World Development Indicators of World Bank.

3.6. Estimation Methods

3.6.1. Panel Data Methods

Panel data refers to a combination of cross-sectional data over several time periods. [9] The following are the benefits of using a panel data: it controls for heterogeneity of the individuals; there is more information because of several measurements per observation and there is less multi-collinearity in the model; the probability of significance given that there really exists a relationship between the response variable and the predictors is high; more hypotheses, relationships, and structures can be formally tested; and error due to aggregation of outcomes from each individual is reduced or eliminated. [9]

The one-way error component panel regression model is given in Equation (12):

$$Y_{it} = \alpha + \boldsymbol{X}'_{it}\boldsymbol{\beta} + u_{it}, \quad u_{it} = \mu_i + \upsilon_{it} \\ i = 1, \dots, n; t = 1, \dots, T \tag{12}$$

, where i is the index for the individual units, and t is the index for time. $\boldsymbol{X}_{it}$ is a vector of K explanatory variables while $\boldsymbol{\beta}$ is the vector of regression parameters. Lastly, u_{it} is the error term of the model which is composed of two terms: the unobservable individual-specific effect (μ_i) and the remainder disturbance (υ_{it}). The υ_{it} is the usual disturbance in a regression model while μ_i is non-varying over time (time-invariant) and accounts for characteristics specific to a particular individual. Further model assumptions will lead to two types of model: fixed effects model and random effects model. If the $\mu_i's$ are assumed to be fixed parameters while the $\upsilon_{it}{}'s$ are independent and identically distributed with mean 0 and constant variance, and the X_{it} is independent from the υ_{it}'s, then the model is a ***fixed effects model***. A drawback of the fixed effects model is that there are many parameters to be estimated. In addition to the $\boldsymbol{\beta}$ vector, each individual has its own specific effect. Thus, the fixed effects model suffers from large loss of degrees of freedom. In the ***random effects model***, the $\mu_i's$ are assumed to be random and are independent and identically distributed from some distribution with mean 0 and constant variance. The υ_{it}'s are also assumed to be independent and identically distributed with mean 0 and constant variance. The variance of $\mu_i's$ may be different from the variance of the υ_{it}'s. The X_{it} are also independent from the $\mu_i's$ and υ_{it}'s. The random effects model eliminates the problem of fixed effects model which is having too many parameters due to the individual-specific effects. While the fixed effects model assumes that individual-specific effect is correlated with the predictor variable and the other regressors in the model, the random effects model assumes that the variation inherent across individuals is uncorrelated with any other variable in the model. A problem with the fixed effects model is that time-invariant variables will not be estimated and will be dropped from the final model. For random effects model, time-invariant variables can be included in the model. To decide which between the two will be used, ***Hausman test*** is used. The ***Breusch-Pagan Lagrange Multiplier Test*** is used to test the significance of the variance of the individual-specific effects. The null hypothesis is that variance is zero versus the alternative hypothesis that the variance is non-zero. If the null hypothesis is rejected, then the random effects model is more appropriate than the usual ordinary-least squares regression model. If there is non-constant variance, then robust standard errors will be used.

3.6.2. Non-linear methods to estimate the gravity model

The application of gravity equation in a panel data which controls for heterogeneity among units or observations is very rich in the literature. When heteroskedasticity and autocorrelation are present, the OLS estimators may still be linear, unbiased, and asymptotically normally distributed but no longer have the minimum variance among linear unbiased estimators. [9] Further, in the presence of non-constant variance or heteroskedasticity, the crucial assumption of the error term being independent from the regressors is violated and the OLS estimation is inconsistent. [57] They also pointed out that taking the logarithm of the variables does not really solve the problem. Another data problem is the presence of many zeroes in the response variable, coined as the zero-inflated problem. Data of trade flows between countries usually contain a hardly negligible amount of zero-valued observations. [69] However, when the zero-inflated problem is present, the consequences are not negligible and needs to be taken seriously. Zero values may be interpreted as either zero trade flows or as missing values. The former can be attributed to firms' selection behaviour, i.e., zero trade flow is observed when no firm in the potential exporting country finds it profitable to bear the fixed costs of trade and sell to the destination market. [51] Therefore, from this perspective, zeros should be modelled in a selection process. The validity of log-linearization of the models as a solution to the existence of several zero trade flows is an important issue in modelling. [28] The usual logarithmic transformation of the model for estimation purposes still causes problems even if panel data estimation methods are used. [69] Since the logarithm of zero is undefined, then the log-linearization of the models will result in the omission of observations with zero trade. This omission leads to inefficiencies in the model estimation due to the loss of information. The treatment of zero trade flows in the estimation is critical for at least two reasons. First, the improper handling of zeros causes the classical selection

bias. [34] Second, most potential export flows are not present, and the incidence of these "export zeros" is strongly correlated with distance and importing country size. [8] Several studies acknowledged that in the presence of heteroskedasticity in the data and in the existence of many zero trade flows, the ordinary linear model estimates using ordinary least squares will either yield to loss of information if zero flows are truncated or will give biased parameter estimates if not truncated. [7, 68] Moreover, the panel fixed effects methods will have sample selection bias and will yield to problems in the estimation of the standard errors, and may lead to unreliable results. [36, 52] There are alternative methods in estimating gravity models in such scenarios. These methods are non-linear methods and are also widely used in the literature.

