

Jayasooriya, S. P.

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## Bayesian gravity model for digitalization on bilateral trade integration in Asia

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**ADB Working Paper Series**

**BAYESIAN GRAVITY MODEL FOR  
DIGITALIZATION ON BILATERAL  
TRADE INTEGRATION IN ASIA**

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S. P. Jayasooriya

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**Asian Development Bank Institute**

S. P. Jayasooriya is a Chartered Economist (Economic Policy) at Innovation4Development Consultants in Sri Lanka.

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Please contact the authors for information about this paper.

Email: [spj0525@gmail.com](mailto:spj0525@gmail.com)

Asian Development Bank Institute  
Kasumigaseki Building, 8th Floor  
3-2-5 Kasumigaseki, Chiyoda-ku  
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500  
Fax: +81-3-3593-5571  
URL: [www.adbi.org](http://www.adbi.org)  
E-mail: [info@adbi.org](mailto:info@adbi.org)

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**Abstract**

The impact of globalization in terms of bilateral trade is a renowned theoretical underpinning in the literature. Nevertheless, testing a trade integration model of bilateral trade is not sufficiently well estimated with the Bayesian approach to provide pragmatic evidence of trade integration from the digitalization in Asia. Moreover, in identifying the factors determining trade integration, testing for digitization using the Bayesian gravity equation is vital. After performing a series of simulation experiments, a relationship between import volume and simulated trade determinants was predicted for the digitalized trade model. The results of the estimated coefficients on GDP in the country of origin and GDP of the country of destination are positively significant predictors of the import growth. The distance between the countries has a negatively significant estimation that implies barriers in trade. The model predicts trade integration, especially towards the trade digitalization in Asia. The Bayesian approach of the gravity model gives robust estimates for determining the impact factor for the importation of trading countries, including the fact that the elasticities of total trade inflow with respect to distance, population, and area of the country of destination and the exchange rate of the country of origin are negative while the proxies of digitization are positively significant. Further, economic size, area, and exchange rate of the destination, and population and area of the country of origin are positively predicted by the model. The estimated parameters are directly the elasticities, in which increases in GDP in a reporter country is consistent with the higher import volumes. Further, evidence of the gravity equation is used for understanding trade potential, and after some integrations, the estimation is applied for the real trade. The measures of bilateral trade resistance or costs associated with the trade flow of the digitization has influenced the expanding of the digital indicators in the model in the Asian economies. Finally, digitalization of trade integration can be implemented across Asia with evidence and robust estimates of the gravity model, including robustness checking. The Bayesian experiment for the estimation of the impacts of the trade integration in Asia predicts an increase of GDP, digitalization proxies, population, exchange rate, and area of the destination as predominant predictors in the Bayesian gravity model. Thus, the results revealed that digitalization has affected the plausible trade agreements for trade integration in Asia.

**Keywords:** Bayesian gravity model, digitization, import growth, trade integration

**JEL Classification:** F11, F14, F15, F62

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# 1. INTRODUCTION

Impacts of globalization result in trade integration since it is advantageous in many developing economies. Adapting to bilateral trade is fundamental for the trade facilitation and integration process by digitizing, considered a key determinant for international trade policies, and the potential of digitizing is an essential source of comparative advantage for Asia. Theoretical structures for the nexus between trade flow and trade integration determinants are studied in a number of seminal studies using the gravity model. Increased import and export has accelerated the integration of trade among countries in Asia, where countries have continued to implement open economic policies with a greater direction to open the markets. They have made extensive efforts to implement economic integration not only with their neighboring countries but also with other countries in different regions of Asia. Since 1990, many Asian countries have been involved in regional trade agreements (RTAs), with more than 30 agreements, including multilateral and bilateral RTAs, in Asia. Among these, ASEAN, AFTA, SAARC, and SAFTA, with a focus on trade volume and economic growth, are significant in terms of integration. Within the wide range of literature, Frankel (1994), Ramasamy (1995), Endoh (1999), Thorn and Goglio (2002), Elliott and Ikemoto (2004), and Siah (2009) investigated the effects of ASEAN and AFTA, while Hassan (2001), Hirrantha (2004), Batra (2004), Rahman, Shadat, and Das (2006), and Gul and Yasin (2011) examined SAARC and SAFTA. To facilitate open economic policies in terms of trade integration, this study analyzes the Bayesian Gravity Model for Asian countries to thoroughly evaluate the determinants of import volume. From an economic growth standpoint, open economic policy analysis has been devoted to explaining the relationships with trade integration at the aggregate level. Nevertheless, the literature shows a gap in Asian countries in providing empirical evidence to foster open economic policies for trade integration.

