Article

Not peer-reviewed version

Augmented Gravity Model of Trade with Social Network Analysis

Çağay Coşkuner *, Richard Sogah, Glenn P. Jenkins

Posted Date: 16 August 2023

doi: 10.20944/preprints202308.1161.v1

Keywords: international trade; trade volumes; real effective exchange rate; China; USA; social network measurement; Linder theory; poverty reduction

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 August 2023 doi:10.20944/preprints202308.1161.v1

Article

Augmented Gravity Model of Trade with Social Network Analysis

Çağay Coşkuner [1,*], Richard Sogah [1] and Glenn P. Jenkins [2]

[1] Department of Economics, Eastern Mediterranean University, Gazimagusa 99628, Turkey; cagay.coskuner@emu.edu.tr (Ç.C.); sogahrichard67@gmail.com (R.S.)
[2] Department of Economics, Queens University, Kingston, ON K7L3N6, Canada and Cambridge Resources International Inc., Cambridge, MA 02141, USA; jenkinsg@queensu.ca;
* Correspondence: cagay.coskuner@emu.edu.tr

Abstract: International trade has been one of the most significant economic activities among countries, and its contributions towards a country's economic growth and sustainable development have been acknowledged. In recent times, international trade and global trade networks have received preeminent attention due to the sharp growth in trade volumes and its contributions to poverty reduction and general welfare. Despite the growth in global trade volumes, there are worrying concerns about the unprecedented changes in international trade patterns and growing imbalances in trade in recent times. Whereas China's trade volumes have more than tripled over the last decades and have maintained the largest trade surplus spot ahead of Germany, other major trade surplus countries such as Japan, the USA, etc. have become trade deficit countries with their trade volumes increasing at a much slower pace. In view of the growing imbalances in global trade volumes, we use an augmented gravity model of trade that incorporates social network measurement, the real effective exchange rate which is a measurement of international competitiveness, as well as the Linder theory of trade, to investigate the factors that determine the export performance of countries. Using data from 51 countries for 41 years, our results indicate that the GDP of both the home country and the partner country affects the home country's exports positively. Similarly, the real effective exchange rate REER, trade openness OPEN and dummy variables BORDER, ENGLISH, and EU have produced positive and statistically significant coefficient estimates, and these are in line with our theoretical expectations.

Keywords: international trade; trade volumes; real effective exchange rate; China; USA; social network measurement; Linder theory; poverty reduction

---

1. Introduction

International trade is one of the most important economic activities among countries, and its contributions towards a country's economic growth and sustainable development are self-evident. For centuries international trade has existed because of the mutual benefits it generates among trading countries [1]. In other words, trade improves welfare and increases production in countries that are trading with each other. From the consumers' point of view, international trade provides households with access to cheaper and high-quality imported consumables which raises consumers' welfare. It also provides consumers with different varieties of products with better quality at competitive prices. This is largely due to competition between domestic producers and foreign suppliers. In terms of producers, international trade allows countries to specialize in the production of goods at which they are the most productive. Thus, domestic resources are allocated more efficiently, and productivity increases. Moreover, enlarged consumer markets allow the exporting producers to reap the benefits based on scale such as economies of scale and increasing returns to scale. It also enables producers to import high-quality raw materials at cheaper prices.

In recent times, international trade and global trade network has received significant attention among policymakers, governments, international organizations, and other stakeholders due to its significance in poverty reduction. Research has shown that in the long run, international trade is associated on average with high economic growth and sustainable economic development. For instance, the Netherlands in the 1800s had accumulated substantial wealth through shipping and trading. Recently, the rapid growth experience among the Asian tigers (including Singapore, Hong Kong, Korea, and Malaysia) and other countries such as China, India, etc. have all been associated largely with international trade [2]. The high economic growth from international trade leads to job creation, increases opportunities, and a growth in labour demand and wages which are fundamental to poverty reduction.

Reports from multiple sources indicate that the number of people living in extreme poverty around the world has fallen by around one billion since 1990 due to the growth in international trade [3]. Given this evidence and the need to reduce poverty, trade has been recognized as an engine for inclusive economic growth and poverty reduction in the 2030 Agenda for Sustainable Development. The 2015 joint WTO-World Bank publication, *"The Role of Trade in Ending Poverty"* reinforced the evidence that trade has played a critical role in poverty reduction and that the further integration of developing economies into an open global economy will be crucial for achieving the global objective of ending extreme poverty by 2030 [3,4].

Given the benefits of international trade and its contribution to poverty reduction, there has been a sharp growth in global trade over the last three or four decades, and the growth in trade shows no signs of slowing down [5,6]. In value terms, global trade has increased considerably from approximately $16 trillion in 2011 to $28 trillion in 2021 [7]. Despite the growth in international trade value, there has been an unprecedented change in international trade patterns and growing imbalances in trade over the past decades. Amongst the major trading economies, China's trade volumes have more than tripled over the last decade and have maintained the largest surplus position ahead of Germany and other major trading economies in recent years [7]. Similarly, China has become the largest trade partner for large swaths of Latin America and Africa, while the United States is China's largest trade partner [33]. On the other hand, another large trade surplus country, Japan, has become a trade deficit country in recent years with trade volumes of other major trading economies also increasing at a much slower pace. Much more markedly, over these decades, the US economy experienced an ever-growing trade deficit. Whiles studies have shown that trade flow and export performance of a country is determined by factors such as the GDP of the country and that of its trading partners, REER, distance, etc., multiple sources have shown that China's unprecedented trade expansion over the past decades could partly be associated with digital transformation and social network which has transformed the pattern of the country's global interconnectedness and global trade [33,34].

In light of these changes in international trade patterns, we attempt to investigate the export performance of the countries. More specifically, the purpose of this paper is to identify the factors which affect the export performance of the countries. We employ the Gravity model of trade which relates the export and/or trade volumes directly to the GDPs of the trade partners, and inversely to the distance between the two countries as the framework. The framework is augmented with dummy variables to account for the impacts of common borders, language, and history [8]. In addition, we test for the effects of the Linder hypothesis which posits that the more similar the per-person income levels between the countries, the bigger the trade between them. We also incorporate real exchange rates in our model, as it is one of the well-known international competitiveness measurements. In doing so, we examine if appreciated currencies (higher real effective exchange rate -REER) – which makes the import products cheaper in the domestic market - do increase the import of partner countries from the USA. Finally, we combine economics with social network analysis and thus augment the model with the inclusion of social network measurements. Thus, we use reciprocity, in-degree, and out-degree centrality measurements as explanatory variables.

