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Review

Gravity Model and International Trade: A Survey of the Literature

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Abstract: The gravity model, which is applied to international trade, explains the conceptual models of international business. It has been used in various areas of the global economy, such as trade, foreign direct investment, and even the determinants of tourist demand at the level of countries and sectors of economic activity. In terms of the methodology, this study of the gravity model followed the PRISMA requirements and bibliometric analysis (co-occurrence of keywords and network of co-authorship), which were applied to the Scopus database. In terms of the results, economic, geographical distance, and location variables are essential in explaining international trade.

Keywords: gravity model; international trade; transport cost

1. Introduction

Location theories associated with geographical proximity versus distance (e.g., Isard and Peck 1954; Isard 1969; Anderson 1979, 2011; Anderson and van Wincoop 2003) allow us to explain trade flows in the context of monopolistic competition, where economies of scale and industrial concentration are determining factors.

This research evaluates the gravity model's importance in explaining international business. In this context, we revisit the models of the gravity equation and illustrate their use in various empirical studies of international trade.

At the early stage of our research, we used geographical and cultural variables, namely the concept of geographical distance, the border, and common language, to explain total bilateral trade.

To what extent does the common language and border trade benefit bilateral trade?

Recent studies (e.g., Leitão 2023; Capoani 2023; Pacheco and Matos 2022; Balogh and Leitão 2019; Khayat 2019; Venables 2019) demonstrate the motivation of economists to study international trade and the spatial economy. They use these variables as explanatory factors of trade flows via geographical characteristics and country characteristics.

The common language, border, and geographical proximity allow for reduced transaction and transport costs (e.g., Leitão 2023; Pacheco and Matos 2022; Balogh and Leitão 2019). In the next phase, we will revisit intra-industry trade (IIT) and evaluate the impact of demand, economic dimension, trade imbalance, and geographical distance on IIT, following the advantages of gravity models to explain global value chains (GVCs).

Moreover, we explore the implications of market size and geographical distance in the context of reducing transport costs and fostering bilateral trade. How do these factors influence the global economic landscape?

International economics and theories of international trade have long demonstrated the importance of the economies' sizes (economies of scale and market potential) in explaining bilateral trade. This idea has been developed in classical, neoclassical, and new international trade theories. However, the spatial economy and the development of the new economic

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geography proposed by Krugman (1991, 1995), Fujita (1999), Fujita et al. (1999), Fujita and Krugman (2004), and Venables (2019) demonstrate the importance of the gravity model, namely localisation variables and the potential market in the context of increasing returns to scale in monopolistic competition, where the Dixit and Stiglitz (1977) models, Krugman (1979), and Lancaster (1980) allow us to explain the new theories of international trade with particular emphasis on intra-industry trade.

Furthermore, it is essential to mention Krugman's (1991) model to explain industrial localisation, Krugman and Venables (1990) on the issue of centrality (centre versus periphery) and mobility, as well as Fujita et al. (1999) about the circular economy (agglomeration and circular causality). The models referred to are based on increasing returns to scale, the issues underlying the potential market, and the characteristics of monopolistic competition.

Our contribution in this article is to present a survey of the literature review, with particular emphasis on the relationship between the gravity model and international trade. Therefore, we present the conclusions of the selected studies relevant to the topic in question. Subsequently, we consider an analysis of the results using bibliometric indicators on the Scopus database.

In terms of the structure, this investigation presents the literature review in Section 2, the data and methods in Section 3, the results in Section 4, and the conclusions in Section 5.

2. Literature Review

In this section, we revisit some empirical studies that validate the importance of the gravity equation arguments to explain the conceptual models of international business. Thus, the main issues of the gravity model relate to localisation, economic and cultural variables, and even the process of economic integration. As a rule, in the gravity equation, the dependent variable is trade flows, exports, imports, total trade, or intra-industry trade (e.g., Leitão 2023; Balogh and Aguiar 2022; Khayat 2019; Balogh and Leitão 2019).

When we revisit the numerous studies on bilateral trade and the gravity model, we observe that the economic dimension, referring to economies of scale between two or more countries, is essential for differentiating products and achieving competitiveness. Recent studies by Leitão (2023), Capoani (2023), Pacheco and Matos (2022), Balogh and Leitão (2019), and Balogh and Aguiar (2022) demonstrate that the country's gross domestic product, per capita income, or populations i and j are positively related to trade flows.

Another issue usually raised in this type of research is geographical proximity and border costs. Thus, studies demonstrate that the closer the trading partners, the greater the predominance of trade gains (e.g., Balogh and Aguiar 2022; Brkić et al. 2021; Łapińska et al. 2019; Yotov 2012).

The common language, colonies, and trade agreements promote bilateral international trade. This idea is stated, for example, by Leitão (2023), Ginsburgh and Weber (2020), and Grin (2003). Several authors consider that a common language reduces transaction costs and is considered a common good (e.g., Bergstrand et al. 2015; Egger and Larch 2008).

In terms of econometric models, the most recent studies have used panel data and, more specifically, the Poisson pseudo-maximum likelihood (PPML) estimator, as analysed by Santos Silva and Tenreyro (2006), Martínez-Zarzoso (2013), Larch et al. (2019), and Leitão (2023). The studies demonstrated that using a PPML estimator to solve bias is preferable.

Newton's laws of physics were introduced to international trade, as demonstrated in the studies by Tinbergen (1962), Isard (1969), Anderson (1979), and Anderson and van Wincoop (2003). Transport costs were assessed by geographical distance, border, and common language. Furthermore, the size of economies, the potential market, the population, and the diversification of the demand function have been used with great frequency by gravity models. In this section, we seek to conduct a literature survey focusing on the relationship between the gravity model and bilateral trade and the interaction between gravity and intra-industry trade (IIT). Furthermore, the relationship between global value chains (GVCs) and the gravity model is also evaluated.

The gravity equation can take the following expression:

$$VT_{ik} = \alpha \times GDP_i \times GDP_k / DIST_{ik} \quad (1)$$

where *VT* is the volume of international trade (exports, imports, total trade, or intra-industry trade), α represents the constant of the equation, and *GDP* is the GDP of economies *i* and *k*, respectively. Finally, *DIST* will be the geographical distance between trading partners. Thus, $GDP_i > 0$; $GDP_k > 0$; and $DIST_{ik} < 0$. From what was said above, the common language (*LANG*) and the border (*BORDER*) and trade agreements (*FTA*) stimulate international trade. So, $LANG > 0$; $BORDER > 0$; and $FTA > 0$. In this context, the studies of Baier and Bergstrand (2007), Anderson and Yotov (2016), and Egger (2000) support the gravity equation.

The models of Krugman (1979), Lancaster (1980), Helpman (1981), and Helpman and Krugman (1985) explain IIT considering the geographical proximity between two countries, demonstrating that reducing the geographical distance allows for reducing transport and transaction costs, promoting IIT. In an integrated market, the number of varieties increases, giving rise to intra-industry trade. As a rule, the models mentioned have two sectors, one differentiated and another that allows for satisfying domestic demand (agricultural goods). As can be seen, IIT will occur within economies with identical characteristics. Usually, consumers have similar preferences (e.g., Krugman 1979). It is also important to note that the models of Lancaster (1980) and Helpman and Krugman (1985) use assumptions of monopolistic competition and the Heckscher–Ohlin model, where it is possible to introduce the concepts of abundance and factor intensity. Thus, economies of scale and industrial concentration promote IIT. In this context, cultural affinities (common language and former colonies) also stimulate IIT.