International trade is associated with individuals, sectors, and regions in increasing prosperity for long-term economic growth. Opening the national economy always consists of winning parties as well as losing parties with a focus on trade policymakers attempting to maximize the positive net gains. This suggests that the trade integration of those sectors needs to be considered with careful analysis and evaluation of policies for open economic scenarios, mainly because of the high risks and heterogeneous impacts of the countries in economically opening to the distribution of income, assets, and opportunities. The free trade can be slowed down, stopped, or prevent others from benefiting due to political influences. Nonetheless, if potential adverse effects are controlled, an open economy can achieve positive impacts at national, sectoral, and individual levels. Generally, these kinds of policies are related to trade-related integration, enhancing the distribution from economic opening.

## 1.1 Targeting Trade-Related Integration

Open economic policies have been applied in many Asian economies with different intensities, frameworks, and strategies. However, a limited review on trade integration on open economic policy for developing countries can be perceived in the underpinning literature. Trade integration is defined as measures and policies, including financial factors, focusing on the implementation of trade reforms and trade policies between countries. Trade integration measures and policies include using other measures to eradicate the deficit in the balance of payments, adjusting to the world trading conditions and changing commodity prices. Further, trade integration supports

activating target transformation and enhancing the competitiveness of import while measuring the burden of trade liberalization.

This study aimed to provide pragmatic evidence of trade policies in the Asian countries for already established trade agreements. The quality of the executed policies and reforms is highly varied among these countries which need studying the trade integration. Based on the above discussion, the purpose of this paper is to examine the trade integration with the evidence of trade policies under the digitalization of Asian countries. It investigates the contribution of trade facilitation and integration in promoting a country's trade integration for fostering growth.

The paper is organized as follows. In the second section, a review of the literature is presented, and in the third, there is a brief discussion on the specification for the gravity model. In this section, a Bayesian gravity equation is developed, which accounts for more econometric issues than in previous studies for robust estimation of the impacts. The fifth section provides the simulated and estimated results along with discussions. Subsequently, concluding remarks follow the empirical results section.

## 2. LITERATURE REVIEW

International trade is accelerated under multilateral free trade negotiations providing a theoretical foundation for accepting substantial part of trade is bilateral among developed countries, which makes the impact of trade liberalization uncertain. Thus, the literature proposes numerous theories for trade integration in line with digitalization. Numerous theories and models on trade integration explain the advantage of bilateral trade in developed and developing economies for gaining maximum benefits with open economic policies. The gravity model, at the macroeconomic level, predicts the effects of trade liberalization on the economies fostering economic growth. The literature provides a number of seminal studies on the application of the gravity-based model for trade integration. The literature includes the contributions of Tinbergen (1962) and Pöyhönen (1963). Accordingly, the new trade theory supports validations of the theories for building the models with increasing returns of scale, competition, and transport costs (Anderson 1979; Bergstrand 1989; Helpman and Krugman 1985). Tinbergen (1962), Pöyhönen (1963), and Linnemann (1966) applied the gravity model analogy for trade relationships among various countries. Furthermore, Bayomi and Eichengreen (1995) designed the model that was used for an expanded period to determine the variations of trade in numerous studies. Therefore, the empirical results of the overall gravity model are considered robust and best fitted to the data for empirical evidence and open economic policies.

Although the empirical progress of the gravity model is advanced over time, Baldwin (1994) and Leamer (1994) disapproved the gravity model on the basis of not the existing theoretical insight of the relationships. In general, the gravity model determines the trade patterns and potentials of factors such as transport costs, border and nonborder barriers, geographical and cultural features, and other regulatory constraints that impact the trade between countries. Therefore, a theoretical foundation for the gravity model was developed to best-fit results. Thus, a reduced form of gravity models based on trade theories such as Heckscher-Ohlin's models is developed.

