UNIVERSITAT DE BARCELONA
BUSINESS SCHOOL

MSc
Business Research

MASTER THESIS

Assessment of the bilateral trade potential between China and the European Union

MSc IN BUSINESS RESEARCH

University of Barcelona

Autora: Jiayu Ouyang
Director: Oscar Claveria Gonzalez

Barcelona, 14 de Junio de 2024

Contents

Abstract

This study uses an extended gravity model to analyze the determinants of bilateral trade flows between China and the EU from 2002 to 2022. The results show that trade flows between China and the EU are mainly affected by economic size, adjusted geographical distance, trade dependence and real effective exchange rate. Specifically, both China's per capital GDP and the EU countries' per capital GDP have a significant positive impact on bilateral trade flows, highlighting the role of economic growth in promoting trade volume. The distance variable, which combines geographical distance and an adjusted distance variable based on crude oil prices, has a significant negative impact on trade flows, reflecting the constraints of transportation costs and geographical distance on international trade.

The study confirms the reliability of the model and the consistency of the results through multiple collinearity diagnostics and robustness tests. The fixed-effect model is found to be the most suitable for analyzing the data in this study, and the Hausman test results further support the choice of the fixed-effect model.

In addition, the study calculates a trade potential index (TPI) and classifies China's trade relations with EU countries into three categories: great potential, potential for development, and potential for reshaping, based on the ratio of actual trade volume to theoretical trade volume. The results show that although China's trade relations with most EU countries are close to or at the theoretical optimum level, there is still potential for further improvement in trade volume with some countries.

This study fills a major gap in the academic literature, providing new insights into the understanding of China-EU trade flows and practical recommendations for policymakers and businesses to optimize trade relations and address trade barriers. In addition, the study points to future research directions, such as incorporating cultural and historical factors, extending the study period, and exploring the impact of digital trade and technological progress on China-EU trade.

Through these analyses, the study emphasizes the importance of economic growth, exchange rate stability and trade relations in promoting sustainable trade development. By continuing to strengthen bilateral trade cooperation, optimizing trade policies and promoting economic integration, China and the EU can further deepen their trade relations and achieve mutual benefit and win-win results.

Keywords: *International trade, China, European Union, Gravity Model.*

Resumen

Este estudio analiza los determinantes de los flujos comerciales bilaterales entre China y la Unión Europea durante el periodo comprendido entre 2002 y 2022 mediante un modelo de gravedad comercial ampliado. Los resultados muestran que los flujos comerciales entre China y la UE están influidos principalmente por factores como el tamaño económico, la distancia geográfica ajustada, la dependencia comercial y el tipo de cambio efectivo real. En concreto, tanto el PIB per cápita de China como el PIB per cápita de los países de la UE tienen un impacto positivo significativo en los flujos comerciales bilaterales, lo que indica que el crecimiento económico impulsa los volúmenes comerciales. La variable de distancia ajustada (que combina la distancia geográfica y los precios del crudo) tiene un impacto negativo significativo en los flujos comerciales, lo que refleja el efecto limitador de los costes de transporte y la distancia geográfica sobre el comercio.

La fiabilidad del modelo y la coherencia de los resultados se confirmaron en este estudio mediante el diagnóstico de multicolinealidad y pruebas de robustez. El modelo de efectos fijos resultó ser el más adecuado para analizar los datos de este estudio. Los resultados de la prueba de Hausmann corroboraron la elección del modelo de efectos fijos.

Este estudio también calculó el Índice de Potencial Comercial (IPC) y clasificó las relaciones comerciales de China con los países de la UE en tres tipos en función de la relación entre el volumen comercial real y el volumen comercial teórico: gran potencial, potencial pionero y potencial de remodelación. Los resultados muestran que, aunque las relaciones comerciales de China con la mayoría de los países de la UE se acercan o se sitúan en el nivel teóricamente óptimo, todavía hay margen para seguir aumentando el volumen comercial en determinados países.

Este estudio viene a colmar una importante laguna en la literatura académica al aportar nuevas ideas para comprender los flujos comerciales entre China y la UE, y ofrece sugerencias prácticas a los responsables políticos y a las empresas para optimizar las relaciones comerciales y hacer frente a las barreras comerciales. Al mismo tiempo, este estudio señala direcciones para futuras investigaciones, como la incorporación de factores culturales e históricos, la ampliación del período temporal del estudio y la exploración del impacto del comercio digital y los avances tecnológicos en el comercio entre China y la UE.

A través de estos análisis, este estudio destaca la importancia del crecimiento económico, la estabilidad de los tipos de cambio y las relaciones comerciales para promover un desarrollo comercial sostenible. Si siguen reforzando la cooperación comercial bilateral, optimizando las políticas comerciales y promoviendo la integración económica, China y Europa podrán profundizar aún más sus relaciones comerciales en beneficio mutuo.

Palabras clave: *Comercio internacional, China, Unión Europea, Modelo de Gravedad.*

1. Introduction

The bilateral trade relationship between China and the EU has a significant impact on the regional and global economic landscape (Commission European). With a GDP of $16,670.6 billion and $18,321.2 billion respectively (World Bank, 2022), the two economic giants are among the world's largest trading partners. The interaction between them plays a vital role in shaping global market dynamics and promoting economic stability.

Upon becoming a member of the World Trade Organization in 2001, China has progressively embedded itself within the international trade network, evolving into a significant force within the global economy. Over the subsequent years, the nation's active participation and profound engagement have catalyzed its transformation into an economic powerhouse, demonstrating substantial influence on worldwide commerce. This integration has laid a solid foundation for strengthening trade relations with the EU and provided many opportunities for cooperation (Algieri, 2002). Over the past two decades, the trend of regional economic integration has promoted closer trade relations between China and Europe and created many opportunities for cooperation.

The opening of the China-Europe Railway Express in 2011 marked the beginning of a new era of land trade, significantly reducing transportation time and costs. This development marks the flourishing of economic ties between China and Europe. The Belt and Road Initiative (BRI), proposed in 2013, has further expanded the connectivity of trade routes and infrastructure, strengthened economic ties, and opened up broader channels for cooperation.

In 2020, China and the EU reached an agreement in principle on the Comprehensive Agreement on Investment (CAI), which was an important milestone in China-EU trade relations, although it subsequently encountered challenges in ratification. After the epidemic, China and the EU have once again tried to strengthen political and economic exchanges, and EU leaders visited China to strengthen bilateral relations and emphasize the importance of this relationship.

As the 20th anniversary of the China-EU Comprehensive Strategic Partnership in 2023 approaches, both sides have reaffirmed their commitment to deepen economic relations amid global challenges. This evolving relationship is characterized by major progress and strategic initiatives, highlighting the dynamic nature of China-EU trade. Employing a gravity model to scrutinize the China-EU trade dynamics offers valuable insights into the underpinnings and prospective enhancements of their commercial ties. Notwithstanding a wealth of research on their bilateral trade, significant voids persist in comprehending the precise catalysts behind trade disparities and opportunities for optimization. So many previous studies exclusively focus only on simple data sets while missing the complex factors that help to regulate trading flows.

Furthermore, one notable shortcoming of these studies is that they tend to rely heavily on the application of reduced-form models while the gravity model is a strong econometric tool that helps researchers to analyze effectively bilateral trade relations. While this approach entails a broad range of variables including economic magnitude, trade regulations, and the geographical distance between two trading partners (Zymek, 2022), it offers a more all-inclusive view of the trade relations. In order to fill these gaps, we believe that our analysis may provide several insights regarding the nature of China-EU trade relations, the factors that drive the interdependency, and the equity of trade relations between the two regions and the potential for their improvement.

