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The United States' Clothing Imports from Asian Countries along the Belt and Road: An Extended Gravity Trade Model with Application of Artificial Neural Network

Danny Chi Kuen Ho [1,*], Eve Man Hin Chan [2], Tsz Leung Yip [3] and Chi-Wing Tsang [4]

[1] Department of Supply Chain and Information Management, The Hang Seng University of Hong Kong, Hong Kong 999077, China
[2] Faculty of Design and Environment, Technological and Higher Education Institute of Hong Kong (THEi), Hong Kong 999077, China; evechan@vtc.edu.hk
[3] Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hong Kong 999077, China; t.l.yip@polyu.edu.hk
[4] Faculty of Science and Technology, Technological and Higher Education Institute of Hong Kong (THEi), Hong Kong 999077, China; ctsang@vtc.edu.hk
* Correspondence: dannyho@hsu.edu.hk

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Abstract: In 2013, China announced the Belt and Road Initiative (BRI), which aims to promote the connectivity of Asia, Europe, and Africa and deepen mutually beneficial economic cooperation among member countries. Past studies have reported a positive impact of the BRI on trade between China and its partner countries along the Belt and Road (B&R). However, less is known about its effect on the sectoral trade between the B&R countries and countries that show little support of the BRI. To address that gap, this study examines the changing patterns of clothing imports by the United States (US) from China and 14 B&R countries in Asia. An extended gravity model with a policy variable BRI is built to explain bilateral clothing trade flow. A panel regression model and artificial neural network (ANN) are developed based on the data collected from 1998 to 2018 and applied to predict the trade pattern of 2019. The results show a positive effect of the BRI on the clothing exports of some Asian developing countries along the B&R to the US and demonstrate the superior predictive power of the ANN. More research is needed to examine the balance between economic growth and the social and environmental sustainability of developing countries and to apply more advanced machine learning algorithms to examine global trade flow under the BRI.

Keywords: clothing trade; Belt and Road initiative; gravity trade model; panel data regression; artificial neural network

1. Introduction

Textiles and clothing industries have been driving the economic growth and development of low-income and developing countries like Bangladesh and Cambodia through improved trade, gross domestic product (GDP), employment, and foreign currency receipts [1]. As the United States (US) is the world's second biggest clothing market, any major changes in its GDP and trade policy would significantly affect clothing trade flows. In parallel, China, as the world's biggest clothing supplier, has a key role in shaping global clothing trade patterns. Worth noting is the roll-out of China's Belt and Road Initiative (BRI). It is a development strategy proposed by China in 2013 that aims to promote the connectivity of Asia, Europe, and Africa and to deepen mutually beneficial economic cooperation among member countries [2].

Despite the lack of US support and commitment to the BRI, any study of recent US–Asia bilateral clothing trade should not ignore the influence of this initiative, as promotion of unimpeded trade is a priority for the BRI. Given China's dominant role in the production and export of clothing products, major changes brought by the BRI will shape the sources of supply and patterns of global trade over time. With the establishment and improvement of trade-supporting infrastructure like power plants, highways, ports, and industrial and logistics parks in developing countries along the Belt and Road (B&R), new sources of clothing supply would emerge. Relocation of clothing factories from China to these countries could grow to take advantage of the relatively lower labor costs and improved infrastructure for trade facilitation. In this way, a win-win situation may be achieved. On one hand, developing countries could benefit from the expansion of their clothing sector, which contributes to export-led economic growth. On the other hand, countries with a large demand for clothing products could have more choices of supply. It is thus important to examine how clothing supply from China and other Asian countries has changed in the US market in the context of the BRI.

The current study's objectives are to (1) develop an extended gravity model to predict clothing imports of the US from China and 14 Asian countries under the BRI and to (2) compare the model's predictive power by panel data regression and artificial neural network (ANN) in the US's clothing imports from 1998 to 2019. This study is valuable as it contributes to the literature on global trade on two fronts. First, it addresses an important yet under-researched area of bilateral trade under the BRI. Although more empirical studies have focused on trade along the B&R, they tend to examine trade flows between China and its trading partners at the country level (e.g., [3–5]) and not trade between B&R and non-B&R countries at the sectoral level. As the BRI aims to promote unimpeded trade through better connectivity of infrastructure and facilities across geographical boundaries, developing countries that have joined the BRI would have a chance to build stronger links to global value chains that connect to high-profit markets that do not necessarily have to be part of the B&R region (e.g., the US). Improving trade not only within but also beyond the B&R region is particularly important for labor-intensive sectors like clothing because more jobs could be created for female workers and their welfare could be improved. Moreover, the entry barriers to the market are relatively lower than those of the industries that demand high-skill labor, advanced technologies, and large capital investment (e.g., new energy automobile). Despite the importance of integrating into global value chains and getting more orders from foreign buyers, little is known about the potential impact of the BRI on improving developing countries' exports to high-profit markets. The current study aims to fill this gap.