Many economists derive the foundation for the gravity model using the theoretical perspective of trade including Ricardian, Heckscher-Ohlin, and New International Trade Theory (Anderson 1979; Helpman and Krugman 1985; Deardorff 1995, 1998; Feenstra et al. 2001; Eaton and Kortum 2002; Anderson and van Wincoop 2003). But Anderson (1979) presented a gravity model from all types of product differential models. Later, Bergstrand (1989) derived the Heckscher-Ohlin model. Helpman and Krugman (1985) developed the monopolistic competition model with increasing returns and transport costs. Recently, the gravity model has been extended on the basis of traditional models and reached more robust and consistent conclusions (Deardorff 1995; Anderson and van Wincoop 2003; Helmers and Pasteels 2005). The gravity model is used in data samples to investigate bilateral trade flows considering their incomes, bilateral distance, and dummy variables for a common language, common borders, and any of the regional or bilateral agreements. Last, trade potential between partner countries at the sectoral level is estimated by Baroncelli (2005) by incorporating the simulated SAFTA-bound future tariffs. However, it contains some methodological flaws such as endogeneity and violations of assumptions of Jensen's inequality.

On the other hand, digitization has made an enormous impact on the trade between countries. Digital trade includes digitally enabled transactions in goods and services. Thus, growing digital connectivity is also enabled, increasing radiational or supply chain trade in goods. According to Miroudot and Cadestin (2017), as a consequence of digitization, trade in minor, low-valued physical packages and digitally delivered services is growing. In addition, digitization changes how companies interact with their customers, other companies, and government; a globalized world with hyperconnectivity, production, design, delivery, and consumption is geographically detached through trade and constantly connected through digital networks (Lopez-Gonzalez and Jouanjean 2017). The digitization of trade has brought changes in terms of the scope, scale, and speed of trade.

Undoubtedly, digitalization changes the many economic activities of the industries through digital retailers, associated firms with joining supply and demand matching services, are increasingly providing, or facilitating access to warehousing, logistic, e-payment, credit, and insurance services with a supportive environment. Asian open economies are largely dependent on the integration of bilateral trade for economic growth. Overall, this has the effect of boosting the efficiency and production capacity of domestic firms, thereby enhancing their competitiveness in the global markets. Digitalization has become the key factor on this basis, which helps international trade to be smooth and fast.

### **3. DATA AND EMPIRICAL METHOD**

#### **3.1 Data**

Forty-three countries over the period 1995–2018 in Asia are considered for the database. Based on the availability of data, annual data on GDP, population, area, exchange rates, and other influential variables and trade agreements of the country of origin and destination are generated from assorted years of the World Bank; all nominal values of the variables are converted to constant 2015 US dollars using the CPI. All nominal variables are expressed in real terms. Under this study, the CEPIL Bilateral Trade Database from 1995–2018 compiled along with the World Development Indicators of the World Bank is used, with bilateral import flow as the key dependent variable. Further, those data are supported by the CEPIL Geodist dyadic data set and the CEPIL gravity data set (Head and Mayer 2013). The data on GDP and population



have been updated with the World Bank Development Indicators. The areas of the country of origin and destinations were measured in km<sup>2</sup>. Dummy variables are used to measure whether the two countries are contiguous, sharing a common language or common religion. Additionally, the data was gathered on five variables measuring digitalization data from the Global Competitiveness Index Report of the World Economic Forum, namely: (i) mobile telephone subscriptions/100 people; (ii) mobile-broadband subscriptions per 100 people; (iii) fixed-broadband Internet subscriptions per 100 people; (iv) fixed telephone lines/100 people; and (v) Internet users' percentage of adult population.

### **3.2 Empirical Method**

This empirical method follows the previous empirical studies on the gravity application and is then extended to the estimation of the Bayesian approach with econometric specifications.

This empirical method is employed to control for econometric issues for robust estimations. The trade flows in Asian economies are not necessarily related to the long-run equilibrium since Asian economies are still in the transition market economy. In this section, the "gravity" specification model for trade volumes and trade partners is used to estimate the equation to provide a benchmark. Much of the economic literature devoted substantial efforts to producing trade theories and describing and predicting the subsequently observed export and import flows. One such empirical attempt is to model the gravity models, which have become the pillar of the empirical literature on the determinants of international trade (Anderson 2011). The standard gravity model provides all bilateral flows of trade at time  $t$  between the reporter and the partner. In brief, a gravity equation explains the trade with the size of the economies and their distances, suggesting a stable relationship between the size of the economies, proximity, and trade among countries to infer trade flow potentials and to estimate the effects on trade of institutions such as customs unions, monetary agreement, exchange rate mechanism, ethnic ties, linguistic identity, and international borders. Physical distance is an explanatory variable for trade measure resistance issues such as transaction costs, transport costs, perishability/loss of goods during transport, synchronization costs, communication costs, and cultural distance.