Although numerous articles have discussed the issue of China,'s relationship balance of trade with the EU (UNU-WIDER) , studies that investigate the nature of factors that lead to trade imbalance look limited. Knowledge of these factors becomes central to effective formulation of policies aimed at dealing with the trade deficit. Recent research comprises some lacking individual and coalesced views, frequently targeting single facets of the trade relation. It would therefore be useful to approach the problem of understanding trade from an integrated perspective, thus particularly including the determinants outlined above. The most common model is the gravity model which focuses on the GDP, distance and trade agreements while the China-EU trade has not attracted a lot of researchers. Applying this model can give insights regarding self-generated trade potential and its dynamics, as well as sources of potential activity that can serve as points of intervention for policymakers (Zhang et al. , 2022).

Through the research and measurement of the trade gravity model, some key questions are answered: First, it is necessary to establish the empirical model of China-EU trade and selecting appropriate variables that might influence the trade flows, including economic size (GDP), geographical distance, trade policy and etc. Second, critically analyze the dynamics of China-EU bilateral trade and the causes for trade imbalances. Trade imbalance is the major question of debate in this case; specifically, it is addressing the following question: This question is; What are the causes of trade imbalance and what can be done to solve this problem? This entails formulation of policies, negotiation of trade hooks, and development of economic frameworks that assist in the proper distribution of flow of trades. Last but not least, regarding both the current and future prospects of China-EU trade relations, it is necessary to outline the trends and possible further developments aimed at enhancing trade cooperation and integration of the two regions' economies.

This paper aims at the main objective of testing the China-EU bilateral trade potential by applying the gravity model and reconstructing the table of China-EU bilateral trade The analysis and measurement of the quantitative model can provide analysts' relatively objective measurement results to help with the future development of China-EU bilateral trade. This entails an analysis of the characteristics that influence evolution of trade and examining how trade relations can be rebalanced. However, by focusing on such factors as economic size, the distance between countries, and the trade policy in relation to current accounts, it gives a perfect overview of the existing trade problem of imbalance and ways of improving it.

2. Literature Review

Among the variety of contributions to the field of economics and trade, one can find numerous attempts by scholars to extend the common research blueprint, the gravity model. Linnemann (1966) developed this approach further by adding such factors as endogenous variables, size of population and others and thus increasing its explanatory capabilities. Later on, the gravity model has been more developed with the inclusion of other economic/non-economic factors, which make a model to be constant in providing results of international trade.

The most basic formula used to estimate the anticipated trade values is the gravity model, which was first suggested by Tinbergen (1962) This formula postulates that the volume of trade between any two countries is directly proportional to the product of their gross domestic product and inversely proportional to the distance between these two countries. This is due to the fact that the model is easy to understand and produces accurate results thus its common adoption in international trade analysis. A lot of research works have used the gravity model to analyze current China – EU trade and has pointed out the means that affect the trading volumes. Most of the studies, including Yang and Shan (2007) and Ding and Liu (2016) consider GDP and distance are the crucial factors while other indicated the role of trade policy, infrastructure, and political issue. Zhang (2015) and Yan and Cai (2021) extend additions of financial development indicators and real effective exchange rate to shed width to the hypothetical coverage of the proposed model.

All of these have employed cross-sectional approach, panel data approach, and time series analysis. These methods have further confirmed the findings of the gravity model, the results of which are thus supporting the hypothesized general statistical relationship between trade flows, GDP, distance and other pertinent variables. For instance, Ding and Liu (2016), implemented panel data analysis on the effects of economic integration on China's exports to EU, while Zhang (2015), employed time series analysis to assess the effects of financial development on trade.

The main conclusions reveal that China'd GDP growth has a positive impact on exports and imports of goods with EU member states. Pro-o Ventures like Belt and Road Initiative have also helped ramp up trade by cutting travel time and costs on infrastructure. Another factor that has influenced trade flows also include trade policies note the China International Import Expo that aimed to promote integration and liberalize the trade. Quite expectedly, the economic size of two trading partners is the most dominant factor that affects the level of bilateral trade as measured by the absolute trade potential: China and the EU have a vast absolute trade potential since they are two of the world's largest economies with a larger stock of production and consumption capacities. Had there been less income, people would have been able to spend significantly less, so there is a direct relationship between GDP and export/import. Previous theories that emerged during the same period, such as the absolute advantage theories of trade spearheaded by Tinbergen (1962) and Linnemann (1967), also asserted that larger economies trade more in order to their their larger sized economy sizes. According to Zhang (2015), financial development is seen to have the function of improving the trade volume, that is to say, to enhance the improvement of better financial services to reduce transaction costs.

However, distance is a barrier to movement of items, which results to increased transport costs and time, thereby pulling down trade. This has however been cushioned by other actions like China EU express which has increased the volume of trade due to time and and cost considerations. Yang and Shan, (2007) emphasized the significance of upgraded structure within the perspective of trade efficiency. At the same time, BRI has created the new opportunities for the import/export opening up the new trade routes, having positively influenced connectivity between China and Europe, and highly stimulating the trade volume.

Trade policies, including tariffs, non-tariff barriers, and agreements such as the China-EU Initiative, have a significant impact on trade flows. Policies that promote free trade and reduce barriers promote bilateral trade. For example, Ha and Jin (2012) demonstrated that the trade agreement between China and the EU promoted increased trade volumes by reducing tariffs and non-tariff barriers. Zhang (2015) stressed the importance of financial policies in promoting trade by ensuring a stable financial environment and reducing currency risks. However, Tan (2017) analyzed trade closeness and complementarity and conducted an empirical analysis using the gravity model on China-EU bilateral trade data from 1999 to 2014 to explore trade potential. His findings revealed that the trade closeness between China and the EU showed a declining trend.

The China-EU trade imbalance is characterized by a persistent EU trade deficit with China. Thus, comparing the EU import from China in 2002 to that of 2022, the EU's import from China increased from EUR 73. of from EUR 429 billion to EUR 627 billion. 450 people million, and exports from EUR 32 Million to EUR 4 billion. Seven billion to two hundred and thirty EUR. 4 billion: This has underlined the growing entrenchment of trade interdependence and valued persistent trade imbalance (World Bank, 2022). Such asymmetry reveals the fact that the EU has increasingly relied on import Chinese products and requires the countertop strategy on trade flows. The causative factors for this shift includes volatility in production co-efficient, fluctuating consumption pattern and the nature of industrial base. The comparison of the two nations, where China has comparative advantage in production while the EU demands quality and cheap products has favoured importation of goods from China (Rodrik, 2006). In the same vain, restrictive measures as well as competitive disadvantages have also restricted EU exports to China through placing barriers to the market access. In their studies, Linnemann (1967) as well as Zhang (2015) point out to these respective structural factors and the imperative to concisely supply pertinent policy response to trade imbalances.

Solutions proposed for the EU include enhancing the export competitiveness of EU firms, engaging in dialogue to secure trade conditions favorable to the EU in China, and diversifying sectors that are favored by the EU. It recognizes this reality through measures that entail the removal of non-tariff barriers as well as encouraging investment in industries such as value addition. Yang and Shan (2007) further assert that there is a balance that could be achieved in the EU's external trade if export quality is enhanced and diversification of export markets embraced. Financial policies and innovation investment are some of the areas that Zhang (2015) focuses on as the key to enhancing export capacity of the EU.