The paper uses panel data covering 51 countries and 41 years from 1980 to 2020. Thus, the contribution of the paper to the literature is two-fold: Firstly, it uses an extensive dataset with 2091 observations. Secondly, as one of the rare studies, it makes use of social network analysis in the model which accounts for the deep structure of all exchanges. The rest of the paper is organized as follows. Section 2 presents the Literature review. Section 3 provides the Model and the Data for the estimation. Section 5 gives the results and discussions. The Conclusion is presented in section 6.

 doi:10.20944/preprints202308.1161.v1

2. Literature Review

Studies on the gravity models of trade in the literature are replete with evidence from both developed and developing countries. The gravity model of trade posits that the trade volume between any two countries is directly proportional to the GDPs of the trading partner countries and inversely proportional to the distance between them [9]. The distance serves as a proxy for the transportation cost and in some studies trade barriers.

In the literature, [10–12] are the first studies that used Gravity models in analyzing international trade. Tinbergen applied the basic gravity model and the extended version that incorporated dummy variables for trade agreements and the presence of a common border among trading countries to predict the trade pattern among 42 countries. Nevertheless, the initial studies were criticized for the lack of a strong theoretical foundation supporting the gravity model of trade.

Several studies including [13–16] became pioneering works in the field and some provided the previously missing theoretical foundation for the gravity model. Nevertheless, [17] reports that "*despite the model's consistently high statistical explanatory power, its use for predictive purposes has been inhibited owing to an absence of strong theoretical foundations*".

The [18] explores the validity of the general gravity model of trade by reviewing studies from several authors. The paper analyses the relationship between trade volumes among two countries (dependent variable) and the independent variables including the GDPs of each country, a composite term for measuring the trade barrier between the two countries, and two trade barrier terms between the given countries and the rest of the world. The transportation cost is approximated by the distance between the two countries. The model also incorporates dummies for islands, landlocked countries, common language, colonial history, and neighbors. The impact of regional trade agreements (RTAs) is investigated by differentiating between trade creation and trade diversion with "Both-in RTA" and "One-in-RTA" terms applied. The authors then extend the model to address advanced issues such as zero-trade flows, and tariff equivalents for non-tariff barriers.

A study by [19] highlights that for a large selection of countries, there is support for the gravity model of trade in the literature. The literature finds strong evidence for the coefficient estimates for the GDPs of the two countries to be around 1 while the distance term to be around -1. The authors underscore the paradox of the distance term as they point out the huge innovations and advances in transportation technology, trade barriers, and the nature of goods traded over the century. Similarly [20] also investigate if the effect of distance term has changed over time. On the other hand, [21] show how to deal with different country sizes, while [22,23] addresses the zero-trade flows in data.

The author [24] uses a gravity model to analyze the role of Free-Trade-Area memberships on the flows of trade and Inward FDI. The study relied on UN COMTRADE and UNCTAD FDISTAT databases involving 170 countries from 1976 to 2005. The author finds evidence that the sign for coefficient estimates for distance is negative and significant at 1%, while the coefficient estimates for joint GDPs and joint per capita GDPs are positive and significant at a 1% significance level. The study also finds evidence that coefficient estimates for all FTA memberships used in this study have a positive sign at a 1 % significance level.

After observing that the scale of intra-trade within three specific regional groupings, namely the European Union, Asia-Pacific, and North America, has been considerably imbalanced, [25] analyzes the trade creation and trade diversion effects of the regional trade agreements (RTAs) on trade volume among the Asian countries. The study uses annual trade data for the period 1980-2009 within the framework of the gravity model. The findings of this study are mostly consistent with the literature. The coefficients of real GDP, population, and distance have expected signs and are statistically significant at a 5% significance level in all models.

A study by [26] use new panel data within a structural gravity approach to estimate the trade and welfare effects of Brexit. Using different post-Brexit scenarios, the authors find that the UK's exports of goods to the EU are likely to decline within a range between 7.2% and 45.7% in six years after Brexit has taken place. For the UK, the negative trade effects are only partially offset by an increase in domestic trade and trade with third countries.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 August 2023 doi:10.20944/preprints202308.1161.v1

Other studies such as [27] use panel data from the EU and the Mediterranean countries for the period of 1993-2007 to study the effects of trade agreements between the EU and the Mediterranean countries. Similarly, [28] uses panel data from Turkey and 10 EU countries for the period of 1998-2002 to analyze the impact of the customs union signed between Turkey and the EU. While [28] uses exports as the dependent variable, [27] uses bilateral trade as the dependent variable.

In relation to studies on the gravity model of trade and social networks, [29] uses an expanded gravity model in which the predictors consist of GDPs, per capita GDPs, the distance between the trading countries, and dummies for colonial history, common language, common border, membership to EEC and EFTA as well as NET which stands to capture the effects of network structure on bilateral trade volume. The authors find that network structure as well as GDPs are statistically significant at a 1 % significance level in explaining the variation in trade volume.

Also, [30] highlight that intra-firm trades of multinational corporations are important but rigorous empirical studies in the field are limited and scanty. Although recent studies include network analysis of international trade, they consider international trade and firm-level activity in isolation. Thus, they fail to look at whether country-level patterns of trade are a result of firm-level activity. The authors try to fill this gap by combining firm- and country-level data. The study uses an ERGM (exponential random graph model) estimation method where the explanatory variables included such macro terms as reciprocity, sink, popularity, in-degree, out-degree, transitive closure, and so on. The results turn out to be largely significant.

Similarly, [31] attempts to establish a model for informal trade in developing countries by making use of social network analysis. The paper highlights the concepts of degree centrality, betweenness centrality, closeness centrality, and eigenvector centrality. It also noted that ERGM models are the most popular probability models in social network analysis.

The paper [32] analyzes patterns of international trade and financial integration using complex social network analysis. In so doing, the authors attempt to investigate the similarities and differences in real and financial market integration. The bilateral asset trade data is collected from the Coordinated Portfolio Investment Survey (CPIS), while the trade data is taken from the UN Comtrade database. Then goods market and financial markets are investigated through Assortativity, Clustering, and Centrality. The findings are consistent with the findings of many other papers that have applied network analysis to international trade flows. Results also show that goods markets are more densely connected than financial ones and that both types of networks display a disassortative, star-shaped structure dominated by a handful of hubs.