Based on the Heckscher–Ohlin hypothesis, the model of Falvey and Kierzkowski (1987) developed a theoretical model to explain vertical intra-industry trade (VIIT) based on the value of the remuneration of endowments factors (W—remuneration of the labour factor; R—remuneration of the capital factor). Considering a 2 × 2 × 2 matrix (two countries, two goods, and two production factors, K refers to capital intensive, and L refers to labour intensive). The K factor is mobile between industries of the same sector, with product differentiation occurring in the intensive goods of the K factor. Thus, the preference for high- or low-quality products in international trade depends on consumer income. The income distribution is fundamental to explaining lower VIIT (low quality) and higher VIIT (high quality).

The supply depends on the value of W or R remuneration costs. Thus, if a country has low remuneration (costs) of the capital factor (R), it will have advantages in this factor by producing and transacting high-quality products in international trade. If, on the contrary, a country has low wages for the labour factor (W), it will transact low-quality products in international trade.

Another conceptual reference is the model by Shaked and Sutton (1984), which explains VIIT based on an oligopoly market structure through a sequential game. The company decides to enter a particular market, following the level of quality and price. The authors demonstrate that quality is associated with a fixed cost, which they call "sunk cost." Furthermore, consumers are distributed according to their income, showing that they have access to different types of quality depending on their income.

Next, we present the empirical studies they use as explanatory factors, the gravity model, and countries' characteristics. So, the demand function or endowments factors (the difference between income per capita) on IIT, which the empirical studies of Leitão and Faustino (2013), Proença and Faustino (2015), and Brkić et al. (2021) demonstrate, show that similar countries present a negative correlation between the income and IIT difference.

The size of economies, generally evaluated as the average per capita income, is fundamental for intra-industry trade. Several studies, (e.g., Greenaway et al. 1994; Bagchi and Bhattacharyya 2019; Brkić et al. 2021; Zaninović 2022), demonstrate a positive relationship between the dimension or economic size and IIT.

The imbalance of trade is a control variable. Usually, studies find a negative correlation between imbalanced trade and IIT (e.g., Lee and Lee 1993; Łapińska et al. 2019).

Finally, geographical distance and common language have also been used to explain the IIT equation when using the assumptions of the gravity equation. As mentioned, geographical distance allows for transport and transaction costs to be assessed. Thus, the lower the transportation costs, the higher the intra-industry trade index. The common language also stimulates intra-industry trade. Studies by Brülhart (2009), Balogh and Leitão (2019), Bagchi and Bhattacharyya (2019), and Zaninović (2022) demonstrate that there is a negative correlation between geographical distance and IIT and a positive impact of language on promoting IIT.

Furthermore, language economics (e.g., Ginsburgh and Weber 2020; Grin 2003; Leitão 2023) refers to the idea that a common language aims to reduce transport and logistic costs, since similar languages and cultures stimulate international and foreign investments.

The effect of Portuguese exports was investigated by Leitão (2023) based on the gravity equation. This study used econometric strategy OLS, random effects, and panel quantile regression. The econometric results showed that economic dimension, the Portuguese language, geographical distance, and country risk promote Portuguese exports, and they are based on the assumptions of the gravity model.

Balogh and Aguiar (2022) investigated the agricultural sector as it applied to the Latin American experience. They used a gravity equation with a Poisson pseudo-maximum likelihood estimator (PPLM). The results revealed that the economic size of exporters and importers is essential to explaining exports. The geographical distance, border, and standard language aim to explain the gravity model. Moreover, the regional trade agreement and environmental summits also influence Latin American exports.

Brkić et al. (2021) considered the agrifood sector and studied the intra-industry trade determinants between Bosnia and Herzegovina and EU countries. Economic size and common historical culture are positively correlated with IIT, and geographical distance and differences between productively are negatively associated with IIT.

The empirical study of Łapińska et al. (2019) considered the intra-industry trade between Poland and EU countries by the pharmaceutical sector. Pharmaceutical products and government health spending stimulate IIT. Moreover, the study also showed that gravity proxies typically used in this study are according to the expected hypotheses.

Another contribution is the study of Khayat (2019), in which the author applied a gravity model using random effects and an OLS estimator to six economies. This study used exports, imports, and total trade as the dependent variables. The results showed that economic size, measured by income per capita and population, positively impacts bilateral trade. Additionally, geographical distance is negatively correlated with bilateral trade.

According to the literature review (e.g., Krugman 1979; Lancaster 1980; Helpman 1981; Brander and Krugman 1983), horizontal intra-industry trade (HIIT) is explained by similar types of demand. Greenaway et al.'s (1994) methodology inflates the level of vertical-industry trade (VIIT), which was demonstrated when the researchers used this complementary methodology to separate horizontal and vertical intra-industry trade.

Kandogan (2003) proposed a new method to separate HIIT and VIIT in this context. However, with the Kandogan methodology, HIIT is higher than VIIT; in line with this, Doanh and Heo (2018) studied HIIT in Korea using a GMM system. The average income per capita between trade partners was considered as the economic size or scale that positively affects HIIT. This result is according to previous studies such as that of Thorpe and Leitão (2013). Moreover, the geographical distance variable negatively impacts HIIT, and the imbalance trade variable and difference in income per capita (similar or dissimilar demand) negatively correlate with HIIT. Additionally, the difference between income per capita reveals that trade partners present similar demand and utility functions of consumption.

The agricultural intra-industry trade experiences for Baltic countries were investigated by Jámbor et al. (2016) using a GMM system estimator, and the results are consistent for the effect of geographical distance and the equations of HIIT and VIIT. The equation of

VIIT also demonstrated that productivity and vertical product differentiation encourage this type of trade. Although the variables of foreign direct investment and the difference in income per capita negatively affect VIIT, these results reinforce the importance of horizontal intra-industry trade when similar characteristics are essential between trade partners.

Proença and Faustino (2015) considered the intra-industry trade using parametric and semiparametric panel data and considered the gravity equation. The authors used as dependent variables (IIT—intra-industry trade; HIIT—horizontal intra-industry trade; VIIT—vertical intra-industry trade). For the absolute value of the difference between the income per capita of trade partners, Proença and Faustino (2015) found a negative effect on IIT and HIIT, revealing that similar demand promotes bilateral trade. Nevertheless, the authors continue to observe a negative relationship between the difference in income per capita and VIIT. This result is unexpected; according to the theoretical model of VIIT, there is a positive effect of different income per capita and VIIT, showing the impact of dissimilar demand between trade partners. Consequently, geographical distance variables and trade imbalances are negatively associated with IIT and HIIT.

The association between IIT and the gravity model was investigated by Brülhart (2009) using the OLS estimator for the period 1962–2006. The empirical results demonstrated that the economic dimension, geographical distance, and border effects are based on the gravity model assumptions.

The fragmentation of international production (e.g., Jones and Kierzkowski 2001; Faustino and Leitão 2011; Yang 2022; Doan and Le 2024; Greaney and Kiyota 2020; Fertő et al. 2024) demonstrates the importance of studying trade in parts and components as well as final products. Typically, this type of trade is carried out by larger and multinational companies (Jones and Kierzkowski 2001; Faustino and Leitão 2011). Fragmentation leads to subcontracting or outsourcing practices in different markets and geographical areas.