### **3.3 Gravity Model**

A number of theoretical frameworks and models are presented in the literature to show the determinants of trade flow. Although the gravity model is designed on the basis of Newton's gravity law, several adjustments to the model are made in the form of trade integration analysis (Grogger and Hanson 2007). These approaches are widely used in the analysis of trade exports or imports because of their robust forecasting characteristics (Fertig and Schmid 2000; Karemera et al. 2000; Kim and Cohen 2010). With the use of different pull and push factors, gravity models are deepened by the inclusion of more variables (Volger and Rotte 2000; Hatton and Williamson 2002; Gallardo-Sejas et al. 2006; Mayda 2010; Ortega and Peri 2013). The gravity model is widespread with the specification with the time invariant fixed effects with the time shocks, and origin and destination country to account for the unobserved heterogeneity. Bertoli and Fernandez-Huertas Moraga (2013) found that without specifying the fixed effects, the models suffer biases because of multilateral resistance to trade.

Considering all the factors, the model specification for the gravity model is as follows:

$$\begin{aligned} \log \text{Import}_{odt} = & a_0 + a_1 \log \text{GDP}_{ot} + a_2 \log \text{GDP}_{dt} + a_3 \log \text{Pop}_{ot} + a_4 \log \text{Pop}_{dt} + a_5 \log \text{Dis}_{od} \\ & + a_6 \log \text{Digitization Index}_{odt} + a_7 \log \text{Area}_o + a_8 \log \text{Area}_d + a_9 \log \text{Exch}_{ot} \\ & + a_{10} \log \text{Exch}_{dt} + a_{11} \text{Sib}_{\text{conflict}_{dt}} + a_{12} \text{Conrelig}_{dt} + a_{13} \text{Comlan}_{dt} + m_{odt} \end{aligned}$$

where  $\log(\text{Import}_{odt})$  signifies the natural logarithm of the imports from country of origin (o) to country of destination (d) at time t.  $\log(\text{GDP}_{ot})$  and  $\log(\text{GDP}_{dt})$  indicate the logarithm of the GDP in the origin (o) and destination (d) countries at time t, respectively.  $\log(\text{Pop}_{ot})$  and  $\log(\text{Pop}_{dt})$  denote, respectively, the logarithm of the population in (o) and (d) at time t.  $\log(\text{Dis}_{od})$  is the logarithm of geographical distance between capital cities of countries; Digitization index is composed of log of mobile telephone subscriptions/100 people; the log of mobile-broadband subscriptions per 100 people; the log of fixed-broadband Internet subscriptions per 100 people; the log of fixed telephone lines/100 people, and the log of internet users' percentage of the adult population respectively.  $\log(\text{Area}_o)$  and  $\log(\text{Area}_d)$  indicate the natural logarithm of the area of origin (o) and destination (d) countries.  $\log(\text{Exch}_{ot})$  and  $\log(\text{Exch}_{dt})$  denote, respectively, the logarithm of the exchange rate in the origin (o) and destination (d) countries at time t. The remaining variables are dummy variables indicating whether the two countries share a common official language (comlan), share a language spoken by at least 9% of the population in both countries (comlanethno), and have a common religion (comrelig). As previously mentioned, time fixed effects and origin and destination country fixed effects are also included in the model. Last,  $u_{odt}$  denotes a random error term.

However, the gravity model suffers from issues, such as how to deal with zero trade, and bias for log model estimation in the presence of heteroskedasticity; endogeneity in the gravity equation: Causation between trade and trade policy could be reversed when, in the case of the signature of an FTA, there exists a selection of countries based on the intensity of trade, and not the other way round; spatial correlation; and omitted variables biasing coefficients systematically. In order to address these issues for robust estimation, this paper applies the Bayesian approach for the gravity model in the econometric specification.

### 3.4 Bayesian Approach

The Bayesian statistical inference is based on Bayes' Theorem (Bayes 1763). The study of the Bayesian approach used the sample information transforming the prior knowledge of the researchers into posterior knowledge. Despite the subjective measures such as beliefs and intuition, without considering the observations, the base theorem is conditional on the sample data. The theorem makes inference about the unknown parameters as  $(\theta)$ , and conditionally on the sample statistical information  $(x)$ . The Bayesian statistics complete theoretical overview, for example in Bernardo and Smith (1994). The scheme of Bayesian inference and Bayes' Theorem are presented in Table 1.