Although there have been several studies on the gravity model of trade in the literature, however, studies on the gravity model of trade that incorporate social network and its application to trade flow analysis remains patchy and thin. Similarly, most of the recent studies that incorporate social network analysis of trade are carried out at the micro-level rather than at the aggregate level. Those limited studies done at the country level are also undertaken with limited datasets. In view of these, we contribute to the literature by adding to the few existing empirical studies on the gravity model of trade with social networks and its application to trade flow analysis at the macro level using extended datasets.

3. Materials and Methods

3.1. The Model

In identifying the factors which impact the volume of exports, this study adopts the gravity model of trade and augments it with a number of other explanatory variables. The basic gravity model states that trade volume is directly proportional to the GDPs of the partner countries, and inversely proportional to the distance between the partner countries. Thus, our basic model for US Exports is given as:

$$\log(\text{export}) = \beta_0 + \beta_1\log(\text{GDP}) + \beta_2\log(\text{GDP\_USA}) + \beta_3\log(\text{DISTANCE}) + \beta_4\log(\text{LINDER}) + \beta_5\log(\text{REER}) + \beta_6\text{OPEN} + \beta_7\text{ENGLISH} + \beta_8\text{BORDER} + \beta_9\text{EU} \quad (1)$$

 doi:10.20944/preprints202308.1161.v1

where,

"export" is the USA's exports to partner countries, in US dollars;
"GDP" is the GDPs of the USA's trade partners in US dollars;
"LINDER" is the absolute value of the difference between the GDP per capita of the trade partner country and the GDP per capita of the USA, in USdollars;
"DISTANCE" is the distance in kilometers between the capital city of the partner country and Washington DC;
"REER" is the real effective exchange rate for each trade partner country;
"OPEN" is the trade openness index for each trade partner country;
"ENGLISH" is a dummy variable to capture the common language effect;
"BORDER" is a dummy variable to capture the effect of sharing a common land border;
"EU" is a dummy variable for all European countries having common history with the reference countries of the US and UK.

To improve this model, the concepts of social network analysis are incorporated into the basic model. Thus, we augment the model with variables capturing reciprocity, in-degree and out-degree centrality of a node (which is a trade partner of the USA). An in-degree centrality is the number of edges leading to a node; thus, it indicates the popularity of a node. In trade data, since almost all countries trade with each other, we have to define an edge as a trade link between the two countries if the exports or imports of the trade partner are a certain percentage of the total world trade. In this paper, we take this as 0.05%. Thus in-degree centrality for each country will be the sum of the edges leading to the node (that is the number of countries from which the partner country imports, where the imports are more than 0.05% of world trade). Likewise, out-degree centrality is the sum of the edges directed from the node (that is the number of countries to which the partner country exports, where the exports are more than 0.05% of the world trade).

In line with these, the reciprocity measurement will be the edges as one of the US imports from the specified partner country is more than 0.05% of the total world trade. Thus, the extended model which includes the social network analysis is given by equ. (2):

$$\log(\text{export}) = \beta_0 + \beta_1 \log(\text{GDP}) + \beta_2 \log(\text{GDP\_USA}) + \beta_3 \log(\text{DISTANCE}) + \beta_4 \log(\text{LINDER}) + \beta_5 \log(\text{REER}) + \beta_6 \text{OPEN} + \beta_7 \text{ENGLISH} + \beta_8 \text{BORDER} + \beta_9 \text{EU} + \beta_{10} \text{RECIPRO} + \beta_{11} \text{IN\_DEG} + \beta_{12} \text{OUT\_DEG} \quad (2)$$

where,

"RECIPRO" captures the effects of reciprocity measurement;
"IN-DEG" captures the effects of in-degree centrality measurement; and
"OUT-DEG" captures the effects of out-degree centrality measurement.

3.2. Theoretical Expectations

Theoretically, we expect that the GDP of partner countries will have positive impacts on US exports. This is so because the higher income of a partner country increases its imports, which also increases its imports from the USA. On the other hand, the gravity model of trade states that the distance between the two trading countries stands to capture the effects of transportation costs. This distance is approximated as the distance between the two capital cities, and therefore, the distance and the trade volume between the two countries are inversely related. Thus, the coefficient estimate of "distance" is expected to be negative.

Similarly, Linder's theory of trade states that the more similar the countries are in terms of their GDP per capita values, the bigger the trade between them. Thus, we expect the coefficient estimate for LINDER to have a positive sign. The augmented gravity model of trade states that more trade-open economic systems would have larger trade volumes between the trading countries. Therefore, the coefficient estimates for OPEN are also expected to be positive.

In terms of real effective exchange rates, appreciated currencies make the import products cheaper, thus increasing the import volumes. Hence, we expect a positive sign for the coefficient estimates of REER as higher REER means more appreciated currencies for the partner countries, increasing their imports. In the augmented gravity model of trade, common language, common land borders, and common historical backgrounds which are captured by ENGLISH, BORDER, and EU respectively increase with the trade. Thus, we expect positive coefficient estimates for these dummy variables.

For the social network measurements, they may have impacts on exports via two different channels: (i) all three measurements (reciprocity, in-degree and out-degree centrality) may reduce transportation costs, as they represent already established trade routes or systems. Hence, they may be expected to have a positive impact on US exports. (ii) On the other hand, they may also be some measurements of competitiveness. Thus, out-degree centrality measurement for the partner country may show that it is a successful exporting country while in-degree centrality may indicate lower competitiveness and thus a significant importing country. Here, in-degree centrality of partner countries then is expected to have a positive sign for the US exports while out-degree centrality may have negative coefficient estimates. Given the two opposing effects, we expect the sign for out-degree centrality to be ambiguous, while those of the reciprocity and in-degree centrality to be positive. Finally, the sign of coefficient estimate for the GDP of the USA is theoretically ambiguous.

3.3. Data

In an attempt to identify factors contributing to the increase in US exports to partner countries, our study relies on panel data that includes observations for 51 countries in 41 years, (i.e., from 1980 to 2020). The list of countries included in the dataset can be found in Appendix A. These countries are also coded as numbers from 1 to 51 in the same order (as in country Code) in the dataset. The dependent variable in the study is the export volume from the USA to the partner countries. This data is in constant US dollars and it is obtained from the IMF DOTS (Direction of Trade Statistics) dataset.