Fragmentation and vertical specialisation were presented by Jones and Kierzkowski (2001), where the authors explained the globalisation process and the adjustment of the labour market (wages and endowment factors) based on the Ricardo and Heckscher–Ohlin models, i.e., the hypotheses of classical and neoclassical trade theories are revisited in the context of monopolistic competition. Then, the advantages of economies are associated with the relationship between parts and components and the final products.

Vertical intra-industry trade (VIIT) and fragmentation were considered by Faustino and Leitão (2011) in the auto components industry. The sample covers the years 1995–2006 among Portugal, EU 27 countries, and BRIC countries, and they applied dynamic panel data (GMM system) as an econometric strategy. This study considered the dependent variable VIIT, using the Grubel and Lloyd index and the complementary methodology of Greenaway et al. (1994) to separate the horizontal and vertical intra-industry trade. The criterion that is more common in the literature is 0.15 (15%) for differentiated products. Then, when the relative prices of exports by relative imports are inferior to the values of 0.85 and superior to 1.15, the literature states that VIIT exists.

Considering the arguments of the gravity model, Faustino and Leitão (2011) showed that geographical distance has a negative effect on VIIT for Portugal and the EU27. The absolute value of the difference between per capita income among Portugal and its trade partners has a positive effect on VIIT; this result is according to the Linder hypothesis.

More recently, the literature showed that the data on international trade of global value chains (GVCs) divulgated by the OECD presents an advantage over traditional statistics of international trade. Indeed, global value chain statistics aim to evaluate economies' specialisations, since they consider the exports and imports of intermediaries and final goods.

The database organised by the OECD for the TiVA edition of 2023 aims to evaluate all industries or each one in particular for the period 1995–2020.

The empirical study of Greaney and Kiyota (2020) considered the OECD dataset for 35 members of the OECD and 28 non-OECD countries. Using the arguments of the gravity model and PPML estimator (Poisson pseudo-maximum likelihood), the econometric results demonstrated that the geographical distance, regional trade agreement, border, and

common language present statistical significance on all goods, intermediaries' goods, and final goods. Moreover, the variable economic dimensions of origin and destination countries positively affects trade. Following this line, Yang's (2022) study, using different econometric methods, demonstrates that value-added flows find a negative relationship between geographical distance and this type of trade, concluding that barriers to trade are less sensitive in value-added flows than in gross trade.

The investigation by Doan and Le (2024) assesses the impacts of the global value chain on the survival of exports. The gravity equation results demonstrate that governments should promote the global value chain. Thus, the size of economies encourages the survival of exports. The geographical distance reflects the importance of the geographical proximity in reducing transport costs. Furthermore, the study also demonstrates that regional trade agreements reduce trade costs, reducing the risk between trading partners.

Considering the arguments of gravity models, Fertő et al. (2024) evaluated the global value chains for 66 countries from 1995 to 2018 using the OECD dataset. The OLS estimator and PPML (Poisson pseudo-maximum likelihood) are used as an econometric strategy. According to the econometric results, the geographical distance negatively correlates with gross exports and domestic value added. The variables that analysed transport costs, such as border, language, colonies, and regional trade agreement, showed that reducing transport costs increased the global value chains. These findings have significant implications for trade policies, suggesting that reducing transport costs could be a key strategy for promoting global trade. All these variables present a positive effect, and they are statistically significant.

3. Data and Methodology

The data were collected from the Scopus database, and the examination of bibliometric analysis considered the rules of PRISMA (e.g., Page et al. 2022). Using the Scopus online database, we searched for entries between 26 July and 6 August 2024. In the first step, the keywords used were "gravity model and trade", and 3330 articles emerged. Subsequently, the keywords were limited to "gravity model," and 1339 articles emerged between the years 1989 and 2024. In economics, econometrics, and finance, there are 874 articles and 214 articles in business, management, and accounting. We chose to carry out an analysis of the first category, as it is more representative.

In terms of research questions, this article seeks to answer the following questions:

(i) Which keywords have the most occurrences?
(ii) Who are the main authors and their connections?
(iii) What are the most productive institutions and authors?
(iv) Which journals have the highest number of publications on the topic under investigation?

Then, we used VOSviewer software 1.6.20, which was developed by Leiden University's Centre for Science and Technology Studies. This software considers bibliometric analysis.

Anjum et al. (2020) considered that the analysis and respective bibliometric maps of the co-occurrence of keywords aim to evaluate the network and connections of the words used most in the research. Additionally, co-authorship analysis is quite important, as it evaluates the relationships and links between academics and their respective institutions, demonstrating the strength of these links.

In the analysis of co-authorship networks, VOSviewer software identified 22 duplicate documents, which were removed from the network.

Sharma et al. (2022) and Jadhav and Ghosh (2024) used bibliometric analysis to evaluate the relationship between gravity models and trade.

Figure 1 summarises the procedures used in this research. As explained previously, we only consider the use of the gravity model in economics, econometrics, and finance. International economics researchers have used this model more frequently to evaluate trade flows and foreign direct investment.

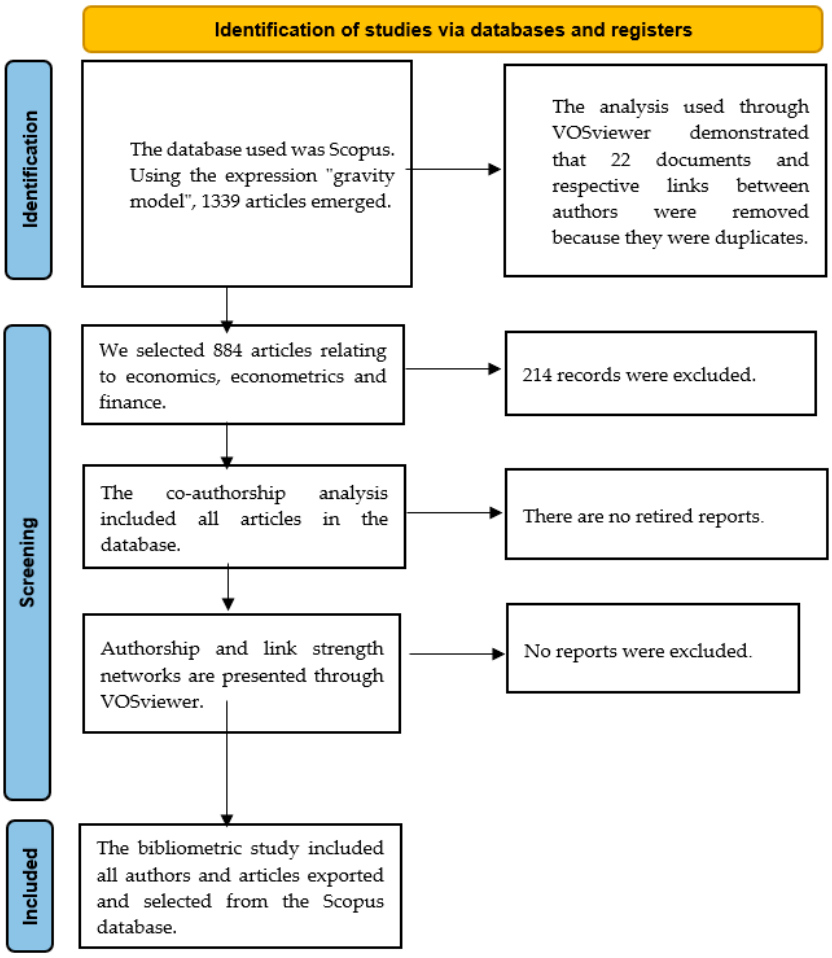

Figure 1. PRISMA flow diagram based on gravity model and trade.