**Table 1: Bayes' Theorem and the Bayesian Statistical Inference**

Posterior knowledge = prior knowledge	likelihood of the data
$p(\theta   x) = p(\theta)$	$p(x \theta) / p(x)$

The empirical issue of the collection of the prior distribution of the probabilities in the model as estimated parameters,  $p(\theta)$ , which shows the knowledge of the researcher needs to be considered. The expert judgement supports the selection of prior distribution in the Bayesian inference. The natural results of the analysis of the posterior distribution,  $p(\theta|x)$  can be summarized by mean, median, etc. In the statistics, the major concept is the subjective probabilities (Ramsey 1926; De Finetti 1937).

### 3.5 Poisson Pseudo-Maximum Likelihood Estimator

A robustness check of the gravity model can be applied using the Poisson pseudo-maximum likelihood estimator with the fixed effect model. On the basis of the nonlinear form of the gravity model derived by Anderson and Van Wincoop (2003), a multiplicative disturbance term can be written as:

$$X_{ij}^k = \frac{Y_i^k E_j^k}{Y^k} \left( \frac{\tau_{ij}^k}{\prod_i^k P_j^k} \right)^{1-\alpha_k} e_{ij}^k$$

The standard gravity model in linearized form can be derived from natural logarithms, but with the logarithmic error term.

$$\log X_{ij}^k = \log Y_i^k + \log E_j^k - \log Y^k + (1 - \alpha_k)[\log \tau_{ij}^k - \log P_i^k - \log P_j^k] + \log e_{ij}^k$$

The mean value of  $\log e_{ij}^k$  depends on higher moments of  $e_{ij}^k$ , and hence includes the variance. The expected value of the disturbance term depends on one or more independent variables because of the inclusion of the variance, if  $e_{ij}^k$  is heteroskedastic. Under heteroskedasticity, it is assumed that the multiplicative errors in the nonlinear model require the adoption of a different approach.

## 4. RESULTS AND DISCUSSION

This section presents the results of the Bayesian gravity model analysis. The annual data from 1995 to 2018 were collected from 43 Asian countries for the study. These Asian countries have bilateral trade relationships within the region and also with the rest of the world. The gravity model is estimated for imports, instead of the total trade turnover, with every trading partner of the Asian countries. The estimations are based on annual values of real trade of the Asian countries with whole-world bilateral partners in each country. Consequently, the gravity model predicts trade in each economy in Asia with every trading partner in the world.

Table 2 above shows the summary statistics of the variables used in the gravity model analysis.

**Table 2: Summary Statistics of the Variables**

Variable	Mean	Std. Dev.	Observations
Trade inflow (import of the trade)	78.64	1,836.82	34,278
GDP of country of origin	2.38e+11	8.11e+11	31,114
GDP of country of destination	1.97e+10	1.84e+10	31,069
Population of country of origin	41.84	192.73	34,278
Population of country of destination	31.37	29.72	32,245
Distance between countries	8,365.86	3,739.20	34,278
Mobile telephone subscriptions per 100 people	86.59	39.15	2,536
Mobile-broadband subscriptions per 100 people	35.08	36.41	4,365
Fixed-broadband Internet subscriptions per 100 people	6.78	9.18	3,578
Fixed telephone lines per 100 people	18.23	16.62	3,535
Internet users' percentage of adult population	31.74	24.50	2,535
GDP per capita of the country of origin	9,428.39	13,003.92	31,746
GDP per capita of the country of destination	7,291.87	10,382.11	31,661
Area of country of origin	788,241.50	227,143.91	34,278
Area of country of destination	542,981.60	529,674.86	34,278

Source: Author's estimations

## 4.1 Gravity Model Estimator

The results of the basic gravity model in Table 3 report the estimation of coefficients for the bilateral trade integration in Asia. In general, these equations fit the data well, indicating that the proposed explanatory variables were significantly related to bilateral trade. The coefficients of determination ( $R^2$ ) range from 62% to 76%. The F-test (p-value) results show that collectively the models were highly significant. These results are in line with the usual gravity model findings from other papers. Starting from the simple standard model, Table 3 shows the results of the estimated gravity model from the basic model to extended model. Equation (1) shows the GDP and distances, while Equations (2), (3), and (4) represent the augmentation with other variables including the digitalization indices.