Second, this study applies a novel approach to ANN to analyze bilateral trade flows and demonstrates how ANN complements the conventional econometric approach. The gravity trade model is frequently used to explain global clothing trade patterns [6], and econometric models are built to fit the data. Most often, multiple linear regression of panel data is applied to examine the relative influence of various economic factors, such as a country's GDP and trade policy, on bilateral trade. More recently, advances in big data availability and affordable high computing power and online platforms have made ANN more accessible for researchers. The use of ANN in this study is relevant and useful not only because of its higher predictive power but also because of its ability to estimate complex trade relationships [4,7]. Although more Asian developing countries have joined the BRI, India is an exception as it has concerns about the expansion of Chinese political influence and interests across South Asia through the BRI [8]. The official Indian narrative of the BRI is not positive, and India's perceptions have been mainly shaped by geopolitical dimensions of the BRI rather than broader developmental aspects [9]. Moving beyond this one-sided view, it would be helpful to explore the BRI's effect on India's clothing exports if India would become a B&R country. To achieve the second objective, the study will develop a model of ANN based on the results of panel regression analysis and evaluate the two approaches based on the unseen data of 2019 exports values. Their predictive performance will be compared with reference to the models' forecast errors. Furthermore, a country's clothing exports can be estimated by the ANN when its B&R membership is changed (e.g., India

becomes a B&R country). This helps to explore the potential impact of the BRI on the exports of B&R and non-B&R countries.

The paper is structured as follows. Section 2 discusses Asia's clothing exports to the US under the BRI. Section 3 presents a literature review with a focus on a gravity model for trade estimation. Section 4 presents the methodology. Sections 5 and 6 present the findings and discuss the panel data regression model and ANN results, respectively. Finally, Section 7 concludes the study with implications for policymakers and future research directions.

2. The BRI and Clothing Trade

2.1. Asia's Clothing Exports under the BRI

Among Asian countries, China has been a leading clothing manufacturer and exporter since the nineties [10]. However, rising production costs and labor shortages in China have led many clothing manufacturers to relocate their labor-intensive production facilities from China to other, lower-cost, countries in the region such as Vietnam [11], Bangladesh [12], Cambodia [13], and the Philippines [14]. The BRI may present opportunities for many businesses to overcome some of the barriers to and risks of relocation. One of the BRI's major outcomes is infrastructure development across the "Silk Road Economic Belt" and "21st Century Maritime Silk Road", which helps to speed up product flows and provide efficient allocation of resources across markets. Improved connectivity of infrastructure and facilities can promote unimpeded trade across geographic boundaries, which are two cooperation priorities of the BRI.

Taking inspiration from the name and purpose of the ancient Silk Road connecting China and Europe for silk trading, the proposed economic corridors of BRI could bring opportunities and challenges to China, developing countries along the B&R, and their trading partners. In the six years since the launch of the BRI, China has signed 171 cooperation documents with 29 international organizations and 123 countries, and the total trade value between China and the B&R countries and regions has exceeded $6 trillion USD from 2013 to 2018 [15]. In Asia, a growing number of countries have officially pledged support to the BRI by memorandums of understanding (MoU) or joint statements/communiques since 2013 (See Table 1 for the sampled countries).

Table 1. The year that the sampled countries joined the Belt and Road Initiative (BRI).

Year	B&R Country *
2013	China, Cambodia, and Pakistan
2014	Bangladesh and Thailand
2015	Indonesia
2016	Myanmar
2017	Philippines, Malaysia, Nepal, Sri Lanka, and Vietnam
2018	Brunei, Laos, and Singapore

* Source: Belt and Road Portal (eng.yidaiyilu.gov.cn).

China has been investing heavily in some mega infrastructure projects under the BRI, such as the Bangladesh-China-India-Myanmar Economic Corridor, a Sri Lankan port city, and an Indonesian high-speed railway, which are all designed to facilitate international trade. In 2020, China signed a number of new BRI infrastructure projects across Asia, including the construction of a railroad and deep-water port in Myanmar, a wind power plant in Vietnam, a biomass plant in Indonesia, and several railway projects across Africa [16]. With its implementation in full swing since 2015 [17] and as an ongoing endeavor, the BRI will continue shaping the global trade of different commodities and products including textiles and clothing.

It appears that the BRI benefits not only China but also developing countries that get the most inflows from foreign direct investment (FDI). For the clothing industry in Asia, the BRI could offer potential trading and expansion opportunities, where businesses with production facilities in China

could be relocated to lower-cost B&R countries in Asia. It is worth mentioning that, since 2015, Vietnam's textile and clothing industry has witnessed a significant increase in FDI from South Korea (a B&R country) and the Greater China region (China, Hong Kong, and Taiwan), which injected more than tens of billions dollars in total to expand the production capacity in Vietnam [18]. The establishment of clothing production facilities in the regional B&R countries could boost their economic development by creating more jobs and improving labor welfare. Most importantly, these B&R countries could take the opportunity to build stronger links to global clothing supply chains and pursue export-led economic growth.

2.2. The US's Clothing Imports under the BRI

The US is the world's second largest clothing importer after the European Union (EU). The US's clothing imports have been growing overall, reaching a record high of 85.2 billion USD in 2015 (see Figure 1) [19]. In 2019, the US imported 83.8 billion of USD clothing products from the world, representing a 74% increase from 48.2 billion USD in 1998. Asia has been a major clothing supplier for the US market by value, with China as the biggest exporter, followed by Vietnam, Bangladesh, Indonesia, and India (see Figure 2).