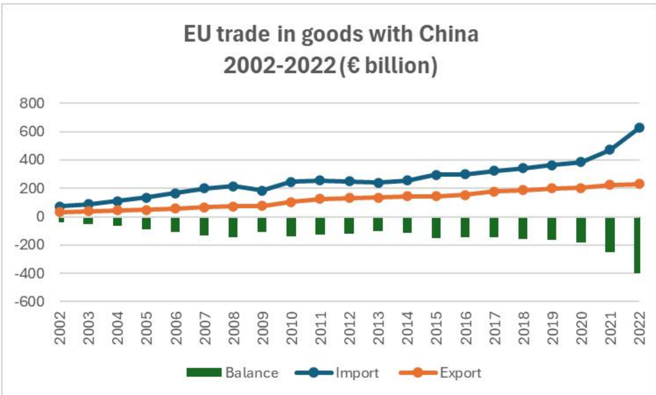
Thus, along with a further increase in exports due to economic development and the launch of new infrastructure projects, the EU could start considering the Belt and Road Initiative as an opportunity. This paper finds out that there exist strategic economic initiatives to promote China and EU trade relations in the future such as the EU-China Strategic Initiative as proposed by Araya (2018). Thus, advance trends show that as the EU acquires better exports, that is when they get back at it and the Chinese market is being liberalized, there are tendencies that volumes of China-EU trade will rise and that the balance of trade will alter. The shift towards green technology and products is also new opportunities for traders between two countries depending on our time, where appropriate technologies such as those in the renewable energy sector could come up in the future.

With these prospects in mind, trade should be encouraged through conducive policies, and infrastructure development, with policies that support manufacturing of new products. Action and policy, at bilateral and multilateral levels, are required to enhance the level of economic integration so as to ensure the continuation of growth and the balancing of trades (Baldwin, 2016). According to Linnemann (1967) and Zhang (2015), stability of the economic environment as well as reduction of trade barriers is key to enhancing trade. In this conception, Stability of the economic environment and reduction of trade barriers were highlighted by Linnemann (1967) and Zhang (2015) as critical in enhancing trade. Moreover, there is also a positive effect on both innovation and the possibilities of new trade relations given the improvement of R and D cooperation.

First of all, this literature review aims to present a general picture of China-EU trade relations, outlining factors that have influenced them in the past, the role of such factors in the current state of affairs, and possible scenarios of the relations in the future. The empirical methodology of this research includes analyzing the trade flows and major factors by applying a gravity model, which will help in understanding how to put forward solutions in order to solve trade deficits and develop further trade relationships between the investigated countries. The results will be useful, not only for collections strategies but for policy formation for nations, and business management for the multitudes of businesses operating in the complex global economy.

3. Data Section

As reported by Eurostat (2022), the top position in the list of the world's exporter belongs to China with the export statistics of €3,413 billion, and the export share of all products from this country occupies 17%. Exporting account for 6% of the total exports of all the goods in the world. The EU comes next on the exporters' list with the figure standing at €2,572 billion, equivalent to 13.2% globally. The EU exporting partner countries Most significant destinations for EU exports in 2023 are China, with a share of 8%. From a total of € 1.67 trillion the internal west European trade is worth 10% but 8% of all EU goods exports. Newscasts have it that the leading imports from China are machinery, motor vehicles, and chemicals, with the biggest imports being telecommunication equipment and cars, and the calculation shows that the first twenty imports account for 61% of total imports. The main EU exports to China in 2023 were automobiles and machinery, highlighting the large amount of trade in high-value sectors.



Source: own elaboration based on Eurostat

In 2022, China was the EU's second largest trading partner, second only to the United States, with total imports and exports of €856.3 billion, accounting for about 15.3% of the EU's total trade that year. China is the EU's largest source of imports, second largest trading partner and third largest export market, highlighting the important economic interdependence between the two regions.

From 2002 to 2022, EU imports from China surged from 73.6 billion euros to 627.4 billion euros, an increase of 752.3%. Meanwhile, EU exports to China increased from 32.7 billion euros to 230.4 billion euros, an increase of 603.8%. While the growth in exports is noteworthy, it is slightly lower than the growth in imports, indicating that the economic integration between the EU and China is deepening.

Share of National Imports and Exports in World Trade (%)

Source: own elaboration based on Eurostat

These trends highlight the critical importance of the China-EU trade relationship and the need to develop strategic trade policies to address the widening trade imbalance and strengthen economic cooperation. By applying a gravity model, this study aims to provide insights into optimizing bilateral trade, benefiting both places and promoting global economic stability. A thorough analysis of these trade dynamics requires a comprehensive understanding of the data sources, variables, and time frames used in the study. The data section provides this important context by detailing the key elements and rationales behind the data selection.

For in-depth analysis, I construct a panel data set covering the trade volume between China and the 27 EU member states from 2002 to 2022. The end point of 2022 is chosen because the latest data can be obtained from reliable sources. Long-term economic analysis of nearly 20 years can help us understand the basic trends of economic development more comprehensively and avoid abnormal data caused by a single event that misleads policy making. For example, reports of the World Bank and the IMF often use data from many years to analyze the long-term trends and recovery paths of the global economy to ensure the reliability and validity of the conclusions and better identify the real drivers of economic growth, especially in the face of major economic shocks such as financial crises and pandemics.

The 27 EU member states were also selected as observation objects because they provide detailed information on China-EU trade relations. The dataset includes annual bilateral trade flows, including exports and imports, GDP of various countries, and policy factors, providing a reliable analysis of trade dynamics between China and the EU. Inspired by the UNCTAD publication "An Advanced Guide to Trade Policy Analysis: When selecting data, this study adopts the Structural Gravity Model (2016)", which includes all aspects of data that would be used in the analysis.

The data used herein this research has been carefully collected from a combination of the most credible databases to eliminate possibility of bias. These sources include united nations commodity trade statistics database UN Comtrade, The World Bank, the international Monetary Fund, the French institute for international economic relations, and Eurostat. For ease in processing, all those collected inventories will be disposed into respective Excel formats.

After that these data compilations will be conveniently imported in the STATA 17. 0 statistical software platform. Within this advanced analytical environment, a set of sequential ‘methodical actions’ would be performed. This is achieved through formulating panel data, featuring control variables, applying logarithmic adjustments to the variables, and performing empirical studies. Finally, the conclusions inferred from these strict methods would be effectively ported as to enable easy access and use to other researchers for further examination and sharing of knowledge.

4. Empirical Analysis

The final category of investigation responds to this research question because it provides a quantitative approach to explore the nature of China-EU bilateral trade, which forms a foundation of our empirical investigation. In line with the established objectives, using the gravity model as the theoretical framework for the analysis, we investigate the critical factors that have influenced the trade flows between the two mammoth economies in the period 2002-2022. Our empirical goal, using a systematic and severe statistical method, is to identify common tendencies in trade dynamics, to support some theoretical propositions, and set out an essential advice on how to improve the quality of the bilateral trade relations, and to measure the bilateral trade plural.

4.1 Methodology

This section outlines the approach used in estimating the bilateral trade prospects within the context of the China- EU trade by employing the gravity model as our estimator. Some of the areas we attempt to address include: the historical evolution of the model, the structure and form of the model, data that feeds the model, criteria used to select the variables for inclusion in the model, and the econometric techniques that are used in the estimation of the model parameters. In order to analyze the trade potential of the specific countries in question, which in this case are China and the EU, the gravity model is used for empirical analysis.