The explanatory variables used in the study include the GDPs of the Partner countries, the GDP of the USA, "LINDER", DISTANCE, REER, "OPEN", the dummy variables including BORDER, ENGLISH, EU, and Social Network Analysis variables ("RECIPRO", "IN-DEG", and "OUT-DEG"). The datasets for the GDPs of the partner countries and the GDP of the USA are all in constant US dollars and have been extracted from the World Bank database. The "LINDER" captures the effects of the Linder Theory. This theory states that the more similar the countries are in terms of their per capita income levels, the bigger the trade volume between the paired countries. Thus, the "LINDER" variable is calculated as the absolute value of the difference between the per capita GDPs (GDPPC) of the USA and the Partner countries. This data is also sourced from the World Bank datasets.

According to the Gravity model of trade, the trade between a pair of countries is inversely related to the distance between the countries as the increasing transportation cost would reduce the trade between them. In the literature, the distance has been proxied as the distance between the capital cities of the paired countries. The data (in kilometers) is obtained from http://ksgleditsch.com/index.html (Kristian Skrede Gleditsch). The Real Effective Exchange Rate (REER) is a measurement of international competitiveness. It is computed as the weighted average of bilateral real exchange rates against the trade partners, where the weights are the trade volumes. However, the bilateral real exchange rate is given by the relation: $RER = NER * P / P^F$, where NER is the nominal exchange rate, expressed in the indirect quotation, thus, the unit(s) of foreign currencies required to purchase a unit of the domestic currency whiles the P and P^F are consumer price indices in home and foreign countries respectively. Therefore, depreciated currencies make domestic products cheaper in international markets, and thus lead to increases in exports, while appreciated currencies make imports cheaper in the domestic markets, and thus increase the imports. This "REER" data comes directly from IMF International Financial Statistics (IFS) dataset.

In terms of trade openness (OPEN), the augmented gravity model of trade states that the trade volume between any two countries would be larger if the mentioned countries have economic systems which are more trade-open. Trade openness is calculated as the sum of total export volumes and total import volumes, divided by the GDP of the country. As such, it measures the share of the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 August 2023 doi:10.20944/preprints202308.1161.v1

GDP that is traded internationally. To calculate trade openness, one needs the total exports and total imports of the Partner countries. These data also come IMF DOTS dataset.

Moreover, we create dummy variables to capture the effects of (i) having a common border "BORDER", (ii) having a common language, "ENGLISH", and (iii) having common history/culture as "EU". Thus, for the variable "ENGLISH", countries that are native English speakers are coded as one, while the other countries are coded as zero. Similarly, for "BORDER", the countries which have a land border with the USA are coded as one, while the others are coded as zero. Finally, for "EU", the European countries are coded as one, while the others are coded as zero.

Pertaining to the Social Network Analysis, we intend to investigate the effects of reciprocity "RECIPRO", in-degree centrality "IN-DEG", and out-degree centrality "OUT-DEG" measurements. In trade data, these concepts can be measured in two different ways: (i) scaled and (ii) scale-free measurements. For scaled measurements, the volume of transactions is used [29]. Thus, given that in this study the directed edges or links are the export volumes from the USA to partner countries, the scaled measurement of reciprocity would be the import volumes from Partner countries to the USA. In-degree centrality of each node (or the popularity of each US trade partner country) is measured as the total imports of these countries (that is the trade leading to these countries) as a percentage of world trade. Similarly, the out-degree centrality of each node is measured as the total exports of these countries (that is the trade leading from these countries) as a percentage of world trade. In the literature and more frequently, scale-free measurement for social network analysis is used. Therefore, the reciprocity links are coded as one if the import from the partner country to the USA is above a certain threshold (α%) of the world trade. In this paper, this is taken as 0.05% of the world trade.

Scale-free in-degree centrality of partner countries is the number of links leading to these US trade partner countries. Since in trade data, almost all countries do trade with each other, we count the links if the imports of these countries from the remaining other countries in the dataset are above a certain percentage of the world trade. Similarly, the out-degree centrality of the nodes (partner countries) is the number of links (exports) from these countries. Again, we count the number of links if the exports are above a certain percentage of world trade. Here, there is no pre-defined percentage value in the literature, thus we choose 0.05% of world trade as the cut-off point. In fact, we have tried a few different percentage values until we have got a good variation of in-degree measurements for the US trade partner countries.

The USA is the reference country while the 51 countries with 41 years of observations (from 1980 – 2020) are the trade-partner countries. This gives the total observations of 2091. Out of the total observations, the Real Effective Exchange Rate (REER) data is not available for 11 countries. Aside from this, there are also other missing observations for other variables in some countries for some years. After omitting the missing data points, the total number of observations obtained is 1586. The REER is one of the well-known international competitive measurements and because of its significance, it cannot be exempted. Therefore, the estimation is conducted in two set-ups; one with REER (1586 observations) and the other one without REER in the set-up (2004 observations).

3.4. Test of Results

The correlation coefficients, the unit root test, and the Hausman test for the selection between Panel Fixed-Effect and Random Effect have been conducted. The dependent variable "exports" is the US exports to partner countries and the independent variable "RECIPRO" captures the effects of reciprocity measurement, thus, the US imports from the partner countries. The correlation coefficient for these two variables is 0.85, indicating that there is a comparatively high and positive correlation between these variables. The explanatory variable IN-DEG measures the in-degree centrality of partner countries, thus, the links leading to partner countries. In scaled social network measurements, these are the total imports of the partner countries. The correlation between the dependent variable and IN-DEG (world export to partner countries) is 0.37, indicating that there is a low correlation between these two variables. The IN-DEG is the world export to partner countries, and OUT-DEG is the partner country export to the whole world. The correlation between these variables and trade openness OPEN are -0.06 and -0.08 respectively, indicating a very low correlation. Similarly, the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 August 2023 doi:10.20944/preprints202308.1161.v1

correlation between IN-DEG and OUT-DEG turns out to be 0.96, which is a relatively high correlation, and therefore to avoid multicollinearity, we decide to use only OUT-DEG measurement and leave out the in-degree centrality measurement. An Augmented Dickey-Fuller unit root test is conducted to test for stationarity. All the variables i.e., GDP, GDPPC, DISTANCE, LINDER, OPEN, and REER turn out to be stationary based on the p-values produced. Therefore, the estimation is done on the level data rather than using the first-differenced data. The Hausman test for the selection of appropriate fixed effect between Panel Fixed-Effect and Random Effect has been conducted and it turns out that the fixed effect is more appropriate.