The first alternative method is the ***Poisson Pseudo Maximum Likelihood Method (PPML)***. The PPML estimator has good properties, such as robustness, in the presence of zeros in the data and heteroskedasticity in the model. [57] Moreover, the heteroskedasticity problem is treated even without precise knowledge on the exact nature of heteroskedasticity. Another good property of the PPML estimator is its consistency even if the dependent variable is not count in nature. Another good statistical property of PPML estimators is the unbiasedness property even when there is heteroskedasticity. [68]

The next method is the ***Feasible Generalized Least Squares (FGLS).*** It is commonly used in estimating panel data models when the error term is not identically distributed and/or when the error terms are no longer independent. An implication of this is that the variance-covariance matrix of the error terms is no longer a diagonal matrix. [34] The FGLS method starts with performing OLS on the pooled data. The OLS residuals are then used to estimate the components of the error variance-covariance matrix for which the structure for every group of observations is fully unrestricted. This flexibility gives the FLGS method robust properties under different patterns of heteroskedasticity and serial correlation. The FGLS method is also robust even without the knowledge on the exact form of the heteroskedasticity problem. [48] The performance model is sensitive to the sample size. [49] For small sample size, FGLS could be the perfect way to deal with the heteroscedasticity problem, while the PPML will be appropriate when the sample size is large and there is measurement error in the dependent variable. PPML bias is found to decrease in large sample sizes while FGLS bias is found to remain almost constant. In addition, the PPML standard error falls considerably but it still remains twice the FGLS standard errors. The choice of the best estimator is dependent on the dataset, and there is no generally best estimator in all contexts. [49]

The third and last nonlinear method that will be used is the ***Heckman two-step method***. The Heckman solution allows for log linear transformation of the model. The zero trade values are considered as censored observations. The two-step procedure first estimates the probability that two countries will trade using the probit model and the Inverse Mill's ratio. The Inverse Mill's ratio is simply the ratio of the probability density function over its cumulative distribution function. Using the estimated probabilities and some threshold value, the first step will give a binary estimate on whether two countries will trade or not. In the second step, the expected values of the trade flows, conditional on the two countries trading based on the first step, is estimated using the OLS method. The first step models the probability that two countries will trade while the second step models the actual trade value between countries who are predicted to trade in the first step. Hence, there will be two sets of explanatory variables. The two sets of explanatory variables may not be mutually exclusive. The independent variables in the first step are called exclusion variables. These exclusion variables should be able to predict the country's probability or propensity to export but not much on the actual level of the exports. [28] The same set of variables can be used for the two steps, while imposing normality in the error terms for both equations. [31, 45] One of the main benefits from using the Heckman two-step model is that it allows researchers to distinguish the impact of trade barriers on the volume or level of trade and the propensity for two countries to trade. [15]

4. RESULTS AND DISCUSSION

This section discusses the important and insightful results of the study. Section 4.1 begins with the discussion of the link between logistics performance and overall trade. Section 4.2 aims to rank the importance of the different indicators of LPI to overall trade. Section 4.3 discusses the results of the non-linear models for each priority sector. This section is further organized by each indicator of LPI to provide some discussion for each. Section 4.4 provides a summary of the results of the non-linear models for each priority sector and also provides additional insights on the ranking of the importance of the LPI indicators for each priority sector. Finally, section 4.5 presents a summary of the answers to the research hypotheses in section 3.4.

4.1. Impact of LPI to overall bilateral trade

Table 1 shows the complete set of estimates of the augmented gravity model using five different estimation procedures: pooled ordinary least squares (OLS), fixed effects (FE) model, random effects (RE) model, random effects with robust standard errors, and feasible generalized least squares (FGLS). Six methods are shown in order to provide a comparison of commonly used estimation procedures of regression models for international trade in panel data.

Table 1. Gravity models for LPI for 5 different estimation procedures

	(1)	(2)	(3)	(4)	(5)
VARIABLES	OLS	FE	RE	RE (robust)	FGLS
Overall LPI (Exporter)	4.647***	1.775*	2.665***	2.665**	4.789***
	(0.775)	(0.961)	(0.813)	(1.251)	(0.315)
Overall LPI (Importer)	3.455***	1.793*	2.159***	2.159***	3.594***
	(0.772)	(0.961)	(0.809)	(0.657)	(0.324)
GDP (Importer)	1.084***	0.973	1.179***	1.179***	0.985***
	(0.0833)	(0.677)	(0.120)	(0.121)	(0.0464)
GDP (Exporter)	1.477***	1.770**	1.634***	1.634***	1.469***
	(0.0856)	(0.700)	(0.126)	(0.141)	(0.0427)
Distance	-0.927***		-1.070**	-1.070**	-0.931***
	(0.229)		(0.461)	(0.481)	(0.115)
GDP per capita growth (Importer)	0.171	0.133	0.153*	0.153*	0.202***
	(0.152)	(0.0925)	(0.0791)	(0.0807)	(0.0511)
GDP per capita growth (Exporter)	0.0565	0.0804	0.110	0.110**	0.103**
	(0.152)	(0.0886)	(0.0790)	(0.0451)	(0.0521)
Common Colonizer	1.168***		1.248***	1.248**	0.757***
	(0.237)		(0.482)	(0.556)	(0.155)
Relative Factor Endowment	0.377***	0.783	0.580***	0.580***	0.355***
	(0.102)	(0.881)	(0.172)	(0.153)	(0.0499)
Common Border	1.236***		1.275**	1.275*	1.032***
	(0.297)		(0.616)	(0.656)	(0.151)
Constant	-49.32***	-55.79***	-51.55***	-51.55***	-46.79***
	(2.837)	(10.17)	(4.950)	(5.544)	(1.627)

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Only the independent variables which are statistically significant are retained and shown in the Table 1. The selection of the independent variables is aided by built-in software selection methods (automatic search procedures) such as stepwise and forward selection methods. Different automatic procedures will give different set of independent variables. The estimates are cross-checked by looking if the signs of the estimates are as expected or are consistent with theory.