Derived from the universal gravitation theory formulated by Newton in 1687, early forms of the gravity model contained conceptual formulas similar to Newton's concept of the law where the force of gravity between two entities is a function of the mass of the two and distance between them, with the force being inversely proportional to the square distance (Capoani, 2023). The basic equation reflecting this concept is the cornerstone of our analysis:The basic equation reflecting this concept is the cornerstone of our analysis:

$$F = G\ \frac{m_1 m_2}{r^2} \tag{1}$$

where **F** is the magnitude of the gravitational force, G is the universal gravitational constant, $\mathbf{m_1}$ and $\mathbf{m_2}$ are the masses of the two objects, and **r** is the distance between them. The formula demonstrates that the gravitational force between two objects decreases as the distance increases. As society has evolved, gravity models have found applications in various fields. Economists observed that the logic of international trade mirrors the law of gravity in that the amount of bilateral trade between two countries is clearly influenced by the geographical distance between them. Tinbergen (1962) and Linnemann (1966) proposed the standard equation of the gravity model for trade:

$$T_{ij} = A\ \frac{GDP_i \times GDP_j}{Dist_{ij}} \tag{2}$$

where $\mathbf{T_{ij}}$ represents the trade flows between countries i and j; **A** is a constant, and $\mathbf{GDP_i}$ represent the sizes of the economies of countries i and j, respectively, usually measured by the GDP of the two countries, and $\mathbf{GDP_j}$ represents the distance between the countries i and j, typically expressed as the distance between their capitals. According to the equation, the larger the values of $\mathbf{GDP_i}$ and $\mathbf{GDP_j}$ in the numerator, the greater the value of $\mathbf{T_{ij}}$, i.e., the bilateral trade; conversely, as the distance in the denominator increases, the value of trade decreases. In other words, the volume of bilateral trade is positively proportional to the size of the economies and inversely proportional to the distance between them. To facilitate calculation, it is common in empirical studies to take the natural logarithm of both sides of the equation to obtain the following linear form:

$$\ln T_{ij} = \ln A + a \ln GDP_i + b \ln GDP_j - c \ln Dist_{ij} \tag{3}$$

where **a**, **b**, and **c** are the estimated coefficients. a and b denote the correlation coefficients, which are crucial for regression results and reflect the extent to which the GDPs of countries i and j affect bilateral trade. If $a < 0$, then the GDP of country i has a negative impact on bilateral trade; if $a > 0$, then the economic size of country i facilitates trade. The same applies to b and c. The negative sign in front of the distance variable was considered to be a barrier to output, and Anderson and Wincoop (2003) changed the sign in front of the distance term to a positive sign, ultimately resulting in the formula that underlies the trade gravity model that we use as a common convention:

$$\ln T_{ij} = \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln Dist_{ij} + \varepsilon_{ij} \tag{4}$$

where $\boldsymbol{\beta_0}$, $\boldsymbol{\beta_1}$, $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ are the regression coefficients for the additional variables, $\boldsymbol{\varepsilon_{ij}}$ is the error term. In the context of China-EU trade, additional variables are essential to capture the complexities of bilateral trade relations. For example, the BRI significantly impacts trade by improving infrastructure and reducing transportation costs. Including a dummy variable for BRI participation can help quantify its impact. It has been used for many years in the form of the 'gravity equation', but many other factors have been introduced into the model in the past years.

These extended models cover factors like border effect, trade intensity, purchasing power parity real exchange rate effect among other factors affecting the trade partners. The international trade literature has also made use of the concept of "multilateral resistance" first coined by Anderson and Wincoop back in 2003, as it not only deals with distance between two countries but also the resistance to trade of third countries as well. For instance, incorporating of trade dependence (FTD) variable in the model takes into account the vulnerability of a country of its level of integration in international trade compared to its Gross Domestic Product (GDP).

The findings show that there are several scholarly works that have adopted the expanded gravity model meaning that the model is effective in analyzing China-EU trade. For example, the introduction of other factors like GNI per capital, trade and infrastructure, openness has made easy to understand the forms of trades between these regions (Anderson and Wincoop, 2003; Yang and Martinez-Zarzoso, 2014). These extended models have been used to explain the direction, depth and/or magnitude level that the BRI or the CAI or any other similar enterprises have brought to the trade. Extensions of this model go a long way in give more profound details of factors that underpin trade and bear robust foundation for policy formulation in a bid to enhance bilateral trade. Based on these considerations, the final form of the trade gravity model used in this study can be expressed as follows: Based on these considerations, the final form of the trade gravity model used in this study can be expressed as follows:

$$\ln \mathrm{T_{ij}} = \alpha + \beta_1 \ln \mathrm{GDP_i} + \beta_2 \ln \mathrm{GDP_j} + \beta_3 \ln \ \mathrm{Dist}_{\mathrm{\ ij}} + \beta_4 \ln \mathrm{FTD_j} + \beta_5 \ln \mathrm{Pop_i} + \beta_6 \ln \mathrm{Pop_j} + \beta_7 \ln \mathrm{REER_{ij}} + \varepsilon_{\mathrm{ij}} \quad (5)$$

Thus, the presented model could enable a detailed analysis of the influence of various factors on the subject trade relations and create the basis for an effective policy enhancing China-EU bilateral trade. In this research, the dependent variable under measurement is the trade flow from China to any of the 27 member states in the EU. The theoretical explanations and data sources for the explanatory variables are detailed as follows:The theoretical explanations and data sources for the explanatory variables are detailed as follows:

Table 1 Description of explanatory variables

Variable Symbol	Expected Symbol	Variable Name	Theoretical Description	Source of Data
T_{ij}		Bilateral trade flow	It encompasses both exports and imports of goods and services between these countries within a given year.	WITS/UN Comtrade Database
GDP_i and GDP_j	+	Gross Domestic Product of Country i and j	GDP reflects the economic size of a country, which is a critical determinant of trade volume according to the gravity model.	World Bank
$Dist_{ij}$	-	Geographical Distance	The distance between country i and country j, usually expressed as the distance between the two capitals, the higher the value, the higher the communication and trade transport costs, making trade between the two countries more difficult.	GEO-CEPII Database
FTD_j	+	Trade Dependence of Country j	Trade dependence is calculated as the ratio of a country's total trade (exports plus imports) to its GDP. This variable is included to capture the degree to which an economy relies on international trade.	Own elaboration based on World Bank
Pop_i and Pop_j	+	Population of Country i and j	Population size can influence trade flows as larger populations may indicate larger markets and greater production capacities.	World Bank
$REER_{ij}$	+	Real Effective Exchange Rate	The REER between China and EU member states, sourced from BIS and IMF, adjusts the nominal exchange rate for inflation differentials and trade balance, impacting the relative prices of traded goods and services.	IMF/BIS

The data collected from these sources span multiple years, allowing for robust panel data analysis. The inclusion of these diverse variables aims to provide a comprehensive understanding of the factors influencing China-EU trade flows and to identify potential strategies for optimizing bilateral trade relations. The model's specification and the breadth of data ensure that the analysis captures both traditional economic determinants and contemporary factors affecting international trade.

4.2 Results

Once the model was established, the extended gravity model was empirically tested using Stata 17.0. During the initial data analysis, the results were found to be unsatisfactory. Upon reviewing the literature, the author identified the issue: as the gravity model of trade deals with non-temporal series variables, the spatial distance variable indexed by the distance between the capitals of the two countries is fixed. This can lead to multicollinearity problems, as noted by Jiang and Zhang (2012).

This method changes the distance into a time series variable so as to effectively avoid the situation of multicollinearity while also getting a clearer picture of the costs of trade between two trading nations. The distance is then improved which in turn serves to optimize the entire data set to be used subsequently into the process. In the revised model (5), the variables comprised the log of trade flow, the log of China's GDP, log of the EU's GDP, the log of adjusted distance, the trade dependence, China's population, the population of the EU, and the REER.