4. Results and Discussions

The results from the two separate estimations, one with scaled social network measurements, and the other with scale-free social network measurements are presented in Table 4a. The USA is the reference country while the remaining countries are the trade-partner countries. The US export to partner countries is the dependent variable. Column 1 and 2 of Table 5a presents the results for which scaled social network measurement is used and column 3 and 4 gives the results where scale-free social network measurements are applied.

In column 1, the coefficient estimate for the GDP of the partner country is 0.58 with a p-value of 2.2e-16. Thus, partner country GDPs have a positive coefficient estimate which is statistically significant at a 0.1% significance level. More specifically, a 1% increase in the partner's GDP increases the US exports to the partner country by 0.58%. Similarly, the coefficient estimate for the GDP of the USA is 0.89 with a p-value of 2.2e-16. Thus, the US GDP has a positive coefficient estimate which is statistically significant at a 0.1% significance level. The DISTANCE and LINDER variables turn out to be statistically insignificant, while the coefficient estimates for REER and OPEN variables are positive and significant at a 0.1% significance level. These are in line with our theoretical expectations. Similarly, ENGLISH, BORDER, and EU dummy variables have positive coefficient estimates which are all statistically significant at 0.1% significance level. These are also in line with our theoretical expectations.

For the social network measurements, the reciprocity variable has a positive coefficient estimate and is statistically significant at a 0.1% significance level, while the out-degree centrality has a negative coefficient estimate, but this is statistically insignificant. In column 2, the REER is omitted from the model in order to prevent loss of data as there are no REER data for 11 countries. As a result, the number of observations increased from 1586 to 2004. The results are similar to those in column 1. GDP, GDP_USA, OPEN, BORDER, ENGLISH, EU, and RECIPROCITY have positive coefficients which are statistically significant at a 0.1% significance level, while out-degree has a negative coefficient estimate which is statistically insignificant. Furthermore, DISTANCE and LINDER again turn out to be statistically insignificant.

In Columns 3 and 4, the results of the model that applied the scale-free social network measurement with and without REER are presented. The results in Column 3 are similar to those in Column 1: GDP, GDP_USA, REER, OPEN, BORDER, ENGLISH, and EU have positive coefficient estimates which are statistically significant at a 0.1% significance level. LINDER is still statistically insignificant, while DISTANCE turns out to be statistically significant at a 5% significance level but of the wrong sign. For the social network measurements, the results are reversed compared to Column 1 results. OUT_DEG has a positive coefficient estimate which is statistically significant at a 0.1% significance level, while reciprocity turns out to be statistically insignificant. Similarly, results in Column 4 are similar to those in Column 2 with the exception of social network measurements: GDP, GDP_USA, OPEN, BORDER, ENGLISH, and EU have positive coefficient estimates which are statistically significant at 0.1% significance level, while DISTANCE and LINDER are still statistically insignificant. Regarding the social network measurements, the results are reversed compared to Column 2 results. OUT – DEG has a positive coefficient estimate which is statistically significant at a 0.1% significance level, while reciprocity turns out to be statistically insignificant.

Table 4. a: Estimation Results (Dependent Variable: USA exports).

	Scaled Social Network Measurements (1)	**(2)**	**Scale-free Social Network Measurements (3)**	**(4)**
	REER included	REER excluded	REER included	REER excluded
Log(GDP)	0.584816 (2.2e-16)***	0.664908 (2e-16) ***	0.67867 (2e-16) ***	0.689333 (2e-16) ***
Log(GDP_USA)	0.887051 (2.2e-16)***	0.719249 (2e-16) ***	0.89316 (2e-16) ***	0.764656 (2e-16) ***
Log(DISTANCE)	0.535110 (0.27363)	0.387348 (0.377257)	1.23371 (0.014300) *	0.512115 (0.250825)
Log(LINDER)	0.007969 (0.71674)	0.009566 (0.661845)	0.03249 (0.149884)	0.022012 (0.324259)
Log(REER)	0.285645 (2.4e-09)***		0.30597 (7.2e-10)***	
OPEN	0.557539 (2e-16) ***	0.651710 (2e-16) ***	0.51828 (2e-16) ***	0.639878 (2e-16) ***
BORDER	3.280101 (2e-16) ***	2.898850 (2.8e-16)***	4.12166 (2e-16) ***	3.423747 (2e-16) ***
ENGLISH	0.503667 (1.6e-08)***	0.464285 (2.5e-07)***	0.38689 (2.7e-05)***	0.352279 (0.00015)***
EU	1.406151 (2e-16) ***	1.153620 (2e-16) ***	1.20603 (2e-16) ***	1.048181 (2e-16) ***
Reciprocity	5.431874 (2e-16) ***	5.379964 (2e-16) ***	0.03202 (0.414094)	-0.033917 (0.305357)
In-degree				
Out-degree	-0.805452 (0.60487)	-1.545762 (0.318654)	0.02283 (0.00016)***	0.024234 (1.7e-05)***
Adjusted R-squared	0.9711	0.9654	0.9693	0.9639
sample size	1586	2004	1586	2004

Note: The numbers in parenthesis are p-values. ***; **; * and indicate significant at 0.1%; 1%, 5% and 10% significance level.

To account for reverse causality between the US GDP and the US exports (dependent variable), the model is modified by incorporating the lagged form of GDP_USA so that the higher US exports cannot cause higher values for lagged GDP_USA. The results failed to find support for the LINDER variable. Instead of using the LINDER variable, a separate GDPPC variable which is the absolute value of the difference between the US and partner GDPPC values is applied and the results are shown in Table 4b.