For all the models for aggregate trade, the coefficient of overall LPI is significant and the signs are consistently positive for all of the estimation procedures. Based on the Hausman test, the p-value of the model on aggregate trade is 0.6631 (> 0.05). Therefore, the random effects model is more preferred than the fixed effects model. Nonetheless, both the fixed effects and random effects models gave similar insights as far as the relationship between LPI and overall export is concerned. The p-value of the Breusch-Pagan Test is close to zero, which implies that the pooled OLS method is inferior to the random effects model. Both the Hausman test and the Breusch-Pagan test says that the random effects model is superior over the fixed effects model and the pooled OLS method. Both the robust random effects model and the FGLS method gave consistent results which are positive and significant estimates for overall LPI of both the exporter and the importer. This strengthens the result that the LPI and aggregate trade have a positive relationship.

The signs of the controlling variables are also logical and consistent with the literature. GDP has a significant positive association with trade while distance is negatively related with trade for all models. The fixed effects model has no estimate for distance since it is a time-invariant variable. Moreover, countries with higher GDP per capita growth, with a common colonizer and with common borders have significantly higher trade value of exports. Lastly, countries with higher relative factor endowment have higher trade value. This is consistent with the theory that bilateral trade flows are positively related with country differences in terms of technological advancement. [20]

In the models which include the six indicators of LPI, the same controlling variables used in the models for overall LPI were also used. However, only the results for the FGLS method is shown. The reason for this is that the FGLS method accounts for the heteroskedasticity problem in the model and that several simulation studies and analytical studies have shown the superiority of the FGLS method over its methodological counterparts. This is explained in the methodological framework of this papers in section 3.2.2. Moreover, this will also facilitate the comparison of the different indicators with respect to their statistical and practical importance in explaining bilateral trade in section 4.2. Table 2 shows the coefficient estimates. Different model runs are implemented for the different components to avoid the problem of multicollinearity. All the parameter estimates of the components of LPI are consistently positive, both for the exporter and importer.

4.2. Ranking of the importance of the components of LPI to overall trade

This section provides a discussion on the relative importance of the different components of the LPI by looking at the magnitude of the estimated coefficients. The actual magnitude of the estimates can be used to rank the different indicators since all of them are commensurate. Standardization of the coefficients is not required and straightforward comparisons of the absolute value of the coefficients will suffice to ascertain the ranking of the six indicators in terms of their importance in statistically explaining the bilateral trade values.

As noted previously, since the response variable in the data is bilateral trade, then there is a distinction in the model on who exports and who imports. Therefore, the ranking of the indicators for the exporters is different from that of the importers.

For the exporters, the tracking and tracing component has the highest magnitude, which is closely followed by timeliness, and then by ease of arranging international shipments. Thus, the export value is more sensitive in the said three indicators, i.e. a unit increase in the score for the mentioned components will lead to a bigger increase in the average trade value, holding all other factors in the model constant. Lastly, the smallest magnitude among the components for the exporter is on the customs and border clearances component.

For the importers, the highest magnitude among the six components is also on the tracking and tracing component. The estimate for tracking and tracing is apparently significantly greater than the estimates for the other components. The component which follows is the ease of arranging international shipments whose coefficient is more than half of the former. The smallest magnitude is also on the customs component, which is the same as for the exporter.

Generally, there is a difference in the ranking of the components with respect to their importance in the models as measured by the magnitude of the coefficients in absolute terms. However, it is worth noting that the most important and the least important component is the same for both the exporter and the importer, which are tracking and tracing and customs, respectively. Shown also in the table are the averaged estimates for each component. The ranking of the

Table 2. Model estimates for overall LPI and its components based on FGLS.

	Exporter		**Importer**		**Average**	
Components	Estimate	Rank	Estimate	Rank	Estimate	Rank
Overall LPI	*4.789***		3.594***			
Tracking and Tracing	5.831***	1	7.577***	1	6.704	1
Timeliness	5.277***	2	2.301***	5	3.789	2
Ease of arranging international shipments	4.110***	3	3.088***	2	3.599	3
Quality of services	3.474***	4	2.745***	3	3.120	4
Customs	3.305***	5	2.359***	4	2.832	5
Infrastructure	3.245***	6	2.058***	6	2.652	6

*** p<0.01, ** p<0.05, * p<0.1

Table 3. Gravity models for LPI for 5 different estimation procedures

Sectors	Exporter			Importer		
	PPML	*FGLS*	*Heckman*	*PPML*	*FGLS*	*Heckman*
Agro-based	4.444***	4.559***	3.552*	1.827***	6.553***	6.546***
Automotive	2.555***	18.98***	8.292***	0.403	8.803***	5.793***
Electronics	8.319***	20.43***	13.19***	6.251***	9.855***	10.02***
Fisheries	4.050***	12.39***	7.677***	1.363**	13.54***	9.667***
Health	7.075***	19.17***	6.774***	0.0881	8.213***	7.126***
ICT	6.703***	27.76***	15.44***	3.616***	10.79***	5.162**
Rubber	2.085***	14.21***	6.838***	-0.552	5.544***	5.410***
Textiles	3.599***	9.371***	9.787***	1.183***	3.582***	4.245***
Wood	2.448***	5.356***	1.469	1.074***	9.884***	10.40***

*** p<0.01, ** p<0.05, * p<0.1

averaged estimates is consistent with the ranking for the exporters.