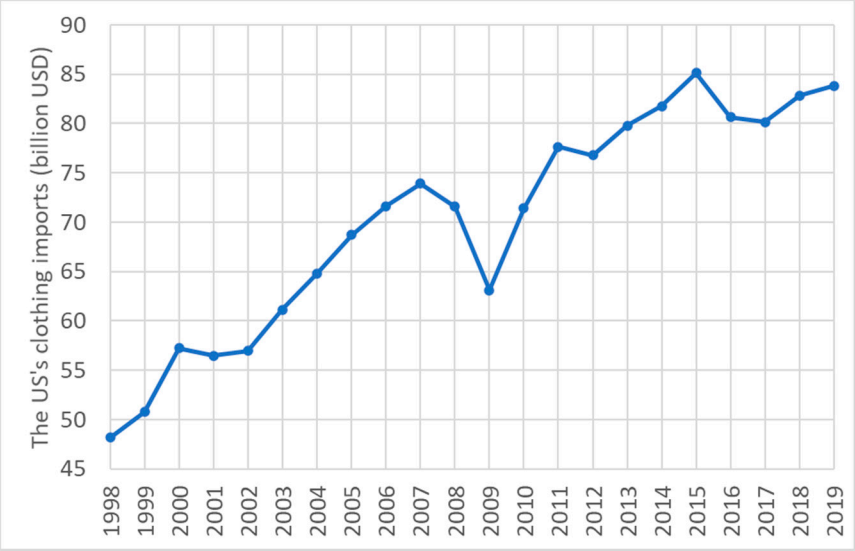

Figure 1. The US's clothing imports from the world.

Although China has outranked Mexico since 2003 and become the biggest clothing supplier in the US market, its export started to fall after attaining a record high of 30.5 billion USD in 2015. A closer examination of the annual change of US clothing imports (see Figure 3) reveals that despite this, 2016 witnessed a 5.3% reduction in the US's annual clothing imports from the world and China's exports to the US dropped significantly by 8.7%. This pattern is also observed in 2017, where the US experienced a very small drop of 0.6% in its total clothing imports but China's exports to the US dropped by 3.2%. This pattern is in sharp contrast to Vietnam's clothing exports to the US. In 2016 and 2017, even when the US's total clothing imports dropped, Vietnam still attained an annual growth of 2.2% and 7% in its exports, respectively. This shows that Vietnam is able to expand its production capacity and capture a higher market share in the US, while China's clothing exports have been reducing from 2015 onward.

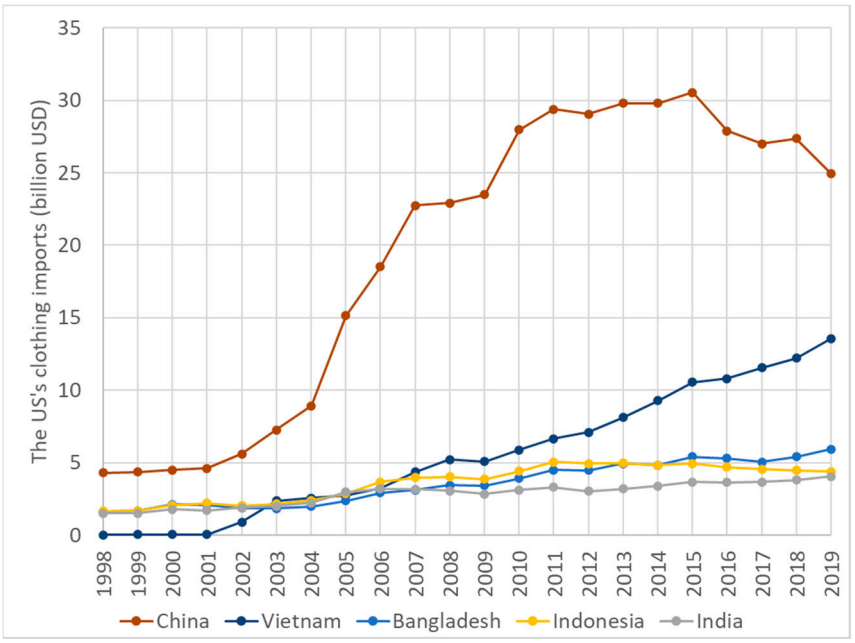

Figure 2. The US's clothing imports from the top five Asian suppliers.

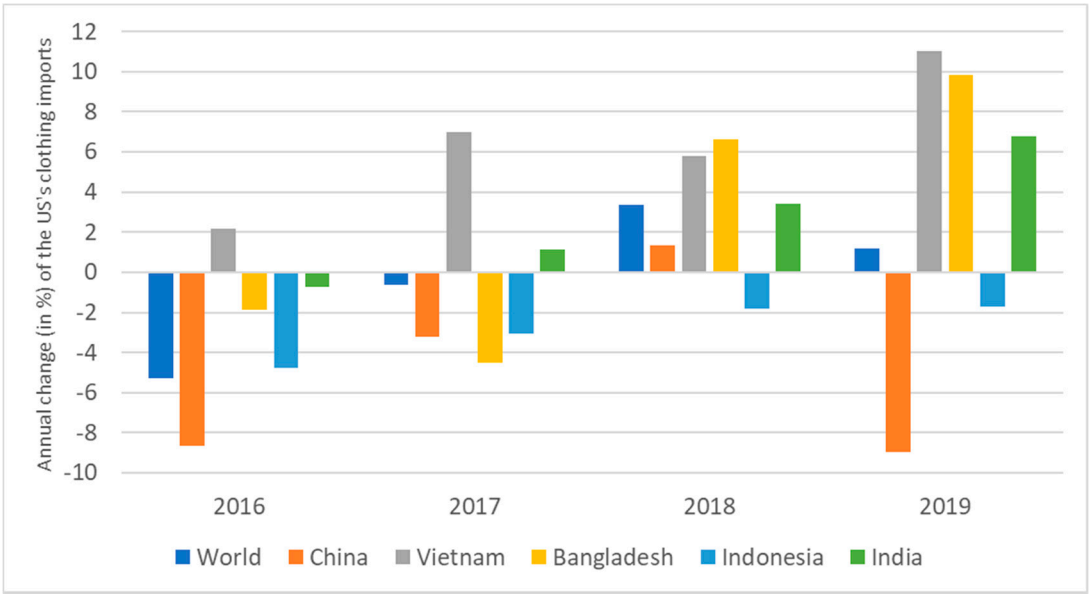

Figure 3. Annual change (in percentage) of the US's clothing imports from the world and the top 5 Asian suppliers.