Table 2: Multicollinearity test outcomes

Variable	VIF	1/VIF
$\ln Pop_i$	25.29	0.039538
$\ln GDP_i$	25.29	0.039547
$\ln Pop_j$	5.93	0.168558
$\ln GDP_j$	5.92	0.168888
$\ln FTD_j$	1.55	0.645843
$\ln Dist_{ij}$	1.42	0.702224
$\ln REER_{ij}$	1.36	0.732964
Mean VIF	9.54	

On strengths of initial regression analysis, the full R squared value was exactly 1.00, it thus may be that the model suffers from multicollinearity, or overfitting issues, as pointed out by Araya (2018). Some of the key discoveries include a positive and significant effect of EU Gross Domestic Product and trade dependence on the trade influx. Thus, the evidence of the significant impact of the change in the political relationship was contrasted with other variables including the adjusted geographical distance, Chinese GDP, China and the EU's population size, and the real exchange rates that did not exert meaningful influence.

In order to diagnose multicollinearity in more detail, the measure of the variance inflation factor (VIF) was computed. The Two studies indicate that while both variables portray China's economic growth, they share high level of multicollinearity with the value reaching 25.29. In addition, presenting the VIF values of EU population and GDP which varies around 5.92-5.93. Based on detailed analysis of all these facts, it becomes realized that China's population is closely related to the GDP with the coefficient of 0.98, which can be considered moderate according to Araya (2018). This finding goes a long way in supporting the assertion made herein that the said variables are afflicted by multicollinearity, which requires that rectifications be made to enhance the stability of the developed model.

To solve this problem, it was decided to replace the original GDP and population indicators with GDP per capital. This recalibration is intended to alleviate multicollinearity issues and improve the model's predictive accuracy. GDP per capital is calculated by dividing total GDP by the population of the corresponding country, ensuring a more nuanced and less relevant representation of economic performance. GDP per capital was calculated as follows:

$$\mathrm{GDP}_{\text{per capital}} = \frac{\mathrm{GDP}}{\mathrm{Pop}} \tag{6}$$

The log-transformed GDP per capital variable was then included in the revised model:

$$\ln \ \mathrm{GDP}_{\text{per capital}} = \ln \left(\frac{\mathrm{GDP}}{\mathrm{Pop}}\right) \tag{7}$$

The revised regression model was specified as:

$$\ln \mathrm{T_{ij}} = \alpha + \beta_1 \ln GDP_{\text{per capital i}} + \beta_2 \ln \mathrm{GDP}_{\text{per capital j}} + \beta_3 \ln(\ \mathrm{Dist}\ _{ij} \times \ \mathrm{OilPricet}\ ) + \beta_4 \ln \mathrm{FTD_j} + \beta_5 \ln \mathrm{REER_{ij}} + \varepsilon_{\ \mathrm{ij}} \tag{8}$$

By means of these modifications, it is expected that supplemented model will reduce the problem of multicollinearity and provide much more reliable estimations of the impacts produced by economic magnitude, geographic distance and other factors for the trade relationship between China and the EU. Future parts will reveal the important thing successes of this advanced mannequin together with their correlation and sensitivity assessments.

To foster an incipient comprehension of the dataset, we commence with the presentation of descriptive statistics pertaining to the principal variables incorporated within the gravity model framework. These statistical summaries offer invaluable perspectives on the data's central tendencies and variability, constituting a critical precursor to conducting regression analyses. By elucidating the mean, median, standard deviation, and other relevant measures, we lay the groundwork for a thorough examination of the relationships between economic size, geographical distance, and trade volumes between China and the EU. This preliminary exploration enables us to identify potential outliers, assess data normality, and ensure the appropriateness of our econometric techniques, thereby fortifying the validity of subsequent findings.

Table 3 Descriptive statistics

Variable	N	Mean	Std. Dev.	Min	Max
ln T_{ij}	567	15.44	1.59	11.19	19.28
ln $GDP_{per\ capital\ i}$	567	8.49	0.76	7.05	9.45
ln $GDP_{per\ capital\ j}$	567	10.12	0.72	7.65	11.80
ln $Dist_{ij}$	567	13.08	0.41	11.97	13.83
ln FTD_j	567	-10.48	0.74	-12.77	-8.01
ln $REER_{ij}$	567	4.54	0.10	4.121	4.95

From the data results in Table 3, we can see that the mean value of the logarithm of trade flow is 15.44, the standard deviation is 1.59, the lowest value of trade flow is 11.19, and the highest value is 19.28, which shows that there are significant differences in trade volume in the sample, and the trade relationship between China and European countries has experienced significant fluctuations over the years.

China's GDP per capital has a mean value of 8.49 and a standard deviation of 0.76, reflecting the significant economic growth in China during the study period. These values range from a low of 7.05 to a high of 9.45, highlighting China's rapid economic development over the study period. The EU countries have a mean GDP value of 10.12, a standard deviation of 0.72, and a range of values from 7.65 to 11.80. These figures reflect the economic disparities within the EU as well as the overall magnitude of the region's economic and trade capacity.

Adjusted distance, which takes into account geographic proximity and crude oil prices, has a mean value of 13.08 and a standard deviation of 0.41. the range of distances is from 11.97 to 13.83, suggesting that geographic proximity varies, better reflecting the actual costs of cross-border trade. The mean value of the trade dependence variable is -10.48 with a standard deviation of 0.74 and a range from -12.77 to -8.01, indicating differences in the degree of bilateral trade dependence among EU countries.

The population of EU countries has a mean value of 15.80 with a relatively low standard deviation, indicating population stability over the period. The population of EU countries ranges from 12.89 to 18.24, indicating significant demographic differences between EU countries. The real effective exchange rate has a mean value of 4.54, a standard deviation of 0.10 and a range of values from 4.12 to 4.95.These values reflect the volatility of the exchange rate over the period of the study, which affects the competitiveness of both exports and imports, and hence the volume of trade.

The average trade flows between China and European countries are quite impressive, indicating that the bilateral trade volume is huge. The values of GDP per capital for China and the EU nations are notably substantial, underscoring the considerable economic clout and trade potential inherent within these two territorial blocs. The application of logarithmic transformations to these variables serves to normalize their distributions, thereby streamlining the process of regression analysis. For instance, simple arithmetic mean of the natural logarithm of GDP per capital is approximately 8.49, accompanied by a standard deviation of 0.76, whereas EU countries exhibit a mean logarithmic GDP per capital of 10.12 and a standard deviation of 0.72. Such transformations actually decrease the skewness and thus makes the data easier for regression analysis as it reduces skewness.

Besides, the real effective exchange rate proved a mean of 4.54 and the standard deviation of 0.10 proving conclusions on the increased volatility evidenced from the period in analysis. This observation underscores the dynamic nature of currency valuations, which can significantly influence trade balances and economic interactions between China and the EU. By subjecting these variables to logarithmic adjustments, we not only enhance the linearity of relationships but also facilitate a more accurate interpretation of coefficients in our regression models, ultimately contributing to a more nuanced understanding of the factors driving bilateral trade dynamics.

After the descriptive statistical analysis, we studied the correlations between the variables to understand their linear relationship and potential impact on bilateral trade flows (Albornoz-Flores and Tonon-Ordóñez, 2020). Understanding these relationships is crucial to identify potential multicollinearity issues that may affect the reliability of regression results. Table 4 shows the pairwise correlation coefficients between the variables. High correlation coefficients (close to 1 or -1) indicate strong linear relationships and, if they are independent variables in a regression model, indicate possible multicollinearity problems (Draper and Smith, 1998).