4. Results

In this section, we will survey bibliometric data using Scopus, which, according to several scholars, is considered one of the most complete databases. Additionally, we use VOSviewer software 1.6.20 to evaluate the network of keywords and co-authorship.

Figure 2 shows the number of documents (scientific articles) published yearly. We selected the more representative years, and we can observe that the number has always been greater than twenty units from 2012 onwards, except for 2006, 2007, and 2011. The years 2017, 2018, 2020, 2021, 2022, 2023, and 2024, with several publications above 50, also stand out.

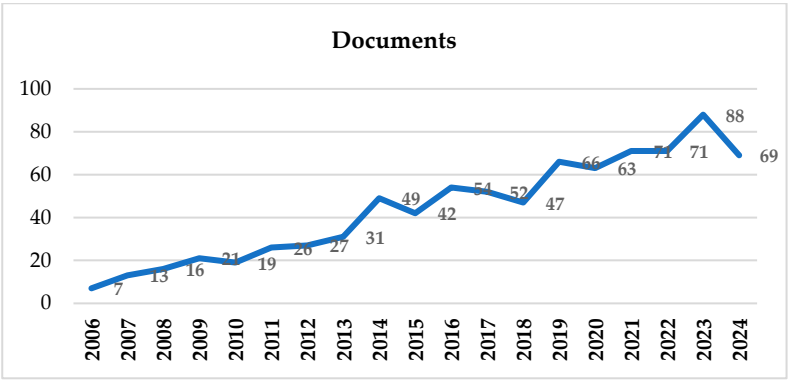

Figure 2. Number of documents per year. Source: dataset from Scopus.

Table 1 presents the number of papers by scientific area. The most important subject areas are economics, econometrics, and finance, with 874 papers, followed by social science (272 papers), and business, management, and accounting emerge in the third position (214 papers). The agricultural and biological sciences and environmental science areas are also important, with 83 and 45 papers, respectively.

Table 1. Gravity model by subject area.

Subject Area	Number of Papers
Economics, econometrics, and finance	874
Social science	272
Business, management, and accounting	214
Agricultural and biological sciences	83
Environmental science	45
Mathematics	18
Arts and humanities	16
Decision sciences	13
Energy	7
Computer science	3
Engineering	3
Earth and planetary sciences	2
Biochemistry, genetics, and molecular biology	1

Source: dataset from Scopus.

In Figure 3, we present the networks of all keywords. The biometric analysis using VOSviewer software demonstrates that international business is predominant, namely the expression of international trade and foreign investors and their determinants.

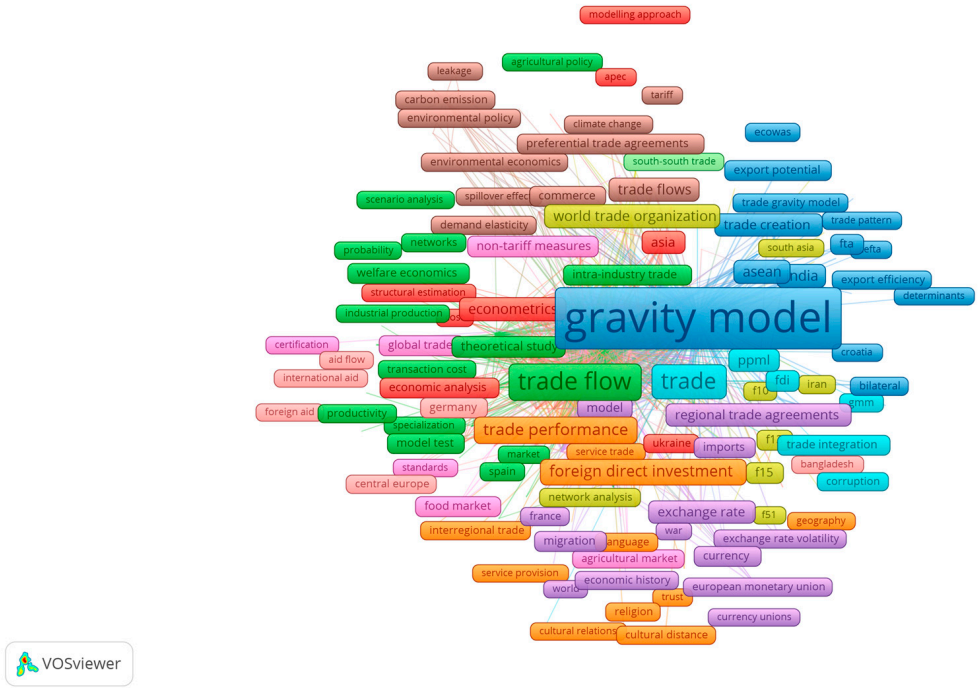

Figure 3. Co-occurrence of keywords. Source: dataset from Scopus and VOSviewer software.

Using the co-occurrence of keywords criterion, we selected the main keywords in Table 2 through VOsViewer software. As you can see, the words with the most occurrences are gravity model, international trade, export, trade flow, trade, and China.

Table 2. The most frequent keywords.

Keywords	Occurrences
Gravity model	874
International trade	486
Export	242
Trade flow	235
Trade	195
China	158
Numerical model	136
Panel data	127
Bilateral agreement	124
Trade policy	117
Trade agreement	109
Gravity	103
Trade relations	86
Trade performance	80
Import	80
Modelling	76
Europe	58

Source: dataset from Scopus and VOSviewer software.

Table 3 shows the number of publications by country considering the subject areas of economics, econometrics, and finance. We selected the top 15 countries. The most important countries are the United States, Germany, China, Spain, and the United Kingdom. The number of publications in India and Italy is also relevant.

Table 3. Gravity model by countries.

Ranking of Country	Number of Publications
United States	149
Germany	87
China	73
Spain	50
United Kingdom	48
India	44
Italy	42
France	37
South Korea	36
Austria	33
Russian Federation	27
Japan	26
Canada	25
Malaysia	24
Turkey	23

Source: dataset from Scopus.

Considering economics, econometrics, and finance, Table 4 displays the 15 most relevant publications, the number of articles published in each journal, and the respective quartile.

Four of the fifteen selected journals are in quartile 1: *World Economy*, *Review of World Economics*, *Economic Modelling*, and *Emerging Markets Finance and Trade*. In quartile 2, we find eight journals: *Applied Economics*, *Economic Letters*, *Journal of Economic Integration*, *Open Economic Review*, *Journal of Asian Economics*, *Foreign Trade Review*, *Economies*, and *International Economic Journal*.

Table 4. Number of publications by journals and best quartile.