3. Literature Review

In this section, the theoretical framework of the gravity model for trade, recent studies using the gravity model for analysis of developing countries' textiles and clothing trade, and the configuration of an extended gravity model for clothing trade under the BRI are presented.

3.1. Theoretical Framework of Gravity Trade Model

The gravity model is the workhorse of the applied international trade literature. It has been frequently used to evaluate the impacts of various trade-related policies and factors [20], starting with Tinbergen [21] and Poyhonen [22], who found that the volume of trade between two countries is directly related to their economic size and inversely related to the geographical distance between them. In other words, countries with a larger economy tend to trade more, and greater distance, which is a

proxy of transportation costs, hampers bilateral trade. The basic gravity model is represented by the following equation:

$$Y_{ij} = \mathrm{A}\frac{X_i \times X_j}{D_{ij}} \quad (1)$$

where

Y_{ij} = Total value of trade between countries i and j
A = Constant
X_i = GDP of country i
X_j = GDP of country j
D_{ij} = Distance between country i and country j.

Anderson [23] provided a theoretical explanation for the gravity equation applied to commodities using a trade-share-expenditure system model. Later, Bergstrand [24] developed a microeconomic foundation for the gravity model and found empirical evidence supporting the proposition that the gravity equation is a reduced form of a partial equilibrium subsystem of a general equilibrium model with nationally differentiated products. Deardorff [25] showed that the gravity equation can be derived from the classic Heckscher–Ohlin model and is consistent with other trade models such as the Ricardian model. Evenett and Keller [26] evaluated gravity equations based on the imperfect specialization of production and found support from the increasing returns theory and Heckscher–Ohlin model. With solid theoretical foundations, the gravity model has been applied extensively in empirical studies of international trade.

3.2. Empirical Studies of Gravity Model for Developing Countries' Textiles and Clothing Trade Analysis

In the literature of sectoral trade, the gravity model has been applied to examine bilateral trade of textiles and clothing (e.g., [6,20,27–31]). The results of these studies support the proposition that greater GDP facilitates trade, whereas longer distance reduces trade. Depending upon the research objectives, past studies have developed extended (also called augmented) gravity models [32], which include (1) economic variables like the gross national product (GNP), per capita GDP, per capita GNP, consumer price index, FDI, rate of inflation, exchange rate, and membership in a free trade area; (2) geographical variables like common borders, landlocked, remoteness, land area, transport time, time difference, population size, and population growth; (3) social variables like common language, religion, and literacy rate; and (4) political variables like colonial link and political stability, among others [33].

As the textiles and clothing trade represents a major driver of economic growth for developing countries, a growing number of gravity trade model studies have focused on export countries like Bangladesh, India, Indonesia, and Pakistan. For example, Rahman et al. [34] examined a panel gravity model of Bangladeshi textiles and clothing export flows to 40 trade partners from 1990 to 2017 and found that GDP, per capita GDP, and real exchange rate of the importers as well as Bangladesh's WTO membership have a strong effect on Bangladesh's textile exports. Majeed et al. [35] found a positive impact of the EU's and the US's generalized system of preferences on Pakistan's exports of cotton and textile products to these markets from 2003 to 2014. Irvansyah et al. [36] examined Indonesian's exports of textiles and clothing products in key markets like the US, Japan, South Korea, and Turkey, whereas Chakrabarty et al. [37] focused on knitwear clothing exports from India to the US.

3.3. Configuration of an Extended Gravity Model for Clothing Trade under the BRI

Empirical studies that apply the gravity model to examine trade at product and sectoral levels under the BRI are growing. For example, based on the estimation of an extended gravity model using trade data at product-level during 2002–2016, Liu et al. [5] reported that cultural distance and institutional distance inhibit China's bilateral trade with the B&R countries. Zhang et al. [38] found positive impacts of trade facilitation on China's forest product exports to 13 B&R countries using transnational panel data from 2007 to 2016. Leng et al. [39] reported that China's wind energy product

trade with the B&R countries has grown rapidly. Shahriar et al. [40] applied a commodity-specific gravity model to study China's meat exports to 31 trading partners from 1997 to 2016 and found a positive impact of the BRI on China's exports. Despite these studies having examined different products, they have the same focus on China's trade with the B&R countries. Less is known about the trade of B&R countries (other than China) with non-B&R countries like the US. To address this research gap, this study develops an extended gravity model featuring a policy variable BRI, which is expressed as the following log-linear equation:

$$\log\left(USimport_{ijt}\right) = \alpha + \beta_1 \log\left(GDP_{it} \times GDP_{jt}\right) + \beta_2 \log\left(D_{ij}\right) + \beta_3 \log(Exrate_{it}) + \beta_4 Landlock_i + \beta_5 WTO_{it} + \beta_6 BRI_{it} + \varepsilon_{ijt} \quad (2)$$