Table 4 Correlation analysis

Variable	$\ln T_{ij}$	$\ln GDP_{per\ capital\ i}$	$\ln GDP_{per\ capital\ j}$	$\ln Dist_{ij}$	$\ln FTD_j$	$\ln REER_{ij}$
$\ln T_{ij}$	1	0.0492	0.5343*	0.3844*	0.3011*	0.0835*
$\ln GDP_{per\ capital\ i}$	0.0492	1	0.0302	0.0551	0.0408	-0.0018
$\ln GDP_{per\ capital\ j}$	0.5343*	0.0302	1	0.3204*	0.1588*	0.3726*
$\ln Dist_{ij}$	0.3844*	0.0551	0.3204*	1	0.3954*	0.1974*
$\ln FTD_j$	0.3011*	0.0408	0.1588*	0.3954*	1	-0.2134*
$\ln REER_{ij}$	0.0835*	-0.0018	0.3726*	0.1974*	-0.2134*	1

Note: * indicates significance at the 5% level; p-values are in parentheses.

From the data in the table, it can be seen that there is a significant relationship between the main variables, especially there is a strong positive correlation between trade flows. Firstly, the correlation coefficient between China's GDP per capital and EU countries' GDP is 0.0302, which shows a weak correlation between them. This indicates a weak relationship between the growth of China's GDP per capital and the growth of EU countries' GDP. This result may reflect the differences in the stage of economic development and growth dynamics between China and EU countries.

The correlation coefficient between adjusted distance and trade flows is 0.3844, showing a moderate positive correlation. Although geographical distance is usually considered to have a negative impact on trade, this result may reflect other trade-enhancing factors such as improved transportation infrastructure and lower transportation costs, which may offset the negative impact of distance on trade to some extent.

The correlation coefficient between trade dependence and trade flows is 0.3011, showing a moderate positive correlation. This finding emphasizes the importance of established trade relations in promoting bilateral trade flows. Countries with high trade dependence are more likely to maintain stable trade flows, indicating the important role of historical and institutional factors in trade relations.

The correlation coefficient between China's GDP and trade flows is, indicating a strong positive correlation between the two. This is consistent with previous analyses and reflects the strong contribution of China's economic growth to bilateral trade flows. The scale and pace of expansion within China's economy wield substantial influence over the magnitude of trade exchanges between China and EU member states. Amplified economic activity directly catalyzes the augmentation of trade volumes, underscoring the symbiotic relationship between economic vitality and trade proliferation.

Conclusively, the real effective exchange rate variable unveils intriguing insights. The correlation coefficient linking the EU's real effective exchange rate to trade flows registers at 0.0835, denoting a positive association. This conveys that variations in the real effective exchange rate exert a pronounced effect on the bilateral trade currents, reinforcing the notion that exchange rate dynamics play a pivotal role in shaping trade patterns.

To ascertain the absence of multicollinearity concerns, the VIF was computed. The diagnostic outcomes reveal that each variable's VIF value resides within the permissible threshold, with the highest VIF capped at 1.36 and an average of 1.27. These figures affirm that the issue of multicollinearity has been effectively mitigated through the refinement of the distance variable, ensuring that the model's explanatory power remains robust and reliable. The average VIF value is lower than the critical value of 10, indicating that the multicollinearity problem of the modified model is not serious (Rawlings et al., 1998).

After the correlation analysis, we further use fixed effect models and random effect models to explore the determinants of China-EU bilateral trade flows. To ensure the accuracy and robustness of the results, Hausman test and robustness test are also conducted. The detailed analysis of each model and its results are as follows (Table 5).

Table 5 Results of the extended gravity model regression analysis

Explanatory variable	(1) OLS	(2) Fixed-effects	(3) Random-effects
ln $GDP_{per\ capital\ i}$	0.038	-0.001	-0.001
	(0.070)	(0.003)	(0.003)
ln $GDP_{per\ capital\ j}$	1.093^{***}	0.969^{***}	0.969^{***}
	(0.084)	(0.011)	(0.011)
ln $Dist_{ij}$	0.777^{***}	0.035^{***}	0.035^{***}
	(0.151)	(0.008)	(0.008)
ln FTD_j	0.255^{***}	0.998^{***}	0.998^{***}
	(0.085)	(0.005)	(0.005)
ln $REER_{ij}$	-1.774^{***}	-0.066^{**}	-0.066^{**}
	(0.600)	(0.026)	(0.026)
Constant	4.634	15.942^{***}	15.940^{***}
	(2.904)	(0.154)	(0.298)
R^2 adjusted	0.362	0.996	-
N	567.000	567.000	567.000

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

Firstly, the fixed effects model was used to control for inter-country heterogeneity by allowing each country pair to have independent values for the intercept term between them, thus controlling for unobserved heterogeneity. The regression results of the fixed effects model show that China's GDP per capital has a significant positive effect on trade flows with a coefficient of 0.969 and a significance level of 1% ($p < 0.01$). This indicates that an increase in China's GDP per capital will directly contribute to an increase in trade with EU countries. The GDP per capital of EU countries also shows a significant positive effect, with a coefficient of 0.035 and a significance level of 1% ($p < 0.01$), suggesting that the size of the EU countries' economies has a significant positive effect on trade flows. The adjusted distance coefficient is 0.998 with a significance level of 1% ($p < 0.01$), indicating that geographical distance has a negative effect on trade flows. The coefficient of trade dependence is -0.066 with a significance level of 5% ($p < 0.05$), indicating that countries with higher trade dependence tend to have larger trade flows. The coefficient of the real effective exchange rate is -0.066, but with a significance level of 5% ($p = 0.05$), indicating that changes in the exchange rate have a negative effect on trade flows.

Second, in order to consider the potential correlation between the observed variables and the unobserved effects, a random effects model was used. The results of the random effects model show that the significant positive effects of GDP per capital in China and GDP per capital in EU countries on trade flows are consistent with the fixed effects model. The coefficient of China's GDP per capital is 0.969 with a significance level of 1% ($p < 0.01$), reconfirming the strong contribution of China's economic growth to trade flows. The coefficient of GDP per capital for EU countries is 0.035 with a significance level of 1% ($p < 0.01$), indicating that economic size has a significant positive impact on trade flows. The coefficient of adjusted distance is 0.998 with a significance level of 1% ($p < 0.01$), indicating a negative effect of geographical distance on trade flows. The trade dependence coefficient, clocking in at -0.066 with a 5% significance level ($p < 0.05$), underscores the pivotal role played by trade dependence in the facilitation and enhancement of bilateral trade volumes. These finding therefore point out that a strong flow interdependence among the trading partners is a key factor that acts as a catalyst to flow of trade.

Similarly, the real effective exchange rate coefficient is noted to be -0.066, also bearing a 5% significance level ($p = 0.05$). This alignment with the fixed effects model suggests that fluctuations in the real effective exchange rate have a discernible impact on trade dynamics, supporting the hypothesis that exchange rate movements significantly influence bilateral trade relationships. Both coefficients, with their respective significance levels, reinforce the notion that trade dependence and exchange rate variability are key determinants in shaping the contours of international trade.

In order to determine the applicability of the fixed effects model and the random effects model, the Hausman test was conducted. The results of the Hausman test indicated that the fixed effect model was more applicable. The results of the test showed a chi-square value of 18.45 and a p-value of 0.01, indicating that the original hypothesis (i.e., preference for the random effects model) was rejected, suggesting that unobserved heterogeneity is associated with the explanatory variables. Thus, the fixed effects model provides more reliable estimates.