4.3. Impact of LPI to sectoral trade

For the models on the priority sectors, the estimation procedures used previously for aggregate trade are no longer appropriate not only due to the inherent heteroskedasticity in the data but also because of the existence of many zero trade flows. Hence, non-linear methods are used in the models which are PPML, FGLS, and the Heckman Two-step procedure. Simulation studies have demonstrated that FGLS is the appropriate model if there is a problem of heteroscedasticity and for which its true form is unknown. [47, 56] Nonetheless, even if FGLS is superior on this aspect, heteroskedasticity is not entirely the problem present in the data. There is also a problem of having zero-inflation in the bilateral trade for which heteroscedasticity is just one of the many possible consequences. Since PPML and Heckman offer different approaches in solving the zero-inflated problem, it is still worthwhile to include the parameter estimates that would be obtained from using the methods. Moreover, there is currently no formal statistical test to decide which between FGLS, PPML, and Heckman should be used in any contexts or in a general set-up, most especially if information criterion model estimates are not available. There is a great reliance on simulation studies done by other researchers to argue that FGLS is superior but results from these simulation studies are case-specific and may not be true for all scenarios. In other words, the FGLS is shown to be superior under the presence of heteroscedasticity but may not be true for all zero-inflated cases. This is the same reason why many existing studies working on the same problem provided the estimates of the three methods side-by-side to facilitate comparison and to show the consistency in the practical implications and insights from the different estimation procedures. [28, 56] Using different estimation procedures but having the same practical implications from the model estimates would strengthen the results of the study.

The PPML method is an iterative procedure and a difficulty was encountered when including too many variables in the model. Moreover, the estimates of LPI or some of its components become insignificant in the presence of the control variables. The suspect is due to the multicollinearity in the independent variables.

Shown in Table 3 are the estimates of the coefficients of overall LPI across the different priority sectors for both the exporter and the importer. Moreover, almost all the estimates have a positive sign except for the overall LPI of the importer for the model on the Rubber sector using the PPML method. Despite a negative sign, the coefficient is not significant.

4.3.1. Infrastructure

The infrastructure component of the LPI measures the quality of the country's transport and telecommunications infrastructure. Table 4 shows that the infrastructure quality of the exporter and importer has, in general, a significant and positive effect on trade for all priority sectors in all three models. The positive coefficients imply that improvements in transport infrastructure, such as road density and road network, air transport, railways, ports, and logistics, results to increase in trade flows. The availability and quality of infrastructure also influences firms' location decisions, such as the establishment of new firm and investment of capital at different locations. [64] Although the literature gives more attention to hard infrastructure, the impact of soft infrastructure, such as ICT, on trade flows cannot be undermined.

Table 4. The panel data estimates for Infrastructure on all Priority Integrated Sectors

Sectors	Exporter coefficient			Importer coefficient		
	PPML	*FGLS*	*Heckman*	*PPML*	*FGLS*	*Heckman*
Agro-based	3.232***	2.820***	2.406	1.255***	4.014***	4.140**
Automotive	1.920***	9.677***	5.201***	0.213	2.699**	2.944*
Electronics	5.781***	10.23***	7.740***	4.239***	4.521***	6.038***
Fisheries	2.930***	5.650***	6.904***	0.855*	5.577***	5.196**
Health	5.020***	9.828***	3.868**	-0.204	3.566***	5.109***
ICT	4.976***	16.02***	9.719***	2.599***	3.217**	2.273
Rubber	1.668***	8.232***	5.231***	-0.43	1.258	2.298*
Textiles	2.699***	5.815***	8.415***	0.803***	1.883**	1.724
Wood	1.982***	4.218***	1.259	0.780***	5.493***	7.265***

*** p<0.01, ** p<0.05, * p<0.1

4.3.2. Customs

Table 5 shows the estimates of the coefficient of the customs component of both the importer and exporter for all the priority sectors.

Table 5. The panel data estimates for customs on all Priority Integrated Sectors

Sectors	Exporter coefficient			Importer coefficient		
	PPML	*FGLS*	*Heckman*	*PPML*	*FGLS*	*Heckman*
Agro-based	3.303***	2.017***	2.092	1.282***	4.516***	4.604**
Automotive	1.953***	12.75***	4.979**	0.23	4.744***	3.616*
Electronics	5.998***	12.76***	7.688***	4.428***	3.038**	6.282***
Fisheries	3.116***	4.740***	3.876	1.021**	5.912***	5.370**
Health	5.272***	11.01***	4.181**	-0.104	3.802***	5.077***
ICT	4.822***	19.46***	10.57***	2.497***	3.796***	2.376
Rubber	1.485***	6.572***	1.369	-0.765*	2.589***	2.372
Textiles	2.711***	6.406***	7.069***	0.707***	0.991	2.455**
Wood	1.694***	1.502	-0.794	0.540*	4.881***	6.591***