where

α is the intercept;
$USimport_{ijt}$ is the value of clothing (in USD) imported from country i (i.e., exporting country) by country j (i.e., the US) at time t;
GDP_{it} is GDP in USD of country i at time t;
GDP_{jt} is GDP in USD of country j (i.e., the US) at time t;
D_{ij} is geographical distance (in km) between the capitals of countries i and j (i.e., the US);
$Exrate_{it}$ is official exchange rate of country i relative to the USD at time t;
$Landlock_i$ is a dummy variable with a value of 1 if country i does not have direct access to sea, otherwise 0;
WTO_{it} is a dummy variable with a value of 1 if country i has joined the World Trade Organization (WTO) at time t, otherwise 0;
BRI_{it} is a dummy variable with a value of 1 if country i has joined the BRI at time t, otherwise 0;
ε_{ijt} is the error term.

In the extended gravity model, four explanatory variables, official exchange rate, landlock, WTO membership, and BRI, are included in addition to GDP and distance. The dependent variable is the US's clothing imports (in USD) from Asian countries. Exchange rate is a key factor affecting clothing trade. In general, a weaker domestic currency stimulates exports. Depreciation of the domestic currency of Asian clothing suppliers against the USD is reflected by a higher value of $Exrate_{it}$. That is, it requires more domestic currency to exchange one USD. It is expected that the sign of this variable is positive. Landlocked countries like Laos are constrained by their geographical limitations, i.e., no direct access to sea. Higher international trade costs are incurred because they normally depend on their transit neighbors' infrastructure for getting access to foreign markets. This problem is more acute when the cargos for external trade have to transit through neighbors' seaports. It is expected that the sign of the variable $Landlock_i$ is negative. WTO membership is of particularly importance to the growth of Asian countries' clothing exports because all quota restrictions on textiles and clothing products among WTO members were scheduled to be removed completely by 2005, as set out in the WTO's Agreement on Textiles and Clothing (ATC). It is expected that the sign of the variable WTO_{it} is positive. Given that the BRI was proposed in 2013, Shahriar et al. [40] created a dummy policy variable with a value of one assigned from 2013 onward and zero otherwise. Different from their approach, the dummy variable of BRI is assigned a value of one for the export country from the year it joined the BRI and onward and zero otherwise in this study. This coding method can better capture the BRI influence on the bilateral trade of individual countries over time. It is expected that the sign of the variable BRI_{it} is positive. For the variable of GDP $\left(GDP_{it} \times GDP_{jt}\right)$, the expected sign is positive, whereas distance $\left(D_{ij}\right)$ is negative.

4. Methodology

4.1. Dataset

Using the proposed extended gravity model, this study estimates the value of the US's clothing imports between 1998 and 2019 from 15 countries in South/Southeast Asia including Bangladesh, Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Nepal, Pakistan, Singapore, Sri-Lanka, Thailand, the Philippines, and Vietnam. Despite the fact that Timor-Leste is also a Southeast Asian country, it does not trade in the clothing industry and therefore is not analyzed. In contrast to other Asian countries, Myanmar is a special case that deserves examination in isolation because of trade sanctions imposed by the US during the study period. From 2004 to 2012, no clothing imports were recorded by the US from Myanmar. Myanmar is excluded from the sample. Since China initiated the BRI in 2013, the remaining 14 Asian countries joined the BRI at different times since then except India. The data are collected from multiple sources (see Table 2). There is no missing data or trade value with zero in the dataset. The values of dependent and four continuous independent variables are log-transformed and then standardized in the pre-processing stage such that their means become zero and standard deviations become one, as these variables have different units of measurement. No transformation is performed on the dummy variables.

Table 2. Data source.

Variable	Unit	Data Source
$USimport_{ijt}$	USD	The US's Office of Textiles and Apparel (Category 1: Apparel)
GDP_{it}, GDP_{jt}	USD	The World Bank
$Exrate_{it}$	Local currency	The World Bank
D_{ij}	Kilometer	SeaRates Website (www.searates.com)
$Landlock_i$	0 or 1	World Atlas Website (www.worldatlas.com)
WTO_{it}	0 or 1	The World Trade Organization
BRI_{it}	0 or 1	Belt and Road Portal (eng.yidaiyilu.gov.cn)

4.2. Panel Data Estimation Approach

This study conducts a regression analysis with panel data through econometric and statistical software—EViews 10. Cross-sectional or pooled ordinary least squares (OLS) regression is often used to estimate the gravity trade model. Yet, biased results may be created by these estimation approaches [41]. This is because heterogeneity is not allowed in the error term for standard cross-sectional regression equations, thus yielding overestimated results. A panel estimation method with fixed effects (FE) and random effects (RE), on the other hand, could overcome the problems created by using the OLS approach. An advantage of using the panel data estimation method is that it can increase the volume of informative data in variability with less collinearity among the variables [42], which allows more degrees of freedom and efficiency. In this study, the panel data from 1998 to 2018 is analyzed to estimate the regression coefficients with pooled OLS, FE, and RE models. Poolability F test is performed for choosing between the pooled OLS and FE models. Hausman test is performed for choosing between FE and RE models. The best regression model is then used to predict the US's clothing imports in 2019. The out-of-sample forecast error of root mean squared error (RMSE) is computed and compared with that of the best ANN.