In columns 1 and 3 of Table 4b, the estimation of the model including the lagged version of the US GDP is shown, however, the results in column 1 include social network measurements, while that of column 3 is the scale-free social network measurements. The results from both columns show that the coefficient estimates for the lagged GDP_USA are positive and statistically significant at a 0.1% level of significance. This suggests a causality from the US GDP towards the US exports. That notwithstanding, in column 3, the coefficient estimate for distance turns out to be wrongly signed but significant at a 5% significance level. Similarly, in both columns and as before, the coefficient estimates for LINDER and DISTANCE are statistically insignificant but statistically significant in column 3.

In terms of social network measurement, reciprocity has a positive and statistically significant coefficient estimate in column 1 but not in column 3, while out-degree centrality has a positive and statistically significant coefficient estimate in column 3 but not in column 1. All other explanatory

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 August 2023 doi:10.20944/preprints202308.1161.v1

variables turn out to be statistically significant, mostly at a 0.1% significance level and with signs similar to those in Table 4a. For columns 2 and 4, the results from the use of separate GDPPC values rather than LINDER variables are presented. The results show that both DISTANCE and GDPPC are statistically insignificant, while the US GDPPC is statistically significant with a negative sign. This implies that higher GDPPC in the USA reduces the USA's competitiveness, and thus its exports. Once again, reciprocity has a positive and statistically significant coefficient estimate in column 2 but not in column 4, while out-degree centrality has a positive and statistically significant coefficient estimate in column 4 but not in column 2.

Table 4. b: Estimation Results (modified regression models).

	Scaled Social Network Measurements		**Scale-free Social Network Measurements**	
	(1)	**(2)**	**(3)**	**(4)**
	with Lagged US GDP	Separate GDPPCs	with Lagged US GDP	Separate GDPPCs
Log(GDP)	0.584816 (2e-16) ***	0.65573 (2.3e-10)***	0.67867 (2e-16) ***	0.551350 (8.9e-08)***
Log(GDP_USA)		1.81839 (0.00021)***		2.430139 (1.7e-06)***
Log(Lag_GDP_USA)	0.887051 (2e-16) ***		0.89316 (2e-16) ***	
Log(DISTANCE)	0.535110 (0.27363)	1.76705 (0.158159)	1.23371 (0.014300)*	0.067705 (0.957900)
Log(LINDER)	0.007969 (0.71674)		0.03249 (0.149884)	
Log(GDPPC)		-0.15408 (0.196962)		0.069553 (0.572215)
Log(GDPPC_USA)		-1.40018 (0.054127)		-2.245706 (0.002958)**
Log(REER)	0.285645 (2.4e-09)***	0.29277 (8.3e-09)***	0.30597 (7.2e-10)***	0.260635 (6.2e-07)***
OPEN	0.557539 (2e-16) ***	0.55167 (2e-16) ***	0.51828 (2e-16) ***	0.486475 (2e-16) ***
BORDER	3.280101 (2e-16) ***	4.25671 (6.8e-06)***	4.12166 (2e-16) ***	3.342627 (0.00068)***
ENGLISH	0.503667 (1.6e-08)***	0.39567 (0.001040)**	0.38689 (2.7e-05)***	0.421122 (0.00094)***
EU	1.406151 (2e-16) ***	1.78251 (5.2e-10)***	1.20603 (2e-16) ***	1.106219 (0.00015)***
Reciprocity	5.431874 (2e-16) ***	5.46413 (2e-16)***	0.03202 (0.414094)	0.047215 (0.234876)
Out-degree	-0.805452 (0.60487)	0.21854 (0.891379)	0.02283 (0.00016)***	0.028096 (1.5e-05)***
Adjusted R-squared	0.9711	0.9712	0.9693	0.9695
sample size	1586	1586	1586	1586

Note: The numbers in parenthesis are p-values. ***; **; * and indicate significant at 0.1%; 1%, 5% and 10% significance level.

Until this point, the estimation results of the model with US exports as the dependent variable are presented. However, given that the US economy is the leading economy in the world and the fact that the US dollar is extensively used as the vehicle currency in international trade flows that sometimes do not directly involve the US, it is prudent that we consider if the above results might be

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 16 August 2023 doi:10.20944/preprints202308.1161.v1

any different for other reference countries. Therefore, we examine the dynamics by using UK exports as the dependent variable, and the results are presented in Table 4c.

The results show that in all four columns, the results are relatively different from the previous case where the US is the reference country and the US exports are the dependent variable. Interestingly, the DISTANCE variable has a negative coefficient estimate (as theoretically expected) and is highly significant at a 0.1% significance level. Coefficient estimates for both partner GDP and UK GDP turn out to be positive and statistically significant at a 0.1% significance level, while the coefficient estimate for the LINDER once again turns out to be statistically insignificant. Furthermore, trade openness OPEN, real effective exchange rate REER as well as dummy variables EU and ENGLISH turn out to have positive coefficient estimates in line with our theoretical expectations, and these are all statistically significant at least at a 1% significance level.

In contrast to our theoretical expectation, the coefficient estimate for BORDER turns out to be negative, and significant at a 1% significance level. The explanation could be that the only land border the UK has is the Irish Republic border and a substantial part of UK trade with Ireland is carried via sea rather than via Northern Ireland. Pertaining to the social network measurements, the coefficient estimates for reciprocity and out-degree centrality are both positive and statistically significant at a 0.1% significance level. These are in line with our theoretical expectations and provide more supportive evidence compared to previous results.

Table 4. c: Estimation Results (Dependent Variable: UK exports).

	Scaled Social Network Measurements (1) (2)		**Scale-free Social Network Measurements (3) (4)**	
	REER included	**REER excluded**	**REER included**	**REER excluded**
Log(GDP)	0.513410 (2e-16) ***	0.51406 (2e-16) ***	0.428009 (2.6e-15)***	0.422822 (2e-16) ***
Log(GDP_UK)	0.942027 (2e-16) ***	0.75332 (8e-16) ***	1.088107 (2e-16) ***	0.919985 (2e-16) ***
Log(DISTANCE)	-0.125626 (0.01230) *	-0.23953 (5.7e-06)***	-0.248889 (2.7e-05)***	-0.459105 (2e-14) ***
Log(LINDER)	-0.004150 (0.78967)	-0.01008 (0.580742)	0.009142 (0.554432)	0.004389 (0.806319)
Log(REER)	0.508890 (2e-16) ***		0.465936 (2e-16) ***	
OPEN	0.386562 (2e-15) ***	0.54471 (2e-16)***	0.426153 (2e-16) ***	0.567025 (2e-16) ***
BORDER	-0.775380 (1.4e-05)***	-0.68608 (0.00027)***	-0.476886 (0.004348)**	-0.417453 (0.018768) *
ENGLISH	2.123227 (2e-16) ***	1.93018 (2e-16) ***	1.844347 (2e-16) ***	1.654926 (2e-16) ***
EU	2.332903 (2e-16) ***	1.99510 (2e-16) ***	2.112321 (2e-16) ***	1.531027 (2e-16) ***
Reciprocity	3.250929 (1.3e-12)***	3.64948 (4e-12) ***	0.365421 (0.00022)***	0.717157 (5.8e-12)***
Out-deg. (partner exp)	7.532099 (1.6e-08)***	7.87072 (1.2e-07)***	0.067185 (2e-16) ***	0.071794 (2e-16) ***
Adj. R-square	0.9715	0.9714	0.9595	0.9603
sample size	1545	1962	1545	1962