Journals	Number of Publications	SJR 2023 (Best Quartile)
World Economy	41	Q1 = 0.94
Applied Economics	22	Q2 = 0.59
Review of World Economics	22	Q1 = 0.64
International Trade Journal	21	Q3 = 0.22
Economic Modelling	18	Q1 = 1.34
Applied Economic Letters	17	Q3 = 0.38
Economic Letters	15	Q2 = 0.73
Journal of Economic Integration	15	Q2 = 0.41
Open Economies Review	15	Q2 = 0.48
Journal of Asian Economics	12	Q2 = 0.83
Emerging Markets Finance and Trade	11	Q1 = 0.78
Foreign Trade Review	11	Q2 = 0.45
Economies	10	Q2 = 0.50
International Economic Journal	10	Q2 = 0.29

Source: dataset from Scopus.

Next, we consider the number of papers published by the top 15 affiliations in Table 5. In the rank, Georg-August-Universität Göttingen emerges in the first place with 18 publications. Following are Universidad Jaume I and the World Bank, with both having 15 publications. The Centre for Economic Policy Research, London, has 13 papers, CESifo GmbH presents 12 publications, and Université de Bordeaux has 10 papers on the topic. The intuitions of BSE—Bordeaux School of Economics, CNRS Centre National de la Recherche Scientifique present 8 and 9 publications, respectively. With seven publications, the following institutions stand out: German Institute for Economic Research, Universidade de São Paulo, Universidade Federal de Vicosa, University of Tehran, Universidad Autónoma de Madrid, and Saint Petersburg State University. In the fifteenth position comes Budapesti Corvinus Egyetem, with six publications.

Table 5. Number of publications by the top 15 affiliations.

Institutions	Number of Publications
Georg-August-Universität Göttingen	18
Universidad Jaume I	15
The World Bank, USA	15
Centre for Economic Policy Research, London	13
CESifo GmbH	12
Université de Bordeaux	10
BSE—Bordeaux School of Economics	9
CNRS Centre National de la Recherche Scientifique	8
German Institute for Economic Research	7
Universidade de São Paulo	7
Universidade Federal de Vicosa	7
University of Tehran	7
Universidad Autónoma de Madrid	7
Saint Petersburg State University	7
Budapesti Corvinus Egyetem	6

Source: dataset from Scopus.

Figure 4 presents the most significant authors who have considered the gravity model issue based on the Scopus database, considering the top 10 authors.

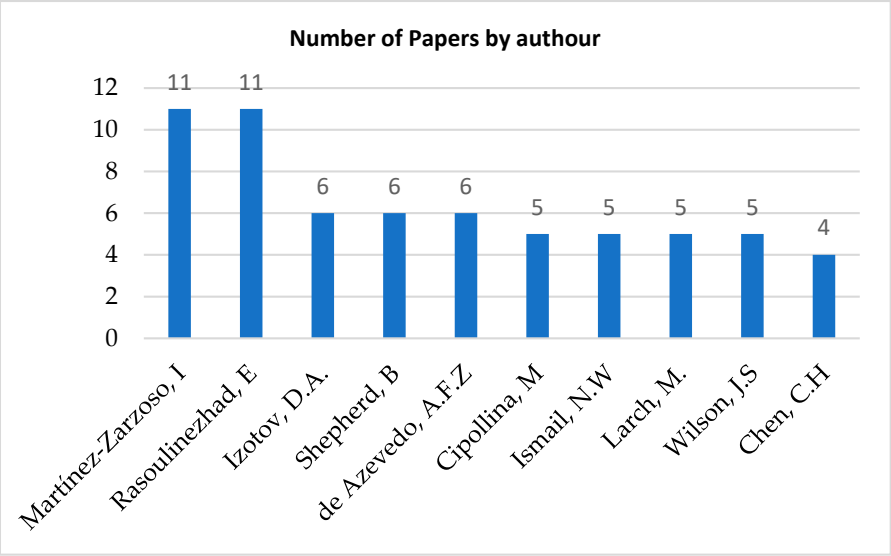

Figure 4. Number of papers by author. Source: dataset from Scopus.

The bibliometric analysis shows that the first five authors published more than five articles. Thus, Martínez-Zargoso, I. and Rasoulinezhad, E. published 11 articles. From the third to fifth position, the authors Izotova, D.A., Shepherd, B., and de Azevedo, A.F.Z published six articles each. With five articles each, Cipollina, M., Ismail, N.W., Larch, M, and Wilson, J.S. stand out. Finally, Chen, C. H. has four articles.

Using a more detailed bibliometric analysis and Vosviewer software, it is possible to observe different clusters and their respective connections.

In Figure 5, the first cluster is represented by Bernhard Brümmer (brümmer, b), Dela-Dem Doe Fiankor (fiankor, d.-d.d), Inmaculada Martínez-Zarzoso (martínez-zarzoso, i.), Laura Márquez-Ramos (márquez-ramos, l.), and Fabio Gaetano Santaremo (santaremo, f.g.). The following authors appear in the second cluster: Scott L. Baier (baier, s.l), Jeffrey H. Bergstrand (bergstrand, j.h), Peter Egger (egger, p.), and Michael Pfaffermayr (pfaffermayr, m.). In cluster 3, Peter Egger (egger, p.) continues to stand out, followed by Mario Larch (larch, m.) and Joschka Wanner (wannar, j.). In cluster four, James E. Anderson (anderson, j.e.), Gabriel Felbermayr (felbermayr, g.), and Yoto V. Yoton (yotov, y.v.) stand out. In the fifth cluster, Alessandro Olper (olper, a.) and Valentina Raimondi (raimondi, v.) stand out.

Still, through VOSviewer software, it is possible to verify that the most influential authors, according to the total link strength criterion, are Mario Larch (larch, m.) with 29 connections, Yotov, Yoto V. (yotov, y.v.) with 26, and James E. Anderson (anderson, j.e.) with 12. Next, we have Jeffrey H. Bergstrand (bergstrand, j.h) with nine relationships, Peter Egger (egger, p.) with seven connections, and Inmaculada Martínez-Zarzoso (martínez-zarzoso, i.) with six networks. As can be seen, this analysis is finer and more robust than the number of publications per author, since this item allows us to evaluate the number of connections that the authors have among themselves.

Considering the Scopus database, we present below the main articles by the authors mentioned above (Table 6). The most significant number of citations from each author and the links between them, referring to the "gravity model" issue, were used as the criteria.