4.3. The Configuration and Implementation of ANN

The proposed ANN has three layers: input, hidden, and output. In the input layer, there are six features (the product of exporter's GDP and importer's GDP, distance between exporter and importer, official exchange rate, landlock, WTO, and BRI), whereas there is one target (prediction of clothing imports) in the output layer. The features of ANN are selected after panel data regression analysis is completed. Predictors that are not statistically significant at $p \leq 0.05$ are excluded. The number of

neurons in the hidden layer (i.e., hidden neurons) is optimized by building various ANNs with hidden nodes of 3 to 15 (see Figure 4). The ANN with the best predictive ability is identified by comparison of RMSE of the testing dataset with unseen data across different networks. Similar to Dumor and Yao [4], this study uses Rectified Linear Units (ReLU) as the activation function. The ANNs are trained using the stochastic gradient descent optimizer with mean squared error (MSE) as the loss function.

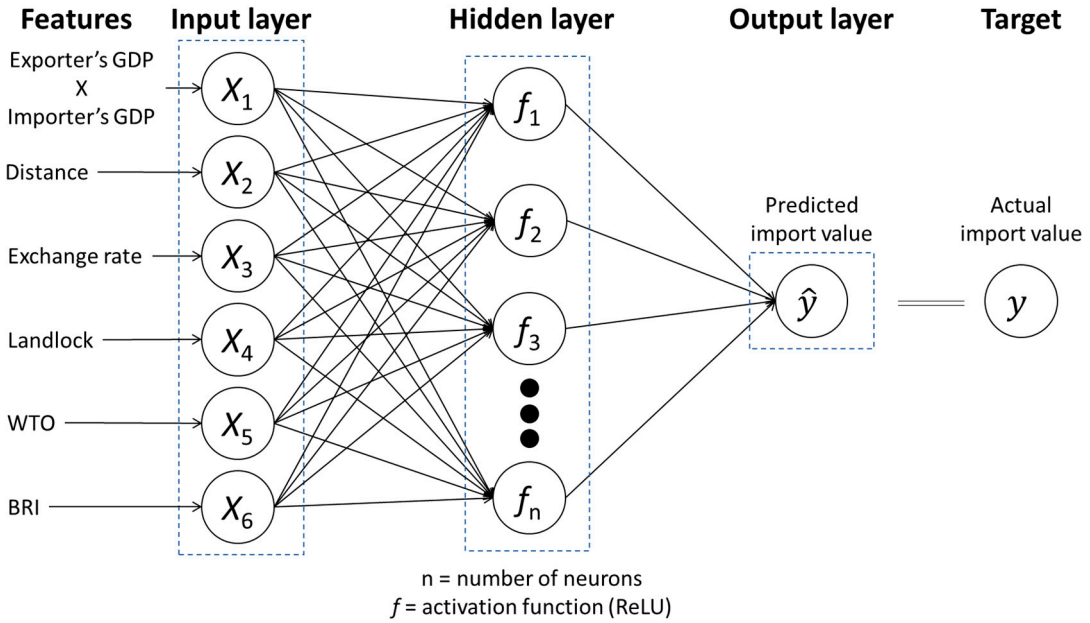

Figure 4. The proposed artificial neural network (ANN) structure.

Instead of dividing the dataset into training and validation sets in one go (e.g., [4,7]), this study applies K-fold cross-validation for training and validation of each ANN. This method provides more robust models and combats over-fitting the model [43]. The 1998–2018 dataset with 315 observations is split randomly into five groups (folds) of equal size. One group is taken as a hold-out or validation set, whereas the remaining four groups form a training set. The model is fit on the training set and the fitted model is evaluated on the validation set. The evaluation score of RMSE is retained, and the model is dropped. This process is repeated five times. The mean of the five RMSEs are calculated for each trained ANN. The 2019 dataset with 15 unseen observations is used for testing of each trained ANN. That is to predict out-of-sample observations. The training dataset is divided into 32 batches, and 200 epochs are set to train each ANN with a learning rate of 0.01. The Keras Sequential model is used to implement the proposed ANNs in Python. The ANNs are created and trained in the Jupyter notebook environment on Google platform.

4.4. Measures of the Model's Predictive Ability

To examine the predictive power of gravity trade model, the conventional econometric analysis and the new approach of ANN are applied. Consistent with past studies (e.g., [4,7]), the prediction accuracy of regression model for panel data is measured by two metrics in this study: the coefficient of determination (R^2) and the RMSE. The magnitude of R^2 indicates the proportion of the variance in the clothing imports that is predictable from the independent variables. The higher the R^2, the better the model fits the data. RMSE is the square root of the MSE, which is the average of squared errors between the predicted values and the actual values of clothing imports:

$$RMSE = \sqrt{MSE} = \sqrt{\frac{\sum_{i=1}^{n}\left(\hat{Y}_i - Y_i\right)^2}{n}} \quad (3)$$

where $\hat{Y}_i$ is the predicted export value, Y_i is the actual export value, and n is the number of predicted export values. A smaller RMSE indicates higher predictive power of the model. This study compares the prediction performance of regression analysis and ANN by RMSE.

5. Findings

5.1. Results of Panel Data Regression Models

The results of the pooled OLS and year-FE models are shown in Table 3. The result of poolability test favors the year-FE model over the pooled OLS model ($F(20, 288) = 4.29$, $p < 0.0001$). And the result of Hausman test favors the year-FE model over the year-RE model ($\chi^2(4) = 28.6$, $p < 0.0001$). The year-FE model explains 74.01% of variance of the US's clothing imports.