*** p<0.01, ** p<0.05, * p<0.1

The positive coefficients imply that coordination among customs and border control agencies is important in trade facilitation efforts. Inefficient custom procedures and border clearance processes can lead to delays and inconveniences. [4] Costly and cumbersome border procedures and standards raise transaction costs and extend delays to clearance of export, imports, and transit cargoes which hinder countries international trade competitiveness. [23] Since custom procedures, on the average, account for one third of the time of import or export, and its efficiency is contingent on the agencies' managers and service providers involved, then there is a need to look at the current practices and institute changes when necessary to improve the system. [21]

4.3.3. Ease of arranging international shipments

Table 6 shows the estimates of the coefficient of the component *ease of arranging international shipments* of both the importer and exporter for all the priority

Table 6. The panel data estimates for international shipments on all Priority Integrated Sectors

Sectors	Exporter			Importer		
	PPML	*FGLS*	*Heckman*	*PPML*	*FGLS*	*Heckman*
Agro-based	4.786***	3.682***	2.985**	1.724***	4.765***	4.578***
Automotive	3.929***	14.09***	5.078***	1.203*	7.349***	3.673**
Electronics	9.638***	18.70***	11.70***	6.759***	7.588***	7.051***
Fisheries	3.551***	12.06***	4.714**	0.814	8.624***	5.844***
Health	8.850***	16.49***	3.906**	0.462	4.162***	3.428***
ICT	7.639***	22.54***	11.36***	3.560***	7.055***	4.211***
Rubber	2.719***	14.80***	5.231***	-0.0809	4.201***	3.807***
Textiles	3.982***	8.826***	7.423***	1.231***	2.728***	3.250***
Wood	2.652***	3.830***	1.308	1.380***	6.032***	6.069***

*** p<0.01, ** p<0.05, * p<0.1

sectors. This component analyses the management of flow of goods regarding the ability to organize shipments efficiently in terms of deliveries and competitive costs. The positive estimates of the coefficients imply that the availability of competitively arranged shipments has an influence on international trade. Ease of arranging international shipments is a component of LPI that does not directly respond to public policies; rather, it is largely determined by the intervention of the private sector, which behaves based on market conditions. However, government policies can also play a crucial role in promoting economic efficiency in the freight transportation sector by producing cost-effective infrastructures to improve access, hence, reducing costs and improving trade. [55]

4.3.4. Quality of logistics services

Table 7 shows the estimates of the coefficient of the component on the quality of logistics services of both the importer and exporter for all the priority sectors. The positive coefficients of this component imply that the quality of logistics services plays an important role in facilitating the international trade of goods. Improving logistics services like third-party logistics, trucking, and freight forwarding is a complex task for policymakers. [42] However, government initiatives such as increasing managerial capacity, setting quality standards developed by professional organizations, regulating business certification and ensuring standardization of operations can help the private sector develop its logistics competencies. [54]

Table 7. The panel data estimates for quality of logistics services on all Priority Integrated Sectors

Sectors	Exporter			Importer		
	PPML	*FGLS*	*Heckman*	*PPML*	*FGLS*	*Heckman*
Agro-based	3.694***	2.226***	2.322	1.404***	4.211***	5.277**
Automotive	1.608***	10.61***	4.963**	0.0824	6.043***	4.836**
Electronics	7.180***	11.85***	8.253***	5.207***	5.723***	7.566***
Fisheries	3.468***	5.669***	4.334*	1.082**	6.599***	5.622**
Health	5.912***	11.19***	4.380**	-0.167	3.708***	5.546***
ICT	5.670***	17.54***	8.992***	2.759***	6.879***	2.788
Rubber	1.267***	7.645***	3.263*	-0.702	2.922***	4.074**
Textiles	3.064***	3.748***	7.245***	1.026***	1.997**	3.098**
Wood	1.771***	2.187**	0.434	0.703**	3.622***	6.970***

*** p<0.01, ** p<0.05, * p<0.1

Table 8. The panel data estimates for timeliness on all Priority Integrated Sectors

Sectors	Exporter			Importer		
	PPML	*FGLS*	*Heckman*	*PPML*	*FGLS*	*Heckman*
Agro-based	6.032***	4.739***	3.805*	2.271***	4.392***	4.794**
Automotive	3.391***	14.77***	10.80***	0.335	6.053***	4.520*
Electronics	10.18***	17.41***	14.57***	7.486***	6.794***	9.387***
Fisheries	5.970***	16.45***	6.582**	2.141***	9.613***	11.35***
Health	9.386***	16.34***	4.011*	-0.205	5.846***	4.581**
ICT	8.868***	27.40***	14.66***	4.481***	10.95***	5.800**
Rubber	3.173***	15.51***	11.10***	-0.595	4.280***	5.956***
Textiles	5.163***	7.763***	6.767***	1.637***	2.213**	3.047*
Wood	3.566***	5.442***	4.195	1.369***	8.741***	9.847***

*** p<0.01, ** p<0.05, * p<0.1

Similarly, improving the quality of logistics services is important because it increases customer satisfaction, which in turn increases the possibility of having strategic partnering and corporate profitability [59]. Attaining excellence in logistics demands continuous improvement in reliability, responsiveness and well-functioning support services. [55]

4.3.5. Timeliness

Table 8 shows the estimates of the coefficient of the timeliness component for both the importer and exporter for all the priority sectors. Time may be considered as a trade barrier and factors affecting timeliness are security screening of cargo, port infrastructure investment, and customs procedures. [39] Timeliness measures the promptness of shipment delivery times. The delays in delivery, lack of shipments, need for physical inspections, use of obsolete communication technology, and poor state of transportation infrastructure are important factors that determine the timeliness component.