Based on the basic estimation (1), the log of DGP of the country of origin and the log of GDP of the country of destination are positively significant while the log of the distance between countries is negatively significant. When the model is extended with the log of the population of the country of origin and log of the population of the country of destination in (2), the population of the country of origin is positively significant, and the population of the country of destination is negatively significant. While it further supplemented by the areas of the countries, the log of the area of the country of destination is also negatively significant. However, the literature provides evidence that some other significant variables can have an influence on the trade flow between the countries in Asia. Hence, the model was further elaborated with the binary variables to incorporate barriers to trade integration. Among those variables, the binary variable for common religion was significantly positive in model (4). This implies that, at a robust estimation level, these factors are highly influenced by the import flow of the Asian economies. Throughout the four models, the GDPs of the original and destination countries are positively significant whereas the distance between the countries is negatively significant.

**Table 3: Results of the Gravity Model for Asian Economies**

Variables: Log (Import)	Coefficients (Std. Err.) (1)	Coefficients (Std. Err.) (2)	Coefficients (Std. Err.) (3)	Coefficient (Std. Err.) (4)
Log of GDP of country of origin	0.51*** (0.03)	0.75*** (0.01)	0.88*** (0.01)	0.61*** (0.04)
Log of GDP of country of destination	0.74*** (0.01)	0.43*** (0.02)	0.45*** (0.02)	0.91*** (0.00)
Log of distance between countries	-0.76*** (0.03)	-0.84*** (0.01)	-0.68*** (0.01)	-0.53*** (0.12)
Log of mobile telephone subscriptions/100 people	0.61*** (0.16)	0.32*** (1.40)	0.25*** (0.91)	0.21*** (0.06)
Log of mobile-broadband subscriptions per 100 people	0.28*** (0.14)	0.36*** (0.30)	0.20*** (0.01)	0.53*** (0.04)
Log of fixed-broadband Internet subscriptions per 100 people	0.22*** (0.10)	0.31*** (0.30)	0.26*** (0.04)	0.26*** (0.06)
Log of fixed telephone lines/100 people	0.24*** (1.40)	0.61*** (0.30)	0.22*** (0.08)	0.19*** (0.06)
Log of Internet users' % of adult population	0.23** (1.13)	0.62** (0.31)	0.14** (0.02)	0.52*** (0.04)
Log of population of country of origin	–	0.17*** (0.02)	0.19*** (0.03)	0.12*** (0.06)
Log of population of country of destination	–	-0.02** (0.03)	-0.93*** (0.03)	-0.44*** (0.00)
Log of area of country of origin	–	–	0.08 (0.01)	0.09 (0.03)
Log of area of country of destination	–	–	-0.33*** (0.02)	-0.54*** (0.04)
Log of exchange rate of country of origin	–	–	-0.46*** (0.06)	-0.32*** (0.05)
Log of exchange rate of country of destination	–	–	0.47*** (0.01)	0.79*** (0.01)
Conflict of the sibling countries	–	–	–	0.44 (0.15)
Common religion	–	–	–	0.98*** (0.33)
Common language of pretrans	–	–	–	0.84*** (0.02)
Common language of posttrans	–	–	–	0.53*** (0.09)
Constant	-8.21*** (0.723)	-7.77*** (0.981)	-7.96*** (0.286)	-12.75*** (0.653)
No. of observations	12,368	12,024	12,852	12,342
R-squared	0.62	0.69	0.72	0.76
F-value	832.40	301.23	201.09	143.66
p-value	0.0000	0.0000	0.0000	0.0000

\* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, and \*\*\* denotes statistical significance at the 1% level.

Source: Author's estimations.

As Table 3 shows, the coefficients on GDP of origin and GDP of destination are significant and positively signed, as are most of the population coefficients. This implies that the rich, highly populated countries tend to trade more in Asia and contribute to the trade integration. Further, it can be explained that trade integration will be successful in

those countries that contribute to trade integration in the Asian region. However, in order to identify the impacts of trade integration, country-specific coefficients need to be calculated. As expected in the model, the coefficients on the distance variable distance between countries were all negative and significant. This also implied that transport costs, a proxy for the geographic distance between the two countries, have a significant influence in determining the volume of trade between countries. This is where digitalization can have a significant influence in minimizing the transaction costs of the trade inflow.

The coefficient on the area of the destination was negatively signed and was significant for the country of destination. Literature suggests that this is because large countries have more natural resources and tend to trade less with other countries. Therefore, it also affects the trade integration of the countries in Asia. The inclusion of the exchange rate shows that an increase in the exchange rate of origin or destination implies a depreciation of the real effective exchange rate. As expected, for the coefficients associated with the importing partner, the exchange rate is negatively significant, whereas the exchange rate of destination is positively significant. Binary for common language at pre-transition and post-transition was also significant in the trade integration of Asia. This implies that the common language and therefore cultural similarities have influenced the trade contracts between countries. This could be due to the use of technologies in the trading process and the use of English as a common language in those countries for international trading.