Table 3. Results of panel data regression models.

The US's Clothing Imports	Pooled OLS	Year-FE
Constant	0.1103	−0.2916 *
Exporter's GDP x Importer's GDP (β_1)	0.3967 ***	0.5256 ***
Distance (β_2)	−0.1740 ***	−0.1307 ***
Exchange rate (β_3)	0.3772 ***	0.4048 ***
Landlock (β_4)	−1.5181 ***	−1.1717 ***
WTO (β_5)	0.1162	0.4038 ***
BRI (β_6)	−0.0723	0.6539 ***
R^2	0.6627	0.7401
Adjusted R^2	0.6561	0.7166
F statistic	100.8355 ***	31.5366 ***

Note: *** $p < 0.001$ and * $p < 0.05$.

The sign of predictor coefficients of the year-FE model is consistent with expectation. The six predictors contribute significantly to the model, as the p-value of regression coefficients is smaller than 0.0001. As expected, larger GDP of both the US and Asian countries contribute to higher bilateral clothing trade ($\beta_1 = 0.5256$), whereas longer distance between them hampers the bilateral clothing trade ($\beta_2 = -0.1307$). Depreciation of domestic currency of Asian countries against USD promotes their clothing exports to the US ($\beta_3 = 0.4048$). However, the landlocked country (Laos in the sample) is disadvantaged in its clothing exports to the US ($\beta_4 = -1.1717$). The clothing exports of Asian countries grow more after they have joined the WTO ($\beta_5 = 0.4038$). The same pattern is observed after the Asian countries have joined the BRI ($\beta_6 = 0.6539$). The year-FE regression model attains the RMSE of 20.85 billion USD in the prediction of out-of-sample clothing imports in 2019.

5.2. Results of ANNs

As shown in Table 4, the mean values of RMSE decrease in the training and validation sets as expected when the number of neurons in the hidden layer (i.e., hidden neurons) increases. However, when the hidden neurons exceed 10, the predictions in the testing set become less accurate, as indicated by the rise of RMSE (>0.1824). The best model is identified when the ANN has 10 hidden neurons because it has attained the best prediction of out-of-sample clothing imports in 2019 with RMSE of 0.1824 (i.e., z-score on the transformed scale) or 2.29 billion USD.

Table 4. Results of ANNs.

	Number of Neurons in the Hidden Layer					
	3	**5**	**9**	**10**	**11**	**15**
Mean RMSE (training)	0.4332	0.3232	0.2873	0.2800	0.2706	0.2535
Mean RMSE (validation)	0.4537	0.359	0.3314	0.3193	0.3088	0.2871
RMSE (testing)	0.5705	0.4634	0.3944	0.1824	0.2733	0.2848

6. Discussion of Results

The regression result shows a significant positive association between the BRI and Asian countries' clothing exports to the US. With the BRI as an ongoing endeavor in which more infrastructure projects are launched and completed and business opportunities continue to materialize, developing countries along the B&R can enhance their attractiveness for FDI in trade-led manufacturing and improve their competitiveness in global trade. The past few years have witnessed a growth in FDI from China injected into the textile and clothing industry in Asian countries including Cambodia, Bangladesh, and Vietnam [32,44]. This trend of relocation of clothing production has driven higher exports from these countries to the US.

Worth mentioning is the losing out of India to Bangladesh in clothing exports in the US market since 2008. Although India and Bangladesh are neighboring countries, their responses to the BRI are different—India has not signed a B&R MoU, whereas Bangladesh is a signatory country of the BRI. In the sample of this study, India is the only non-B&R export country. It is relevant to examine to what degree India would benefit from joining the BRI and, in particular, whether it would improve its clothing exports. The results of the ANN and panel regression analysis show that ANN has higher predictive power, as reflected by their RMSE (2.29 vs. 20.85 billion USD). ANN is applied to examine the change of India's clothing exports if it becomes a B&R country. That involves three steps. The first is to estimate India's exports value based on the unseen, real data of the six features (independent variables) in 2019. The policy variable BRI is coded as zero because India has not joined the BRI. The second step is to estimate India's exports value using the same dataset except that the value of the BRI variable is changed from zero to one. That is to reflect the change of India's B&R membership. The last step is to compare the two forecasted exports values. If there is an increase in exports, there is a potential for India to catch the trade development opportunity after joining the BRI. The ANN predicts that there is a 13.27% increase in India's clothing exports to the US when India becomes a B&R country.

To gather further support for the potential effect of BRI on trade development, the same analysis is performed on three key Asian clothing exporting countries, Bangladesh, Vietnam, and Indonesia. The unseen, real data of 2019 is used. In step one, the value of the BRI policy variable is coded as one because these countries have joined the BRI, whereas in step two, that value is changed from one to zero to reflect the disconnection of these countries with the BRI. In step three of the forecasts comparison, we see that if there is a reduction in exports, these countries would be economically disadvantaged if they cancel the B&R membership. The ANN results show a reduction of 5.38% in Bangladesh's clothing exports to the US when Bangladesh is no longer a B&R country. Similarly, if Vietnam and Indonesia drop the BRI, the reduction in their clothing exports is predicted to be as high as 40.58% and 30.37%, respectively, by the ANN.