To ensure the robustness of the results, additional tests including the use of clustered standard errors were conducted to address potential heteroskedasticity and autocorrelation issues (Gómez-Herrera, 2012). The results of the robustness tests confirm the significance of the key variables. The significance of GDP per capital in China and GDP per capital in EU countries is consistent across models, and these results suggest that economic size is an important determinant of bilateral trade flows. Although the adjusted distance variable is not significant in some models, its negative effect remains, indicating the constraining effect of geographical distance on trade flows. The significance of trade dependence further validates its key role in promoting bilateral trade, while the effect of real effective exchange rate on trade flows is not significant in different models, indicating that exchange rate fluctuations have less impact on bilateral trade flows.

Through the above analysis, we can conclude that the fixed effect model is more applicable to the data of this study, and the reliability of the model and the consistency of the results are verified by different robustness tests. Based on the above regression results (regression coefficients for fixed effects in Table 5), a regression equation is constructed for China's trade volume with the EU over the period 2002-2022 (Ji and Ren, 2020):

$$\ln \mathrm{T_{ij}} = 15.942 - 0.001 \ln \mathrm{GDP_{per\ capital\ i}} + 0.969 \ln \mathrm{GDP_{per\ capital\ j}} + 0.035 \ln(Dist_{\mathrm{ij}} \times OilPricet) + 0.998 \ln \mathrm{FTD_j} - 0.066 \ln \mathrm{REER_{ij}} \tag{9}$$

The coefficient on China's GDP per capital is -0.001, indicating that the impact of an increase in China's GDP per capital on bilateral trade flows is extremely weak and almost negligible. This may reflect that China's economic growth does not directly drive changes in its trade flows with EU countries. On the contrary, the coefficient of 0.969 for GDP per capital in EU countries suggests that an increase in GDP per capital in EU countries significantly boosts bilateral trade flows. Specifically, for every 1% increase in GDP per capital in EU countries, bilateral trade flows increase by approximately 0.969%. This is consistent with economic theory that economic size and affluence have a positive impact on trade.

The coefficient of distance is 0.035, indicating that adjusted distance has a positive effect on bilateral trade flows. This is somewhat different from the traditional gravity model, possibly due to the consideration of the impact of oil prices on transportation costs, reflecting the fact that the negative impact of distance may be offset by the reduction in transportation costs. The coefficient of trade dependence is 0.998, indicating that trade dependence has a significant positive effect on bilateral trade flows. Specifically, for every 1% increase in trade dependence, bilateral trade flows increase by approximately 0.998%. This indicates that established trade relations play an important role in maintaining and promoting bilateral trade. The coefficient of the real effective exchange rate is -0.066, indicating a negative impact on bilateral trade flows. Specifically, for every 1% increase in the real effective exchange rate, bilateral trade flows decrease by about 0.066%. This shows that as the exchange rate rises (meaning the currency depreciates relative to the dollar), bilateral trade flows decrease.

After the results of the empirical analysis, we need to further explore the assessment of trade potential between China and Europe. Through the previous modeling analysis, we have understood the main factors affecting the trade flows between China and Europe and their specific impacts on trade flows. Now, based on the results of these analyses, we will construct a trade potential model to predict the possible development space and potential of China-EU trade in the future.

The trade gravity model is used to predict bilateral trade potential, primarily through the calculation of the Trade Potential Index (TPI). The TPI is calculated by comparing the actual trade volume between two countries with the theoretical trade volume predicted by the gravity model. According to Liu and Jiang's (2002) classification criteria for trade potential, we can classify trade partnerships into three types: if the trade potential index is less than 0.8, it indicates that the two countries have significant potential for bilateral trade, with substantial room for growth, known as the huge potential type; if the trade potential index is between 0.8 and 1.2, it suggests that the trade potential between the two countries has not been fully utilized and there is still room for further development, termed the potential development type; and if the trade potential index is greater than 1.2, it indicates that the existing trade cooperation between the two countries has fully utilized the current trade potential, necessitating the cultivation and innovation of new elements to stimulate further bilateral trade growth, referred to as the potential re-modeling type.

Table 6 The trade type between China and countries along the EU

Country	TPI	Trade Type
Austria	1.04	Potential Development
Belgium	1.19	Potential Development
Bulgaria	0.92	Huge Potential
Croatia	0.89	Huge Potential
Cyprus	0.87	Huge Potential
Czech Republic	1.11	Potential Development
Denmark	1.1	Potential Development
Estonia	0.87	Huge Potential
Finland	1.04	Potential Development
France	1.15	Potential Development
Germany	1.28	Potential Remodeling
Greece	1.04	Potential Development
Hungary	1.06	Potential Development
Ireland	1.17	Potential Development
Italy	1.15	Potential Development
Latvia	0.87	Huge Potential
Lithuania	0.88	Huge Potential
Luxembourg	0.86	Huge Potential
Malta	1.02	Potential Development
Netherlands	1.33	Potential Remodeling
Poland	1.11	Potential Development
Portugal	0.99	Huge Potential
Romania	0.97	Huge Potential
Slovakia	1.07	Potential Development
Slovenia	1.07	Potential Development
Spain	1.11	Potential Development
Sweden	1.09	Potential Development

According to equation (9), we calculate the theoretical trade volume of China's goods with EU countries in 2022. By comparing the actual trade volume with the theoretical trade volume, the data are organized and presented in Table 6.

These data show that there are significant differences in the trade potential of different countries. Countries with high potential include Bulgaria, Croatia, Cyprus, Estonia, Latvia, Lithuania and Luxembourg. The actual trade volume of these countries still has a lot of room for improvement compared with the theoretical trade volume, and they need to strengthen bilateral trade cooperation to explore more trade potential. Potential-exploiting countries include Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden.

The actual trade volume of these countries is close to or has already reached the theoretical trade volume, but there is still some room for improvement. Potential re-modeling countries, on the other hand, include the Netherlands, whose actual trade volume is already significantly higher than the theoretical trade volume. The existing state of trade cooperation has already fully utilized the existing trade potential, and it is necessary to further stimulate the growth of bilateral trade in the future by cultivating and innovating new elements.

Overall, China's trade relations with EU countries are close to or have reached the theoretically optimal level in most countries. However, there is still room to further increase trade volume for the high potential and potential pioneering countries.

5. Conclusions

Bilateral trade relations between China and the European Union (EU) have grown significantly over the past two decades, with China's economic growth playing a vital role in boosting trade volumes. Since China joined the World Trade Organization (WTO), China's accelerated integration into the global trading system has provided numerous opportunities and challenges for trade cooperation with the EU. Empirical analysis using a gravity model confirms that China's GDP per capital has a significant positive impact on trade flows with the EU, while infrastructure projects such as the Belt and Road Initiative (BRI) have boosted trade by reducing transit time and transport costs.

The findings highlight the importance of economic size in determining bilateral trade flows. The EU's GDP per unit of capital has a significant positive impact on trade flows, indicating that richer economies with larger market sizes and stronger production capacity participate in more trade. This highlights the necessity of sustained economic growth and development to strengthen trade relations. The negative impact of the real effective exchange rate on trade flows suggests that exchange rate stability is essential to promote trade. In addition, the important role of trade dependence emphasizes the importance of established trade relations, suggesting that strategic trade agreements and cooperation can further promote bilateral trade.

The study also shows that while China's trade relationship with the EU is at or close to the optimal theoretical level in most countries, there is still room for improvement in high-potential countries and potential developing countries. The countries with high potential evaluated by the gravity model include Bulgaria, Croatia, Cyprus, Estonia, Latvia, Lithuania and Luxembourg. The actual trade volume of these countries still has a lot of room for improvement compared with the theoretical trade volume. Bilateral trade cooperation can be further strengthened, more bilateral trade potential can be tapped, and promoting economic integration will benefit both places. Of course, China and other EU countries also need to maintain their current trade relations and create new cooperation opportunities.