Note: The numbers in parenthesis are p-values. ***; **; * and indicate significant at 0.1%; 1%, 5% and 10% significance level.

In comparing the results from the two estimations i.e., the one with the US as the reference country with the one with the UK as the reference country, the two results are very much similar to each other except for the DISTANCE which turns out to be insignificant. Similarly, and as before, the LINDER variable is statistically insignificant, while the BORDER variable is significant but wrongly signed. All other variables are statistically significant with correct signs. Although the DISTANCE variable is insignificant in this case, however, the adjusted R-square slightly increases.

The two datasets were combined and the two countries, thus, the USA and the UK have been made the reference or home country for further estimation and analysis. This led to an increased number of observations (n = 3131). The estimation results turn out to be 'improved' as all variables now turn out to be statistically significant at 1% significance and of the correct sign. The DISTANCE turns out to be statistically significant with a negative sign as it is theoretically expected; LINDER turns out to be statistically significant with a positive sign but this is not what is theoretically expected. BORDER turns out to be statistically significant with a positive sign as it is theoretically expected; and finally, RECIPROCITY turns out to be statistically significant with a positive sign as it is theoretically expected. Therefore, combining the datasets seem to improve the results. This can be simply due to the increased number of observations in the dataset, or due to reduced bias as we introduce two countries as reference countries rather than just the USA.

5. Conclusion

The paper investigates the factors which impact the export performance of countries using explanatory variables derived from the augmented gravity model of trade, Linder theory as well as social network measurements. The study uses panel data from 51 countries and 41 years from 1980 to 2020. The estimation and analysis have been conducted for three separate cases. For the first case, the USA is used as the reference or home country so the US exports to partner countries are used as the dependent variable. In the second case, the UK exports to partner countries are set as the dependent variable while the third case combined the data and set both the USA and the UK as the reference or home country. Similarly, the estimation and analysis are done with and without REER as well as for the cases with scaled and scale-free social network analysis.

For the case of the USA as the home country, the results show that the GDP of both the home country and partner country affect the US exports positively (as expected from the gravity model of trade). On the other hand, there is no statistical evidence for DISTANCE and LINDER variables. Real effective exchange rate REER, trade openness OPEN and dummy variables BORDER, ENGLISH, and EU have produced positive and statistically significant coefficient estimates, and these are in line with our theoretical expectations. The results are also mixed for social network measurements of reciprocity and out-degree. Using separate GDPPC values rather than LINDER variables, or using lagged values of US GDP values due to reverse-causality issues did not change the results. Similarly using only, a subset of data for the years before the year 2000, did not change the results for DISTANCE (a proxy for transportation cost).

When we use the UK as the home country, or the US and the UK combined as the home country, the results for DISTANCE, reciprocity, and out-degree measurements improve. The DISTANCE variable produces a statistically significant negative coefficient estimate which is in line with theoretical expectations. Reciprocity and out-degree coefficient estimates turn out to be statistically significant and positive, implying that social networks affect export performance positively. All other results are similar to those in the base model where the US is the home country.

In terms of policy, an increasing REER of a country indicates a rise in the value of its currency vis-à-vis trading partners, and thus, a loss of competitiveness. Therefore, based on our results, it is recommended that for a country to increase its export(imports) volume, there is a need for it to lower(raise) its REER to increase(decrease) its competitiveness and thus its exports(imports). However, this is not straightforward as there are caveats to such practices. The effectiveness of the policy (REER) to stimulate net exports(imports) depends largely on the exchange rate elasticity of exports(imports) and other variables. Similarly, it is recommended that for an economy to boost its international trade and exports, it needs to activate the status of openness.

Author Contributions: "Conceptualization, Ç.C. and R.S.; methodology, Ç.C., and G.P.J; software, Ç.C.; validation, Ç.C., R.S., and G.P.J; formal analysis, Ç.C., and G.P.J; investigation, Ç.C., and R.S; resources, Ç.C.; data curation, Ç.C.; writing—original draft preparation, Ç.C., and R.S; writing—review and editing, Ç.C., and G.P.J; visualization, Ç.C.; supervision, Ç.C., and G.P.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data used in this study are openly available and are obtained from the IMF DOTS (Direction of Trade Statistics) database, the World Bank database, and the other sources indicated in the manuscript.

Acknowledgments: "Reserved for the editor and the anonymous reviewers".

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A: List of Countries Used for Panel Estimation

"Canada", "Mexico", "Australia", "New Zealand", "Germany", "United Kingdom", "France", "Italy", "Spain", "Netherlands", "Ireland", "Austria", "Switzerland", "Portugal", "Greece", "Cyprus", "Malta", "Turkey", "Denmark", "Sweden", "Finland", "Norway", "Iceland", "Poland", "Hungary", "Romania", "Israel", "Egypt", "Tunisia", "Algeria", "Morocco", "Japan", "Korea", "China", "India", "Pakistan", "Bangladesh", "Singapore", "Thailand", "Malaysia", "Indonesia" ,"Philippines", "Argentina", "Brazil", "Bolivia", "Chile", "Colombia", "Ecuador", "Peru", "Paraguay", and "Uruguay".