4.3.6. Tracking and Tracing

Lastly, table 9 shows the estimates of the coefficient of the tracking and tracing component for both the importer and exporter for all the priority sectors. This component is generally defined as the process of determining the current and past locations of a unique item. The positive coefficients imply that the ability to accurately track and trace the movement of products,

Table 9. The panel data estimates for tracking and tracing on all Priority Integrated Sectors

Sectors	Exporter			Importer		
	PPML	*FGLS*	*Heckman*	*PPML*	*FGLS*	*Heckman*
Agro-based	4.506***	1.887***	1.162	1.730***	3.607***	4.065**
Automotive	2.474***	8.823***	4.914***	0.237	5.594***	3.814**
Electronics	8.232***	8.602***	5.700***	5.819***	3.658***	6.157***
Fisheries	4.263***	3.908***	5.106**	1.455**	8.474***	6.947***
Health	7.477***	10.40***	5.063***	0.199	5.550***	5.998***
ICT	6.580***	15.01***	7.321***	3.333***	7.024***	2.194
Rubber	2.200***	5.509***	2.276	-0.431	3.332***	3.945***
Textiles	3.684***	2.689***	5.199***	1.325***	2.063***	2.859***
Wood	3.659***	3.744***	0.0283	3.535***	7.227***	8.278***

*** p<0.01, ** p<0.05, * p<0.1

Table 10. The average estimates and rankings of LPI indicators for agro-based, automotive, electronics, and fisheries sectors

LPI Indicator	Agro-based		Automotive		Electronics		Fisheries	
	Ave. Est.	Rank	Ave. Est.	Rank	Ave. Est.	Rank	Ave. Est.	Rank
Customs	3.267	4	8.747	3	7.899	4	5.326	6
Infrastructure	3.417	3	6.188	6	7.376	5	5.614	5
International Shipments	4.224	2	10.720	1	13.144	1	10.342	2
Logistics Services	3.219	5	8.327	4	8.787	3	6.134	4
Timeliness	4.566	1	10.412	2	12.102	2	13.032	1
Tracking and Tracing	2.747	6	7.209	5	6.130	6	6.191	3

which helps companies increase the efficiency of supply chains, increases trade. Managing the exact location and the route of each specified item from origin to destination has been a crucial activity due to the need to reduce transit times. The ability to track and trace is supported by a variety of technologies that aid in giving real-time information on the location and status of these particular items throughout the supply chain. This guarantees the opportunity to increase visibility and control in different logistics operations. [58] Furthermore, this track and trace technology can also be a very important tool for trade facilitation that allows trusted traders to work and cooperate with regulatory agencies in ensuring a level playing field of competition for industries, and also in improving governments' ability to combat illegal trade and those who create profit from this activity. [22]

4.4. Summary of results for the sectoral gravity models

This section discusses a summary of results of the gravity models for the priority sectors of ASEAN. This section also provides a ranking of the six LPI indicators for all priority sectors. To be consistent with the rankings made for the overall trade, the FGLS method was used as the basis in coming up with the rankings. Moreover, to facilitate comparisons, the simple arithmetic mean of the coefficient for importer and exporter was computed. The arithmetic mean was used since this shows that the roles of an importer and exporter are equally important in international trade. Shown in table 10 are the averaged estimates and rankings of LPI indicators for agro-based, automotive, electronics and fisheries sectors. For the agro-based sector, it turned out that timeliness is the most important indicator, followed by the ease of arranging international shipments. A similar pattern can be observed for the automotive, electronics, and fisheries sectors, i.e. the top two LPI indicators are timeliness and ease of arranging international shipments. The rankings of the other LPI indicators do not show a common pattern for the said priority sectors. However, it is worth noting that the tracking and tracing component has the least rank for the agro-based and electronics sectors, and has the second-to-the least rank for the automotive sector.

Table 11 shows the average estimates and rankings of LPI indicators for the 5 remaining priority sectors: health, ICT, rubber, textiles, and wood. The top LPI indicator for the remaining 5 priority sectors is also

Table 11. The average estimates and rankings of LPI indicators for health, ICT, rubber, and wood sectors

LPI Indicator	Health		ICT		Rubber		Textiles		Wood	
	Ave. Est.	Rank	Ave. Est.	Rank	Ave. Est.	Rank	Ave. Est.	Rank	Ave. Est.	Rank
Customs	7.406	5	11.628	4	4.581	5	3.699	4	3.192	5
Infrastructure	6.697	6	9.619	6	4.745	4	3.849	3	4.856	4
International Shipments	10.326	2	14.798	2	9.501	2	5.777	1	4.931	3
Logistics Services	7.449	4	12.210	3	5.284	3	2.873	5	2.905	6
Timeliness	11.093	1	19.175	1	9.895	1	4.988	2	7.092	1
Tracking and Tracing	7.975	3	11.017	5	4.421	6	2.376	6	5.486	2

timeliness. This is consistent with the previous four priority sectors discussed in table 10. From this, it can be implied that the timeliness of the exporter and importer is the most important LPI indicator for all the priority sectors of the ASEAN. For the health sector and ICT sector, the infrastructure component has the smallest average estimate, while for the rubber and textiles sector, the tracking and tracing component has the smallest average estimate. This is also the same observation for the agro-based, automotive, and electronics sector in table 10. This suggests that infrastructure and tracking and tracing are relatively the least important indicators in the trade value of the priority sectors. Nonetheless, it is worth noting that for the wood sector, the tracking and tracking components is the second most important indicator, next to timeliness.