Digitization index, which is measured as the log of mobile telephone subscriptions/100 people, the log of mobile-broadband subscriptions per 100 people, the log of fixed-broadband Internet subscriptions per 100 people, the log of fixed telephone lines/100 people, and the log of Internet users as a percentage of the adult population, is significant in all four models. This implies that digitalization has a significant influence on the trade flow of the countries. Recently, digitalization has had an impact on each and every corner of the countries with the impact of mobile telephones, broadband, the Internet, and fixed telephones to improve the digitization process. Hence, trade has been facilitated by digitalization, especially in e-commerce and e-transactions.

In summary, the coefficient on GDP in country of origin and GDP in country of destination, population, and area of the original country and destination country is positive and significantly predicts the import growth. However, the distance between the countries has a negatively significant estimation in the model. Therefore, for these Asian economies, these macroeconomic variables have contributed to the trade integration. From all the estimations, it can be suggested that trade integration has been significantly affected by the GDPs, populations, and areas of the countries of origin and destination. Therefore, the study suggests that the consideration of the trade integration needs to be deliberated on the impacts of trade flows. Even though the above econometric approach provides evidence on the significant factors that determine the trade integration, the Bayesian approach is required for more precise results of the estimates to give results of robust coefficients to understand the impacts and significance of different variables in the gravity model.

The results corresponding to the Bayesian approach of the gravity model for total import are depicted in Table 4. The estimates result in the robust parameters for determining the impact factor for the importation of the trading countries, in that the elasticity of total imports with respect to distance and population of destination and the exchange rate of origin is negative while it is positive for the proxies of economic size, areas, and exchange rates of destination. The model is tested against its consistency through model testing as shown in Table 5.

**Table 4: Results of the Bayesian Gravity Model**

<b>Variables: Log Import (Log of Trade Inflow)</b>	<b>Mean (Std. Err.)</b>	<b>MCSE***</b>	<b>Median</b>
Log of GDP of country of origin	0.81 (0.00)	0.000	0.622
Log of GDP of country of destination	0.52 (0.07)	0.000	0.734
Log of distance between countries	-0.68 (0.01)	0.001	-0.754
Log of mobile telephone subscriptions/100 people	0.29 (0.02)	0.003	0.493
Log of mobile-broadband subscriptions per 100 people	0.63 (0.00)	0.001	0.297
Log of fixed-broadband Internet subscriptions per 100 people	0.82 (0.02)	0.002	0.429
Log of fixed telephone lines/100 people	0.64 (0.00)	0.000	0.123
Log of Internet users' % of adult population	0.13 (0.02)	0.002	0.425
Log of population of country of origin	0.21 (0.01)	0.001	0.812
Log of population of country of destination	-0.08 (0.02)	0.000	-0.097
Log of area of country of origin	0.03 (0.00)	0.001	0.010
Log of area of country of destination	0.05 (0.01)	0.001	0.212
Log of exchange rate of country of origin	-0.07 (0.01)	0.002	-0.048
Log of exchange rate of country of destination	0.22 (0.12)	0.001	0.094
Constant	-8.04 (0.01)	0.002	-8.217
Number of observations	12,764	12,764	12,764
Random-walk Metropolis-Hastings sampling burn-in	2,800	2,800	2,800
MCMC sample size	12,000	12,000	12,000
Acceptance rate	0.144	0.144	0.144
Efficiency: min	0.002		0.002
Efficiency: avg	0.004		0.004
Efficiency: max	0.011		0.011
Log marginal likelihood	-22,442.01	-22,442.01	-22,442.01

\*\*\*Monte-Carlo Standard Error (MCSE).

Source: Author's estimations.

**Table 5: Bayesian Model Tests**

	<b>Log (ML)</b>	<b>P(M)</b>	<b>P(M y)</b>
Active	-1.75e+05	0.8600	0.6348

Note: Marginal likelihood (ML) is computed using Laplace-Metropolis approximation.

Source: Author's estimations.

## 4.2 Poisson Pseudo-Maximum Likelihood Estimator

This subsection reports on the robustness checks that were conducted for gravity model analysis. First, the Poisson pseudo-maximum likelihood estimator was assessed for the full sample. Table 6 presents the results of the estimated gravity model. It can be seen from the estimator that the quantitative evidence obtained from the Bayesian gravity model for the full sample still holds when accounting for the comparability of the Poisson estimator.