Appendix B: List of Countries used for ERGM and Network Analysis

"United States", "Canada", "Mexico", "Australia", "New Zealand", "Germany", "United Kingdom", "France", "Italy", "Spain", "Ireland", "Austria", "Switzerland", "Portugal", "Greece", "Denmark", "Sweden", "Finland", "Norway", "Hungary", "Romania", "Israel", "Algeria", "Morocco", "Turkey", "Japan", "India", "Pakistan", "Bangladesh", "Singapore", "Thailand", "Malaysia", "Indonesia", "Philippines", "Argentina", "Brazil", "Bolivia", "Chile", "Colombia", "Ecuador", "Peru", "Paraguay", "Uruguay".

References

1. Krugman, P. R., & Obstfeld, M. (2009). International economics: Theory and policy. Pearson Education.
2. Severns, C. (2021). The Development of the Four Asian Tigers. *Borgen Magazine*. https://www.borgenmagazine.com/development-of-the-four-asian-tigers/ (assessed on 6/12/2022)
3. World Bank Group and World Trade Organization, 2015. The Role of Trade in Ending Poverty. World Trade Organization: Geneva. https://documents1.worldbank.org/curated/en/726971467989468997/pdf/97607-REPLACEMENT-The-Role-of-Trade-in-Ending-Poverty.pdf
4. Bartley Johns, M., Brenton, P., Piermartini, R., Sadni Jallab, M., & Teh, R. (2018). Trade and Poverty Reduction: New Evidence of Impacts in Developing Countries. World Bank Group. https://www.wto.org/english/res_e/booksp_e/wto_wbjointpublication_e.pdf
5. Frankel, J. (2000). Assessing the Efficiency Gains from Further Trade Liberalization. Cambridge, MA: Harvard University.
6. Milner, C., & Morrissey, O. (1999). Measuring trade liberalization in Africa. In Evaluating Economic Liberalization: Case-Studies in Economic Development (pp. 60-82). London: Palgrave Macmillan UK.
7. Key Statistics and Trends in International Trade (UNCTAD2022) https://unctad.org/system/files/official-document/ditctab2023d1_en.pdf (assessed on 30-06-2023).
8. Bergstrand, J. H., Egger, P., & Larch, M. (2013). Gravity Redux: Estimation of gravity-equation coefficients, elasticities of substitution, and general equilibrium comparative statics under asymmetric bilateral trade costs. Journal of International Economics, 89(1), 110-121.
9. Yotov, Y. V., Piermartini, R., & Larch, M. (2016). An advanced guide to trade policy analysis: The structural gravity model. WTO iLibrary.
10. Tinbergen, J. (1962). Shaping the world economy; suggestions for an international economic policy.

11. Pöyhönen, Pentti. "A Tentative Model for the Volume of Trade Between Countries," Weltwirtschaftliches Archive, Vol. 90 (1963), pp. 93-100.
12. Linnemann, Hans. An Econometric Study of International Trade Flows, North-Holland (1966).
13. Helpman, E., and P. R. Krugman (1985). Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy. Cambridge, Mass.: MIT Press.
14. Leamer, E. E., & Stern, R. M. (1970). Constant-market-share analysis of export growth. ______. *Quantitative international economics. Boston: Allyn and Bacon*, 171-183.
15. Anderson, J. E. (1979). A theoretical foundation for the gravity equation. *The American economic review*, *69*(1), 106-116.
16. Deardorff, A. (1998). Determinants of bilateral trade: does gravity work in a neoclassical world? In *The regionalization of the world economy* (pp. 7-32). University of Chicago Press.
17. Bergstrand, J. H. (1985). The gravity equation in international trade: some microeconomic foundations and empirical evidence. *The review of economics and statistics*, 474-481.
18. World Trade Organization and UNCTAD (2012), "Analyzing bilateral trade using the gravity equation" Chapter 3 in Practical guide to trade policy analysis.
19. Thomas Chaney (2013), "Gravity Equation in International Trade: An Explanation", NBER Working Paper Series, working paper 19285.
20. Disdier, A. C., & Head, K. (2008). The puzzling persistence of the distance effect on bilateral trade. *The Review of Economics and statistics*, *90*(1), 37-48.
21. Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American economic review*, *93*(1), 170-192.
22. Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating trade flows: Trading partners and trading volumes. *The quarterly journal of economics*, *123*(2), 441-487.
23. Eaton, J., Kortum, S., & Kramarz, F. (2011). An anatomy of international trade: Evidence from French firms. *Econometrica*, *79*(5), 1453-1498.
24. Dean DeRosa (2007), "Gravity Model Analysis", Chapter 6 in Maghreb Regional and Global Integration.
25. Ekanayake, E. M., Mukherjee, A., & Veeramacheneni, B. (2010). Trade blocks and the gravity model: A study of economic integration among Asian developing countries. *Journal of Economic Integration*, 627-643.
26. Harald Oberhofer and Michael Pfaffermayr (2021), "Estimating the trade and welfare effects of Brexit: A panel data structural gravity model", Canadian Journal of Economics, 21.
27. Kepaptsoglou K, Tsamboulas D, Karlaftis MG, Marzano V. (2009), "Analyzing free trade agreements effects in the Mediterranean region: a sure gravity model-based approach." Transp Res Rec; 2097: 88-96.
28. Nowak-Lehmann F, Herzer D, Martinez-Zarzoso I, Vollmer S. (2007), "The impact of a customs union between Turkey and the EU on Turkey's exports to the EU." JCMS. J Common Market S, 45(3): 719- 43.
29. Tushyanthan Baskaran and Tilman Bruck (2005)," Scale-Free Networks in International Trade" German Institute for Economic Research, Discussion Papers 493.
30. Matthew Smith, Sara Gorgoni, Bruce Cronin (2019), "International Production and Trade in a High-Tech Industry: A Multilevel Network Analysis", Social Networks, 59, p.50-60.
31. Olivier Walther (2015), "Social Network Analysis and Informal Trade", Syddansk Universitet, Department of Border Region Studies Working Papers Series, No:1.
32. Stefano Schiavo, Javier Reyes, Giorgio Fagiolo (2010)," International trade and financial integration: a weighted network analysis", Quantitative Finance, 10: 4, 389 — 399,
33. McKinsey Global Institute. (2016). Digital globalization: The new era of global flows. *McKinsey & Company*.
34. Ferrantino, M. J., & Koten, E. E. (2019). Understanding Supply Chain 4.0 and its potential impact on global value chains. *Global value chain development report*, *103*. http://rigvc.uibe.edu.cn/docs/2019-04/20190416233115823419.pdf#page=113