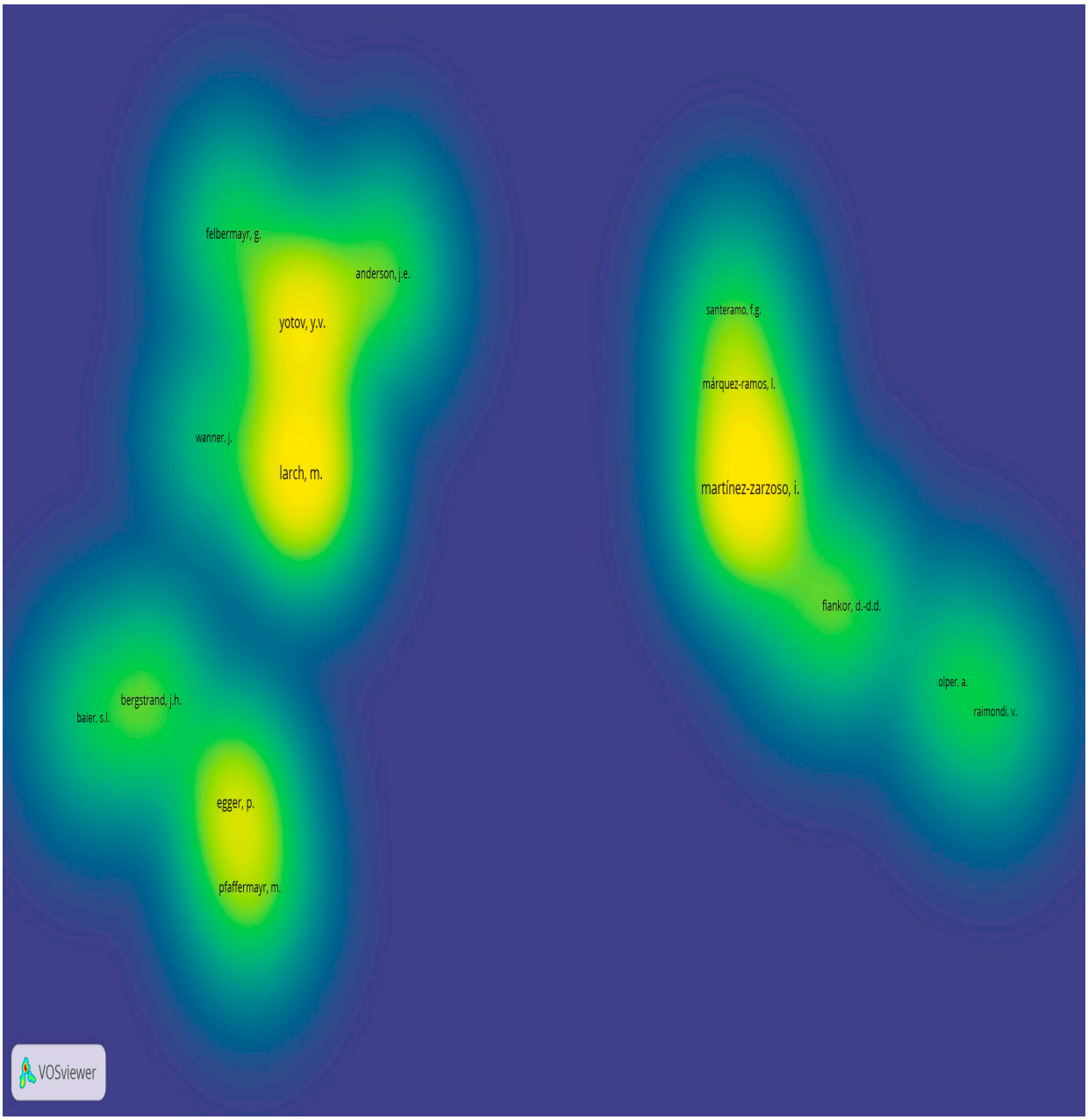

Figure 5. Network of co-authorship. Source: dataset from Scopus and VOSviewer.

Table 6. Top 10 publications by the network of authors.

Article	Authors	Journal	Methodology	Citations
Do free trade agreements actually increase members' international trade?	Baier, Scott L., Bergstrand, Jeffrey H.	*Journal of International Economics* (2007)	Panel data (fixed effects) to evaluate FTA on trade flows.	1326
The growth of world trade: Tariffs, transport costs, and income similarity	Baier, Scott L., Bergstrand, Jeffrey H	*Journal of International Economics* (2001)	OLS for testing the gravity model arguments	444
A note on the proper econometric specification of the gravity equation	Egger, Peter	*Economics Letters* (2000)	Panel data (fixed effects versus random effects) and Hausman test	297

Table 6. *Cont.*

Article	Authors	Journal	Methodology	Citations
Interdependent preferential trade agreement memberships: An empirical analysis	Egger, Peter Larch Mario	*Journal of International Economics* (2008)	Panel data (probit model) considering the preference trade agreements (PTAs)	250
Terms of trade and global efficiency effects of free trade agreements, 1990–2002	Anderson, James E. Yotov, Yoto V.	*Journal of International Economics* (2016)	Panel data (Poisson pseudo-maximum likelihood—PPML) for testing the efficiency of FTA	192
Economic integration agreements, border effects, and distance elasticities in the gravity equation	Bergstrand, Jeffrey H, Larch Mario, Yotov, Yoto V.	*European Economic Review* (2015)	Panel data (Poisson pseudo-maximum likelihood—PPML; OLS) and the arguments of gravity models	192
A panel data analysis of trade creation and trade diversion effects: The case of ASEAN-China Free Trade Area	Yang, Shanping, Martínez-Zarzoso, Inmaculada	*China Economic Review* (2014)	Panel data (Poisson pseudo-maximum likelihood—PPML) and the arguments of gravity models	141
Currency Unions and Trade: A PPML Re-assessment with High-dimensional Fixed Effects	Larch Mario, Wanner, Joschka, Yotov, Yoto V., Zylkin, Thomas	*Oxford Bulletin of Economics and Statistics* (2019)	Panel data (Poisson pseudo-maximum likelihood—PPML) and the arguments of gravity models	124
A simple solution to the distance puzzle in international trade	Yotov, Yoto V.	*Economics Letters* (2012)	Panel data (Poisson pseudo-maximum likelihood—PPML) and the arguments of gravity models	119
The log of gravity revisited	Martínez-Zarzoso, Inmaculada	*Applied Economics* (2013)	PPML estimator and gravity model	111

Source: dataset from Scopus. The citations shown were taken from Scopus on 2 September 2024.

5. Conclusions

The gravity model proposed by Tinbergen (1962), Pöyhönen (1963), Isard (1969), Anderson (1979), and, more recently, Anderson and van Wincoop (2003) aims to explain the flows of bilateral trade and foreign direct investment determinants used in conceptual models of international business. The researchers investigate the demand and supply of trade and investment or tourism demand considering the geographical, economic, and cultural explanatory factors.

This study undertakes a comprehensive evaluation of the gravity model and its relationships with empirical studies of international trade and the question of fragmentation and international production. The results of the literature review and the assumptions of the PRISMA methodology are applied to the Scopus database. The bibliometric study was also complemented with VOSviewer software, where keyword co-occurrence and co-authorship were analysed.

This study answered some research questions, namely that it was possible to observe the authors with the most publications and citations and the journals and institutions with the most impact.

The recent empirical studies of the gravity model demonstrated that scholars used exports, imports, total trade, intra-industry trade, and other competitiveness indexes as dependent variables. Furthermore, the relationship between parts and components and the final product showed that all economies have comparative advantages, and the fragmentation of production explains these phenomena. In this context, international economics study the role of vertical specialisation, namely vertical intra-industry trade

or global value chains (GVCs). Another topic international economists' study is inward foreign direct investment (FDI), which also considers the arguments of the gravity model.

As we illustrate in this article, the economic dimensions measured by income per capita, gross domestic product, or population are used to explain the economic scales. These variables are considered as the economic scales used to achieve product differentiation and competitiveness. According to the literature, the economic scales positively impact bilateral trade.

In this article, it was also possible to examine that the variables common language, border, and trade agreements promote bilateral international trade (e.g., Yang and Martinez-Zarzoso 2014; Baier and Bergstrand 2001).