Shown in table 12 are the average ranks of the LPI indicators, averaged across the nine priority sectors. As expected, timeliness has the highest average rank, followed by ease of arranging international shipments. This means that the trade value for all nine priority sectors in the ASEAN are most sensitive to the timeliness of the exporter and importer and in the ease of arranging international shipments. Also, consistent with the previous results in tables 10 and 11, infrastructure and tracking and tracing have the lowest average ranks.

Table 12. The average ranks of LPI indicators across the nine priority sectors

LPI Indicator	Average Rank
Tracking and Tracing	4.67
Infrastructure	4.67
Customs	4.44
Logistics Services	4.11
International Shipments	1.78
Timeliness	1.33

Overall, it can be concluded that in terms of explaining trade value for the priority sectors in the ASEAN, the changes or movements of the values are least sensitive to tracking and tracing and infrastructure, and most sensitive to timeliness and ease of arranging international shipments.

4.5. Results of the Tests on the Research Hypotheses

The main research findings in line of the research hypotheses are the following:

1. The overall LPI index is indeed positively related with trade, both for the overall and sectoral trade, in the ASEAN. The FGLS method shows a consistent positive and significant estimate for overall trade. Moreover, the FGLS, Heckman, and PPML methods show positive coefficients for the significant terms. This result is intuitive and is consistent with theory since the LPI index is an indicator of the competitiveness of a country in terms of logistics performance.
2. The six indicators of the LPI is positively related with trade, both overall and sectoral, in the ASEAN. There is a difference in the rankings of the six indicators based on the standardized coefficients.
   With respect to the overall trade, the tracking and tracing component is the most important for both the importer and exporter. The ease of arranging international shipments is also a very important indicator. It is the second most important indicator for the importers and is the third most important indicator for the exporters. Lastly, for both importers and exporter, the infrastructure component is the last in the rankings. With respect to the sectoral trade, the ease of arranging international shipments and the timeliness component are the two most important indicators. Consistent for both overall and sectoral trade, the ease of arranging international shipments and timeliness components are relatively very important aspects of logistics performance, while the customs components is the least important. Based on the results for both the overall trade and the sectoral trade, the identified three relatively more important components, which are ease of arranging international shipments, timeliness, and tracking and tracing, are considered as the outputs of the framework used in coming up with the LPI. The aforementioned indicators of LPI are the indicators for service delivery performance due to effective infrastructure, customs procedures, and quality of logistical services. Therefore, the importance of the inputs for logistics performance cannot be understated and downgraded because these are important areas for policy and political regulation in order to achieve good performance outcomes measured by the three outputs.

5. CONCLUSION

This paper uses an augmented gravity model that is estimated using panel data regression methods to investigate the determinants of trade (exports) value for both aggregate trade and trade in the priority sectors of ASEAN member countries. The central framework guiding the empirical research is the augmented gravity model which is a well-accepted and well-

studied model and is superior when it comes to the analyses of international trade flows.

Different estimation procedures, both linear and nonlinear methods, with different assumptions and appropriateness are employed in the analyses. Based on the different approaches employed in the gravity model, whether linear or non-linear methods, the results provide strong empirical evidence that logistics performance has a positive association with trade value, both for aggregate trade and for trade in each of the priority sectors. The empirical success of the gravity model cannot be ignored in its usefulness in understanding exogenous factors that influence international trade. The context of this study is Southeast Asia and the goal of this paper is to seek new empirical evidence on the relationship that logistics performance has with trade value.

The following are the main findings of the analysis:

1. **Based on the different models employed in the gravity model, whether linear or non-linear, the results provide strong empirical evidence that logistics performance has a positive association with trade value, both for aggregate trade and for trade in each of the priority sectors.**

The findings lend additional empirical support to logistics performance as a significant factor in improving trade value in the ASEAN region. For the model using aggregate export as the response variable, the following five different estimation procedures are used and compared: pooled ordinary least squares, fixed effects model, random effects model, random effects model with robust standard errors, and the Feasible Generalized Least Squares (FLGS) model. The robust random effects model and the FGLS method aim to obtain robust standard errors so as to correctly perform tests of significance on the parameters of the model. The final estimation procedure chosen by the researcher is the FGLS method because of its appropriateness in that it is a robust method with several nice properties that make it superior to more commonly used panel regression methods. For the trade on the level of the priority sectors, three non-linear methods are employed in the analysis, namely, Poisson Pseudo Maximum Likelihood method, Feasible Generalized Least Squares method, and the Heckman Two-step procedure. Almost all of the signs of the coefficients of the LPI and its components are positive and significant. Some parameter estimates have negative signs but are statistically insignificant.

2. **There is a difference in the importance of the components for both the exporter and importer. The ASEAN region can therefore implement prioritization of actions and strategies based on the relative importance of the different components of logistics performance.**

With respect to the overall trade, the tracking and tracing component is the most important component for both the importer and exporter, while the infrastructure component is relatively the last in the rankings. With respect to sectoral trade, ease of arranging international shipments and the timeliness component are the two most important indicators. The three relatively most important components are the output indicators of LPI. Even though the input variables of LPI have relatively smaller model estimates, their importance should not be undervalued since these are important areas for policy and political regulation in order to achieve positive outcomes of logistics performance.