Although the above scenarios are hypothetical, both ANN and regression results indicate the potential positive effect of the BRI on clothing exports of some Asian developing countries in the US market. To fully realize the BRI's potential in improving economic growth, developing countries need to enhance geographic, social, and economic factors for trade facilitation. For example, the distance between China and 62 B&R countries in geography (relative geographic distance), factor endowment (capital-to-labor ratio), culture (power distance, uncertainty avoidance, individualism-collectivism, and masculinity-femininity), and institution (measured by the World Bank's Worldwide Governance

Indicators) have been found to affect China's exports from 2007 to 2016 negatively [45]. China's trade agreement partnership and the BRI improve China's exports to 216 partner countries from 2010 to 2015 [46]. The connectivity of 30 B&R countries with China in policy coordination, facilities connectivity, unimpeded trade, financial integration, and people-to-people bonds have been found to contribute to their economic growth [47].

Future studies should expand their focus from the bilateral trade between China and the B&R countries to how developing countries can harness the BRI fully to pursue sustainable development through improving exports to high-profit markets in non-B&R countries like the US and Japan. In these studies, key issues of social and environmental sustainability should be addressed. Of particular importance is that the infrastructure projects funded under the BRI for trade facilitation should not be used intentionally or unexpectedly to fuel South-South competition, driving a new race to the bottom among developing countries along the B&R. That is, to attract FDI in labor-intensive manufacturing industries through improved trade-supporting infrastructure on one hand, and to secure orders from foreign buyers at the expense of local labor welfare through inadequate labor protections on the other hand [48,49]. More research on effective policies and measures, such as trade agreements with social clauses or provisions, that improve labor well-being of developing countries in the B&R context is needed.

Environmental degradation in the form of consumption of dirty energy, release of toxic chemical waste during production, and greenhouse gas emissions, among others, have been major concerns of buyers in developed countries and have growing impacts on the restructuring and operations of global clothing supply chains [50]. Developing countries along the B&R should be cautious about adopting the "pollute first, clean up later" growth strategy [51], which could result in permanent damage made to the natural environment and society that cannot be recovered fully even at high costs. A study of carbon emissions induced by exports and imports between B&R countries shows that China has become a pollution haven for 22 developed countries, and 19 developing countries have become China's pollution havens [52]. Future studies should identify a role model and examine effective mechanisms that developing countries along the B&R can follow and apply to strike a balance between economic growth and environmental sustainability.

Regarding the application of ANN on sectoral trade analysis, unlike past studies that have employed a large dataset (e.g., 4536 observations in Dumor and Yao [4] and 91,094 observations in Wohl and Kennedy [7]), only 315 observations (15 countries × 21 years) are used for the training and validation of ANNs in this study. Despite that, ANN has outperformed linear regression model in predictive performance of the US's clothing imports and corroborated results of past studies. ANN has great potential for use as an alternative method to predict bilateral trade. Without doubt, training a neural network with large datasets helps to avoid overfitting and generalize better. Yet, in some cases, due to various constraints, only a small dataset can be obtained. Future studies should explore using advanced algorithms of machine learning to achieve more accurate predictions with small datasets.

7. Conclusions

This study has expanded the empirical literature of global trade under the BRI. Different from past research that examined bilateral trade between China and the B&R countries, this study focuses on bilateral clothing trade between the US and 15 Asian countries along the B&R. An extended gravity model with a policy variable of BRI has been established to explain the clothing trade pattern from 1998 to 2019. Drawing upon the results of panel data regression and ANN, this study has two conclusions. The first is that there is a positive effect of the BRI on the clothing exports of some Asian developing countries in the US market. This finding is important because it supports the notion that the BRI could bring trade opportunity to developing countries not only by improving their bilateral trade with China, which has been revealed by past studies, but, more importantly, by enhancing the B&R countries' exports to non-B&R countries, such as the US, as shown in this study.

The second conclusion is that ANN outperforms a regression model in the prediction of the clothing exports of some Asian developing countries to the US. ANN also complements the regression model in analyzing the potential impact of policy change. As shown by the ANN results, there is a potential for India to improve its clothing exports to the US by joining the BRI. Moreover, there is a chance for some B&R countries, including Bangladesh, Vietnam, and Indonesia, to experience a reduction in clothing exports to the US to varying degrees if they drop their B&R membership.

The implication of these findings for policymakers is that developing countries in Asia could improve exports performance through participating in the BRI, which brings FDI to enhance trade-supporting infrastructure and expand and upgrade local production capacity so as to build stronger and deeper connections with global value chains and secure orders from foreign customers in high-profit markets. To fully realize the BRI's potential, policymakers need to identify country-specific barriers for building links to global value chains, which could be high costs and unstable supply of energy and key natural resources, insufficient high-skill workforce, weak labor rights protection, loose enforcement of environmental regulations, inefficient customs operations, outdated transport systems, inadequate information and communication technology infrastructure, poor governance and corruption, among other factors. Policymakers need to devise appropriate policies and measures to address the problems and work in close collaboration with other B&R countries and key stakeholders to co-create value for all in the pursuit of sustainable development.

This study is limited to analyzing conventional economic factors in the gravity model. Other factors that bring uncertainty, such as trade protectionism, unstable geopolitics, and social and environmental sustainability, and dynamics that shape global clothing production and trade should be examined in future research. Researchers are advised to employ more advanced machine learning methods in tandem with the conventional econometric approach to examine theoretical models that account for global trade flows at country and sectoral levels under the BRI. That helps to enhance our understanding of the BRI's role and impact on improving connectivity and promoting trade within and beyond the B&R region.

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