Regarding the documents published by countries, we observe that the United States, Germany, China, Spain, and the United Kingdom are the most representative countries.

From our selection of 15 major journals, *World Economy*, *Review of World Economics*, *Economic Modelling*, and *Emerging Markets Finance and Trade* are the most relevant journals, and they are in the first quartile, according to SJR (2023). Regarding the six institutions with a high publication number on this topic, we concluded that Georg-August-Universität Göttingen, Universidad Jaume I, the World Bank, the Centre for Economic Policy Research, London, CESifo GmbH, and Université de Bordeaux are the more representative.

Although the bibliometric study presented has the advantage of systematising the empirical work on the gravity model and international trade for a certain period of temporal analysis (1989–2024), evaluating its trends and the performance of academics and journals, it is also important to present the limitations of this research.

Thus, as a limitation, it is difficult to find a complete database, i.e., with all the information available about researchers and journals. On the other hand, the results may vary depending on the path the researcher uses for his/her research. In our case, the central theme was the gravity model and international trade. In other words, the bibliometric indicators presented only validate our results, i.e., they are not synonymous with a quality measure. It can be seen, for example, that the network of co-authors and their existing connections between academics with the highest number of citations and power in the connection depends on the year of publication of the article, i.e., articles published longer ago are likely to have greater weight in terms of citations and impact.

In future research, it would be interesting to realize one bibliometric analysis that considers the relationship between the gravity model and foreign direct investment (FDI) and understands a causality between these variables. Indeed, many empirical studies evaluate the determinants of FDI based on spatial variables of the gravity model. Therefore, it will be essential to understand and observe the bibliometric gravity model and FDI to synthesize an empirical literature review.

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References

Anderson, James E. 1979. A Theoretical Foundation for the Gravity Equation. *American Economic Review* 69: 106–16.

Anderson, James E. 2011. The Gravity Model. *Annual Review of Economics* 3: 133–60. [CrossRef]

Anderson, James E., and Eric van Wincoop. 2003. Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review* 93: 170–92. [CrossRef]

Anderson, James E., and Yoto V. Yotov. 2016. Terms of Trade and Global Efficiency Effects of Free Trade Agreements, 1990–2002. *Journal of International Economics* 99: 279–98. [CrossRef]

Anjum, Hira Fariha, Siti Zaleha Abdul Rasid, Haliyana Khalid, Md. Moshiul Alam, Salwani Mohd Daud, Hafiza Abas, Suriani Mohd Sam, and Suriani Mohd Sam. 2020. Mapping Research Trends of Blockchain Technology in Healthcare. *IEEE Access* 8: 174244–54. [CrossRef]

Bagchi, Sagnik, and Surajit Bhattacharyya. 2019. Country-Specific Determinants of Intra-Industry Trade in India. *Foreign Trade Review* 54: 129–58. [CrossRef]
Baier, Scott L., and Jeffrey H. Bergstrand. 2001. The Growth of World Trade: Tariffs, Transport Costs, and Income Similarity. *Journal of International Economics* 53: 1–27. [CrossRef]
Baier, Scott L., and Jeffrey H. Bergstrand. 2007. Do Free Trade Agreements Actually Increase Members' International Trade? *Journal of International Economics* 71: 72–95. [CrossRef]
Balogh, Jeremiás Máté, and Giovanna Maria Borges Aguiar. 2022. Determinants of Latin American and the Caribbean agricultural Trade: A Gravity Model Approach. *Agricultural Economics—Czech* 4: 127–36. [CrossRef]
Balogh, Jeremiás Máté, and Nuno Carlos Leitão. 2019. A Gravity Approach of Agriculture Trade: The Nexus of EU and African, Caribbean and Pacific Countries. *Agricultural Economics—Czech* 65: 509–19. [CrossRef]
Bergstrand, Jeffrey H., Mario Larch, and Yoto V. Yotov. 2015. Economic Integration Agreements, Border Effects, and Distance Elasticities in the Gravity Equation. *European Economic Review* 78: 307–27. [CrossRef]
Brander, James, and Paul Krugman. 1983. A 'Reciprocal Dumping' Model of International Trade. *Journal of International Economics* 15: 313–21. [CrossRef]
Brkić, Snježana, Radovan Kastratović, and Mirela Abidović Salkica. 2021. Analysis of Intra-Industry Trade in Agri-Food Produtcs between Bosnia and Herzegovina and the European Union. *South East European Journal of Economics and Business* 16: 53–67. [CrossRef]
Brülhart, Marius. 2009. An Account of Global Intra-industry Trade, 1962–2006. *The World Economy* 32: 401–59. [CrossRef]
Capoani, Luigi. 2023. Review of the Gravity Model: Origins and Critical Analysis of its Theoretical Development. *SN Business and Economics* 3: 95. [CrossRef]
Dixit, Avinask K., and Joseph E. Stiglitz. 1977. Monopolistic Competition and Optimum Product Diversity. *American Economic Review* 67: 297–308.
Doan, Ngoc Thang, and Thanh Ha Le. 2024. The Effects of Global Value Chain on Export Survival. *Foreign Trade Review* 59: 389–411. [CrossRef]
Doanh, Nguyen Khanh, and Yoon Heo. 2018. Horizontal Intra-Industry Trade in Korea: A Dynamic Panel Data Analysis. *Journal of International Logistics and Trade* 16: 1–10. [CrossRef]
Egger, Peter. 2000. A Note on the Proper Econometric Specification of the Gravity Equation. *Economics Letters* 66: 25–31. [CrossRef]
Egger, Peter, and Mario Larch. 2008. Interdependent Preferential Trade Agreement Memberships: An Empirical Analysis. *Journal of International Economics* 76: 384–99. [CrossRef]
Falvey, Rod, and Henryk Kierzkowski. 1987. Product Quality, Intra-Industry Trade and (Im)perfect Competition. In *Protection and Competition in International Trade. Essays in Honour of W. M. Corden*. Edited by Henryk Kierzkowski. Oxford: Basil Blackwell, pp. 143–61.
Faustino, Horácio C., and Nuno Carlos Leitão. 2011. Fragmentation in the Automobile Manufacturing Industry: Evidence from Portugal. *Journal of Economic Studies* 38: 287–300. [CrossRef]
Fertő, Imre, Mahammad Kheyirkhabarli, and Magdolna Sass. 2024. Gravity Models with TiVA Data: Do They Bring New Results? *Applied Economics Letters* 31: 702–5. [CrossRef]
Fujita, Masahisa. 1999. Location and Space-Economy at Half a Century: Revisiting Professor Isard's Dream on the General Theory. *The Annals Regional Science* 33: 371–81. [CrossRef]
Fujita, Masahisa, and Paul Krugman. 2004. The New Economic Geography: Past, Present and the Future. In *Fifty Years of Regional Science. Advances in Spatial Science*. Edited by Raymond J. G. M. Florax and David A. Plane. Berlin: Springer, pp. 139–64. [CrossRef]
Fujita, Masahisa, Paul Krugman, and Anthonhy Venables. 1999. *The Spatial Economy. Cities, Regions, and International Trade*. Cambridge: MIT Press.
Ginsburgh, Victor, and Shlomo Weber. 2020. The Economics of Language. *Journal of Economic Literature* 58: 348–404. [CrossRef]
Greaney, Theresa M., and Kozo Kiyota. 2020. The Gravity Model and Trade in Intermediate Inputs. *World Economy* 43: 2034–49. [CrossRef]
Greenaway, David, Robert Hine, and Chris Milner. 1994. Country-Specific Factors and the Pattern of Horizontal and Vertical Intra-Industry Trade in the UK. *Review of World Economics* 130: 77–100. [CrossRef]
Grin, François. 2003. Language Planning and Economics. *Current Issues in Language Planning* 4: 1–66. [CrossRef]
Helpman, Elhanan. 1981. International Trade in the Presence of Product Differentiation, Economies of Scale and Monopolistic Competition: A Chamberlin-Heckscher-Ohlin approach. *Journal of International Economics* 11: 305–40. [CrossRef]
Helpman, Elhanan, and Paul Krugman. 1985. *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy*. Cambridge: MIT Press.
Isard, Walter. 1969. Some Notes on the Linkage of the Ecologic and Economic Systems. *Papers of the Regional Science Association* 22: 85–96. [CrossRef]
Isard, Walter, and Merton J. Peck. 1954. Location Theory and International and Interregional Trade Theory. *The Quarterly Journal of Economics* 68: 97–114. [CrossRef]
Jadhav, Suhas, and Ishita Ghosh. 2024. Future Prospects of the Gravity Model of Trade: A Bibliometric Review (1993–2021). *Foreign Trade Review* 59: 26–61. [CrossRef]