Based on the main findings of this research, the following are proposed as recommendations. Firstly, policy makers should implement actions to improve logistics in the ASEAN community which is further discussed below. Secondly, the ASEAN can implement prioritization of actions in order to achieve the goals on trading and cooperation in the region. The two most important indicators for the trade value of priority sectors are timeliness and ease of arranging international shipments. It is a striking observation that this is consistently true for all the priority sectors. Hence, this implies that countries should focus on the aspects of timeliness of logistics services and the ease of arranging international shipments in order to achieve an improvement in international trade in the ASEAN region. Nonetheless, it should also be noted that when looking at overall or aggregate trade, together with timeliness and ease of arranging international shipments, tracking and tracing is also a very important indicator. These three indicators are therefore identified as very important aspects of logistics performance. In particular, these three indicators refer to the outputs of the LPI framework, i.e. they are service delivery performance outcomes due to effective inputs, particularly on the infrastructure, customs, and quality of logistical services. Therefore, a great amount of effort should also be exerted in order to improve infrastructure, to make customs procedures and border clearances more efficient, and to modernize and improve logistical services. In the framework of the logistics performance index, these three areas are the areas for policy regulations. Effective policies on these areas will translate to positive outcomes in terms of time, cost, and reliability. These outcomes as measured by timeliness, ease of arranging international shipments, and efficient tracking and tracing are then translated to an increase in international trade, both for the overall trade and for each priority sector in the ASEAN region.

Specific strategies for the inputs of LPI are discussed below.

Countries should continually reassess their current customs processes and border clearance requirements in order to strengthen trade flows which will eventually benefit all countries in the region. Effective information communication technologies are found helpful for the integration of customs and border management operations and performance improvement. [50] The ASEAN countries have put a great effort to harmonize

and coordinate national policies. The streamlining of logistics regulation and policies, which include customs procedures, is a major aspect for the efficiency of the sector and the competitiveness of the countries in the global supply chains. In fact, the importance of providing advice on customs procedures is already acknowledged due to the increasing complexity of supply chains. [19]

Next, the importance of building and improving infrastructures for logistics operations cannot be overstated. It is acknowledged in the literature that one reason for major logistical problems is poor infrastructure. Several countries, including China, Thailand, and Indonesia, acknowledged infrastructure as a key driver for logistics and included this sector as a major part of the national logistics policies and blueprint. Infrastructure development includes the identification of key terminals and ports, building and modernization of other transport modes such as rail and inland waterways, and the creation of other priority facilities which could be specific to particular key industries. [19]. Development and modernization of infrastructures is certainly key to a more integrated logistics system in the ASEAN region.

Moreover, the quality of logistics services is also an important determinant for an increase in bilateral trade flows. This could be done by putting in place standard operating procedures in the delivery of logistics services. Quality logistics services play an important role in trade facilitation. Inefficient logistics services lead to additional cost in terms of time and money, which consequently slows down trade. Equivalently, efficient logistics services give less burden in terms of costs, which consequently lead to competitiveness of countries in terms of trade volume and value. [41] The results of the non-linear methods employed in this research is an additional empirical evidence that inefficient and poor quality of logistics services is a barrier for trade.

The aforementioned strategies are inputs to ease arranging international shipments at competitive prices. This is important since efficient shipments in terms of deliveries and costs are important considerations and factors in initiating trade and managing flows of trade. Government policies and the coordination with the private sector play an important role in facilitating competitive and efficient shipments. Moreover, timeliness in terms of the delivery of logistics services is another output. Two important indicators for timeliness are ship turnaround times and transit times. Timeliness is dependent on the level of efficiency of customs and border clearances and the infrastructure. A change of the landscape or the environment by revisiting existing policies, and by internationalization through forming alliances and linkages of logistics facilities, may be done in order to achieve significant improvements in this aspect. [19] Lastly, effective policies will lead to the availability of information services and the efficiency of the information system for carriers, freight forwarders, and logistics service providers. This will lead to the efficiency of tracking and tracing component which is very important in achieving supply chain visibility.

6. LIMITATIONS AND FUTURE RESEARCH

One limitation of the study is the use of perception-based indicators to measures logistics performance. A future direction for research is to use other available databases and indices such as the Trade Facilitation Indicators and Enabling Trade Index. The Enabling Trade Index is an index measuring trade facilitation based on an assessment of institutions, policies, services, and infrastructures in place which are involved in the facilitation of the flow of goods from one country to another. Some of the indicators under the mentioned pillars are perception-based and are gathered through surveys, while some are readily available statistics from official government databases and from various organizations such as the World Bank, World Trade Organization, and the International Trade Centre. The Trade Facilitation Indicators are sets of indicators developed by the Organization for Economic Co-operation and Development to help countries reduce trade barriers. The main indicators are on the following aspects: information availability, advance rulings, appeal procedures, fees and charges, harmonization and simplification of trade documents, automation of documents and border procedures, streamlining of border controls and procedures, internal co-operation, external co-operation, and governance and impartiality.

Another limitation of this study is that it uses the macro lens in linking logistics performance and trade. Conduct of case studies are very helpful in order to look at fine details and to answer even more specific research which will hopefully corroborate with the results of this study. Also, with this, more specific policy implications can also be crafted and proposed.

Another area for future research is in investigating the factors affecting the inefficiency in trade among countries in the ASEAN. Trade inefficiency refers to the difference between the potential trade and the actual trade. Several trade barriers exist that hinder countries from attaining their trade potential. This study has successfully provided an empirical evidence on the relationship between logistics performance and the trade value both for the overall and sectoral trade. Nonetheless, it is of interest and also useful to look at how logistics performance can help countries attain their trade potential.

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