**Table 6: Results of the Poisson Estimates of a Fixed-Effects Gravity Model**

<b>Variables: Log of Import</b>	<b>Eq 1</b>	<b>Eq 2</b>
Log of GDP of country of origin	0.31*** (0.02)	0.11** (0.03)
Log of GDP of country of destination	0.54*** (0.03)	0.18*** (0.01)
Log of distance between countries	-0.82** (0.02)	-0.03*** (0.00)
Log of mobile telephone subscriptions/100 people	-	0.07*** (0.00)
Log of mobile-broadband subscriptions per 100 people	-	0.06*** (0.01)
Log of mixed-broadband Internet subscriptions per 100 people	-	0.14*** (0.01)
Log of fixed telephone lines/100 people	-	2.03** (0.02)
Log of Internet users' % of adult population	-	0.11** (0.00)
Log of population of country of origin	0.11** (0.00)	-0.18*** (0.01)
Log of population of country of destination	-0.18*** (0.01)	-0.03*** (0.05)
Log of area of country of origin	0.03*** (0.00)	0.07*** (0.02)
Log of area of country of destination	-0.07*** (0.00)	-0.06*** (0.01)
Log of exchange rate of country of origin	0.06*** (0.01)	0.14*** (0.01)
Log of exchange rate of country of destination	0.14*** (0.01)	0.03** (0.12)
Constant	-7.03** (0.01)	-7.03** (0.02)
Number of observations	6,298	6,184
R-squared	0.44	0.54
F-value	176.01	124.90
p-value	0.0000	0.0000

\* denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, and \*\*\* denotes statistical significance at the 1% level.

Source: Author's estimations.

A robustness check of the gravity model has been conducted with estimation of an alternative gravity model using the Poisson pseudo-maximum likelihood estimator. The results revealed that the digitization indicators, such as mobile telephone subscriptions/100 people, mobile-broadband subscriptions per 100 people, fixed-broadband internet subscriptions per 100 people; fixed telephone lines/100 people, and Internet users' percentage of the adult population, are significant at the 5% level.

Similar results can be found in the Poisson pseudo-maximum likelihood estimator in estimating the gravity model with respect to the Bayesian gravity model. The effects of the trade inflow and GDP of the country of origin and destinations are positive while the distance between countries is negative.



## 5. CONCLUSION

The Bayesian gravity analysis was conducted to estimate the degree of impacts of determinants on international bilateral trade providing pragmatic evidence for trade integration in Asian economies. Further, the gravity model was aimed at identifying the regional trade integration with a robustness scenario for the aptness of the trade integration in the region. The Bayesian gravity model reveals that the estimated coefficients on GDP in country of origin and GDP in country of destination, population, and area of the country of origin are positively significant predictors of the import growth. The distance between the countries has a negatively significant estimation showing barriers in trade. The model predicts the trade integration especially towards the trade inflow process in Asia with the rest of the world. The Bayesian approach of the gravity model gives the robust estimates for determining the impact factor for the importation of the trading countries, including the elasticities of total imports with respect to distance and area of destination, and the exchange rate of origin are negative, while the proxies of economic size, areas are positive. The exchange rate of the destination is positive. The estimated parameters are directly the elasticities, in which increases in GDP in a reporter consistent with higher import volumes. The digitization of the regions has a tremendous influence on the trade as depicted in the results, which indicate that digitalization indicators are significant in all equations.

The trade inflow in the model analyzes the “trade creation” and “trade diversion” effects of Regional Trade Agreements. In simulating the scenarios for international trade integration according to explanatory indicators quantify trade potential between two partners. The gravity model is modified for international trade integration according to changes in key determinants; quantify trade potential between two countries and measure the trade costs term instead of trade inflows and to express these costs as a function estimating the barriers for trade integration with the assistance of digitalization. Finally, trade integration can be facilitated across Asia with evidence and simulated scenarios for the estimation of the impacts of the trade inflow in Asia. Therefore, combining all the results of the Bayesian gravity model, one of the significant pieces of evidence of this study is that trade integration can be promoted with the increase of particular significant variables at the country level, while stimulating those towards innovative approaches to trade facilitation in the digitizing process plays a significant role in the policymaking in these economies. Therefore, the research evidence suggests that policymakers should design appropriate trade openness policies with the use of pragmatic findings for Asian countries.

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