Jámbor, Attila, Jeremias Balogh, and Peter Kucsera. 2016. Country and Industry Specific Determinants of Intra-Industry Agri-food Trade in the Baltic Countries. *Agricultural Economics—Czech* 62: 280–91. [CrossRef]
Jones, Ronald, and Henryk Kierzkowski. 2001. A Framework for Fragmentation. In *Fragmentation: New Production Patterns in the World Economy*. Edited by Sven W. Arndt and Henryk Kierzkowski. Oxford: Oxford University Press, pp. 17–34.
Kandogan, Yener. 2003. Intra-Industry Trade of Transition Countries: Trends and Determinants. *Emerging Markets Review* 4: 272–86. [CrossRef]
Khayat, Sahar Hassan. 2019. A Gravity Model Analysis for Trade between the GCC and Developed Countries. *Cogent Economics & Finance* 7: 1703440. [CrossRef]
Krugman, Paul. 1991. Center and Periphery. In *Geography and Trade*. London: MIT Press, pp. 1–34.
Krugman, Paul. 1995. Geography Lost and Found. In *Development, Geography, and Economic Theory*. Cambridge: MIT Press, pp. 30–65.
Krugman, Paul, and Anthony Venables. 1990. *Integration and the Competitiveness of Peripheral Industry*. CEPR Discussion Paper 363. London: CEPR.
Krugman, Paul R. 1979. Increasing Returns, Monopolistic Competition, and International Trade. *Journal of International Economics* 9: 469–79. [CrossRef]
Lancaster, Kelvin. 1980. Intra-Industry Trade under Perfect Monopolistic Competition. *Journal of International Economics* 10: 151–75. [CrossRef]
Larch, Mario, Joschka Wanner, Yoto V. Yotov, and Thomas Zylkin. 2019. Currency Unions and Trade: A PPML Re-assessment with High-dimensional Fixed Effects. *Oxford Bulletin of Economics and Statistics* 81: 487–510. [CrossRef]
Lee, Hyun-Hoon, and Yonng-Youn Lee. 1993. Intra-Industry Trade in Manufactures: The Case of Korea. *Review of World Economics/Weltwirtschafiliches Archv* 129: 159–71. [CrossRef]
Leitão, Nuno Carlos. 2023. The Impact of Geopolitical Risk on Portuguese Exports. *Economies* 11: 291. [CrossRef]
Leitão, Nuno Carlos, and Horácio Crespo Faustino. 2013. Intra-Industry Trade in the Medical and Optical Instruments Industry: A Panel Data Analysis. *Economic Research/Ekonomska Istraživanja* 26: 129–40. [CrossRef]
Łapińska, Justyna, Jana Meluzinová, and Jiří Uhman. 2019. Country-Specific Determinants of Intra-industry Trade in Pharmaceuticals: The case of Poland and its European Union Partners. *Marketing and Trade* XXII: 188–202. [CrossRef]
Martínez-Zarzoso, Inmaculada. 2013. The Log of Gravity Revisited. *Applied Economics* 45: 311–27. [CrossRef]
Pacheco, Luís Miguel, and André Pereira Matos. 2022. Foreign Presence and Export Performance: The Role of Portuguese Commercial Diplomacy. *The International Trade Journal* 36: 147–69. [CrossRef]
Page, Matthew J., David Moher, and Joanne E. McKenzie. 2022. Introduction to PRISMA 2020 and implications for research synthesis methodologists. *Research Synthesis Methods* 13: 156–63. [CrossRef]
Pöyhönen, Pentti. 1963. A Tentative Model for the Volume of Trade between Countries. *Weltwirtschaftliches Archiv* 90: 93–100.
Proença, Isabel, and Horácio C. Faustino. 2015. Modelling Bilateral Intra-Industry Trade Indexes with Panel Data: A Semiparametric Approach. *Computational Statistics* 30: 865–84. [CrossRef]
Santos Silva, J. M. C., and Silvana Tenreyro. 2006. The Log of Gravity. *Review of Economics and Statistics* 88: 641–58. [CrossRef]
Shaked, Avner, and John Sutton. 1984. Natural Oligopolies and International Trade. In *Monopolistic Competition and International Trade*. Edited by Henryk Kierzkowski. Oxford: Oxford University Press, pp. 34–50.
Sharma, Preeti, Sachin Rohatgi, and Deepmala Jasuja. 2022. Scientific Mapping of Gravity Model of International Trade Literature: A Bibliometric Analysis. *Journal of Scientometric Research* 11: 447–57. [CrossRef]
Thorpe, Michael William, and Nuno Carlos Leitão. 2013. Determinants of United States' Vertical and Horizontal Intra-Industry Trade. *Global Economy Journal* 13: 233–50. [CrossRef]
Tinbergen, Jan. 1962. *Shaping the World Economy; Suggestions for an International Economic Policy*. New York: Twentieth Century Fund.
Venables, Anthony J. 2019. Economic Geography and Trade. In *Oxford Research Encyclopedias, Subject Economics and Finance*. Oxford: Oxford University Press, pp. 1–19. [CrossRef]
Yang, Shanping, and Inmaculada Martinez-Zarzoso. 2014. A Panel Data Analysis of Trade Creation and Trade Diversion Effects: The case of ASEAN–China Free Trade Area. *China Economic Review* 29: 138–51. [CrossRef]
Yang, Xuebing. 2022. Value-Added Share and Elasticity of Trade to Barriers. *Applied Economics Letters* 29: 1599–604. [CrossRef]
Yotov, Yoto V. 2012. A Simple Solution to the Distance Puzzle in International Trade. *Economics Letters* 117: 794–98. [CrossRef]
Zaninović, Vink. 2022. The Intra-Industry Trade Dynamics Countries: The Role of Trade Agreements. *Zbornik radova Ekonomskog fakulteta u Rijeci/Proceedings of Rijeka* 40: 129–45. [CrossRef]