Despite the reliable results, this study also has some limitations. Due to data limitations, the gravity model is effective, but it may not capture all the subtle factors that affect international trade, such as cultural ties, historical relations, and political stability. In addition, the long-term trends and structural changes in the global economy may not be fully reflected during the study period from 2002 to 2022. Using GDP per unit of capital as a substitute variable for economic size, although it solves the problem of multicollinearity, may ignore the complexity of economic interactions within the EU.

Prospective investigations could surmount existing constraints by integrating a broader spectrum of variables, encompassing cultural and historical dimensions, thereby furnishing a more exhaustive appraisal of trade mechanics. Expanding the temporal scope of the study and assimilating contemporary data would enable the identification of enduring patterns and the assessment of recent seismic shifts in the global economy, such as the repercussions of the financial crisis and the COVID-19 pandemic on trade dynamics. Furthermore, juxtaposing China's trade dynamics with other principal trading counterparts could yield profound insights into China's trade strategy and its repercussions on the international trade milieu.

In summation, this study advances our comprehension of China-EU trade dynamics by pinpointing the cardinal determinants of bilateral trade volumes and offering strategic perspectives for enhancing trade synergies. The outcomes underscore the primacy of economic expansion, the maintenance of steady exchange rate policies, and the reinforcement of trade linkages in propelling sustainable trade progression. By steadfastly fortifying bilateral trade collaboration, refining trade policies, and cultivating economic amalgamation, China and the EU stand poised to intensify their trade rapport, realizing mutual gains, a win-win scenario, and enduring sustainable development, thereby shaping a more interconnected and prosperous global trade ecosystem.

References

Albornoz-Flores, A. C., and Tonon-Ordóñez, L. B. (2020). Aplicación del Modelo de Gravedad entre Ecuador y la Unión Europea para el periodo 2001 – 2017. UDA AKADEM (En LíNea)/UDA AKADEM, 6, 10-45. https://doi.org/10.33324/udaakadem.v1i6.315

Algieri, F. (2002). EU Economic Relations with China: An Institutionalist Perspective. The China Quarterly, 169, 64-77. https://doi.org/10.1017/s0009443902000062

Araya, D. (2018, November 27). China's Belt and Road Initiative is poised to transform the clean energy industry. Brookings. https://www.brookings.edu/articles/chinas-belt-and-road-initiative-is-poised-to-transform-the-clean-energy-industry/

Baldwin, R. E. (2016). The great convergence: information technology and the new globalization. Graduate Institute of International and Development Studies. https://repository.graduateinstitute.ch/record/294516?_ga=2.178655527.2076136565.1718210458-170544823.1718210458

Briefing, C. (2023, 9 mayo). EU-China Relations: Trade, Investment, and Recent Developments. China Briefing News. https://www.china-briefing.com/news/eu-china-relations-trade-investment-and-recent-developments/

Capacity building for trade policy analysis. (s. f.). UNCTAD. https://unctad.org/topic/trade-analysis/trade-policy-analysis

Ding, J., Liu, M. (2016). A study on the scale effect in Sino-European bilateral trade: An application and extension of the gravity model. Journal of World Economy, 39(6), 100-123.

Draper, N. R., Smith, H. (1998). Applied Regression analysis. In Wiley series in probability and statistics. https://doi.org/10.1002/9781118625590

Capoani, L. (2023). Review of the gravity model: origins and critical analysis of its theoretical development. SN Business and Economics, 3(5). https://doi.org/10.1007/s43546-023-00461-0

Jennings, R. (2024, February 6). China's overseas investments to go green in 2024, 'clear need' for Belt and Road Initiative to focus on renewable energy. South China Morning Post. https://www.scmp.com/economy/global-economy/article/3251003/chinas-overseas-investments-go-green-2024-clear-need-belt-and-road-initiative-focus-renewable-energy

Jiang, D., Zhang, Q. A Gravity Model Analysis on the US FDI into China. Journal of World Economy, 2011(5), pp.28-43.

Ji, W., Ren, W. (2020). The influencing factors and trade potential of China's sports goods exports to Belt and Road countries: An empirical test based on the extended gravity model. Journal of Shanghai University of Sport. https://doi.org/10.16099/j.sus.2020.04.008

Fang, L., Shakur, S. (2018). Impact of trade cost on China-EU agri-food trade. Journal Of Chinese Economic And Business Studies, 16(3), 259-274. https://doi.org/10.1080/14765284.2018.1482089

Gómez-Herrera, E. (2012). Comparing alternative methods to estimate gravity models of bilateral trade. Empirical Economics, 44(3), 1087-1111. https://doi.org/10.1007/s00181-012-0576-2

Linnemann, H. (1966). An Econometric Study of International Trade Flows. Holland Publishing, Amsterdam. - References - Scientific Research Publishing. (s. f.).

Liu, Q., Jiang, S. (2002). Analyzing China's bilateral trade arrangements using the gravity model of trade. https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1348509

Matyas, L. (2017). The econometrics of multi-dimensional panels. In Advanced studies in theoretical and applied econometrics. https://doi.org/10.1007/978-3-319-60783-2

Rawlings, J. O., Pantula, S. G., and Dickey, D. A. (1998). Applied Regression analysis. En Springer eBooks. https://doi.org/10.1007/b98890

Rodrik, D. (2006). What's So Special about China's Exports? China & World Economy, 14(5), 1–19. https://doi.org/10.1111/j.1749-124x.2006.00038.x

Tan, H. (2017). An Empirical Analysis of the Potentialities of China-EU Trade Development - Based on the Trade Gravity Model. J. News Economy, 39, 47-52

Tinbergen, J. (1962) Shaping the World Economy Suggestions for an International Economic Policy. The Twentieth Century Fund, New York. - References - Scientific Research Publishing. (s. f.). https://www.scirp.org/reference/referencespapers?referenceid=1546369

UNU-WIDER : Working Paper : China's trade imbalances. (n.d.). UNU WIDER. https://www.wider.unu.edu/publication/china%E2%80%99s-trade-imbalances

Wang, P., Zheng, Y., Sun, L. (2018). Trade Potential Analysis between China and Europe under lthe Belt and Roadr Initiative. ATLANTI SPRESS. https://doi.org/10.2991/mess-18.2018.1

Yan, J., Cai, J. (2021). Research on the Impact of Sino-US Trade Structure on the Real Effective Exchange Rate of RMB. Discrete Dynamics In Nature And Society, 2021, 1-10. https://doi.org/10.1155/2021/7237378

Yang, J., Shan, W. (2007). Comparisons of Characteristics and Factors between China-EU Trade and China-ASEAN Trade—Based on Gravity Model. International Trade Issues, (11), 21-24. https://doi.org/10.13510/j.cnki.jit.2007.11.012

Yang, S., Martinez-Zarzoso, I. (2014). A panel data analysis of trade creation and trade diversion effects: The case of ASEAN–China Free Trade Area. China Economic Review, 29, 138–151. https://doi.org/10.1016/j.chieco.2014.04.002

Zhang, Q. (2015). Measurement of Bilateral Trade Potential between China and Spain: An Empirical Analysis Based on the Gravity Model. International Trade Issues, 4(2), 56-67.

Zhang, W., Yu, K., Fang, Y. (2022). A gravity model analysis of China's trade in renewable energy goods with ASEAN countries as well as Japan and South Korea. Frontiers in Environmental Science, 10. https://doi.org/10.3389/fenvs.2022.953005

Zymek, A. C. (2022, May 13). Bilateral trade imbalances. IMF. https://www.imf.org/en/Publications/WP/Issues/2022/05/13/Bilateral-Trade-Imbalances-517845