

# Scientific Mapping of Gravity Model of International Trade Literature: A Bibliometric Analysis

Preeti Sharma, Sachin Rohatgi, Deepmala Jasuja\*

Amity University, Noida, Uttar Pradesh, INDIA.

## ABSTRACT

The Gravity Model is the galloper of applied international trade literature. This model allows us to estimate trade-impacts of various trade related policies. Thousands of research studies have applied gravity models in their research works. The purpose of this paper is to look at bibliometric analysis of worldwide publication output based on a gravity model of international trade, as covered by Scopus from 1987 to 2021. The study analyses annual productivity, most productive source titles, prolific countries, eminent institutions, linguistic analysis and productivity of authors and their contribution in the subject area. According to the findings, Estimation of trade variables and projections are the most popular areas of subject specification, while in terms of literature gaps, estimation of economic integration, Extensive and Intensive Margin, and Logistics Performance Index receive less attention. 2019 was the most productive year for research on gravity models in international trade. In terms of contemporary research output, the United States, Germany, Spain, and China are the most productive countries; while as per citation analysis the United States, Germany, and the United Kingdom are the top three countries. The most prolific journals for publishing works in the subject of the gravity model of international trade are Journal of International Economics, American Economic Review, and Review of Economics and Statistics. The study attempts to portray the existing literature more comprehensively by showing research collaborations and bibliographic coupling. The findings of this study can be useful to conduct further studies in the future.

**Keywords:** Gravity Model, Gravity Equation, International trade, Bilateral trade, Economic integration, Scopus.

## Correspondence

**Deepmala Jasuja**

Amity University, Noida, Uttar Pradesh, INDIA.

Email id: deepmalajasuja13@gmail.com

ORCID ID: 0000-0002-5341-1706

Received: 27-07-2022

Revised: 27-10-2022

Accepted: 10-11-2022

DOI: 10.5530/jscores.11.3.48

## INTRODUCTION

The gravity model has always been around in policy circles, because of its robustness and as a versatile tool to analyze all kinds of trade and policy issues. In attempting to understand the pattern of trade in a globalized world, economists have frequently used this model. The model was first presented in 1962 by Jan Tinbergen, the physics-educated Dutch economist in his work shaping the world economy. He used an analogy with Newton's theory of gravitation as the basis for his gravity equation which states that the size of bilateral trade flows between any two countries can be approximated by employing the gravity equation. Since the planets are attracted to each other in proportion to their sizes and proximity, so too are countries. The empirical evidence for the gravity equation in international trade is strong. Both the role of distance and economic size are remarkably stable over time, across different countries, and using various econometric methods. The gravity model is now seen as the workhorse of trade theory, and especially in terms of forecasting the impact of

changes in trade policy on trade costs. The model is flexible to cover a range of economic factors such as tariff and non-tariff barriers and non-economic factors such as cultural differences, differences in religion, language (dis) similarity, the presence or absence of former colonial ties, institutional differences, and difference in technological development and so on. Many Studies<sup>[1-4]</sup> have presented the extensions of the basic model with a substitution structure. The traditional gravity model of international trade is as follows:

$$F_{ij} = G \frac{M_i M_j}{D_{ij}}$$

Where:

$F_{ij}$  denote the bilateral trade between countries  $i$  and  $j$  (denoted as gravitational attraction),  $G$  is the gravitational force,  $M_i$  and  $M_j$  are GDPs of countries  $i$  and  $j$  (denoted as masses of two objects) and  $D_{ij}$  is the distance between two countries.

In the above gravitational force ( $F_{ij}$ ) shows the volume of international trade between any two economies which is proportional to the product of their GDPs (represented as  $M_i$  and  $M_j$ ) and the distance dissuasion function where distance is generally interpreted to include all factors that might create trade confrontation.

## Copyright

© The Author(s). 2022 This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

Initially the model could not gain popularity between 1970 and 1980s. But in last 20 years the model gained popularity due to the seminal contribution by Anderson and Bergstrand. In early 90s the model became fashionable among policy makers due to big changes in world trading systems. Several authors<sup>[5]</sup> have tried to provide the model with such a theoretical basis, using models of imperfect competition and product differentiation, notably whereas Other authors<sup>[6]</sup> prove that the model is also consistent with the Heckscher–Ohlin trade theory under perfect competition. The studies around extended gravity include diverse areas of international tourism (demand, development and analysis), transportation analysis, international trade, world trade and network analysis, migration behaviour, economic integration and interaction, geo-cultural homogeneity, and service trade.

The major focus of this article has been to depict the chronological evolution of scholarly papers in the subject of international trade from 1987 to 2021 using various extensions of gravity models. There has been a lot of research on trade flows, particularly the gravity model. However, no bibliometric examination of the gravity model has been attempted in the literature; we could find one study on the topic.<sup>[7]</sup> With the help of this study, a survey of research completed in the last thirty-four years will be stored in the literature. The primary languages, authors, and source titles of scientific literature on gravity models within the same time period were identified in this study. This article also focused on the evolution of research production in terms of countries and institutions, as well as the productive topic areas that are interested in gravity models.

- The current research addresses three basic questions:
- How much progress did gravity model made over last 34 years?
- Who published and where did they publish?
- What is the intellectual structure of the Gravity Model?
- What are the emerging research themes in the Gravity Model domain?
- What are the future directions in the uses of gravity model?

## Review of Literature

Gravity Models are commonly used to interrogate the volume of trade flows and related policies. From the very first conceptualization of gravity equation<sup>[8]</sup> gone through a lot of changes and development. Over a couple of decades, there is a dramatic progress in understanding the theoretical foundation and improving the empirical estimation. Few studies<sup>[9-11]</sup> have analyzed the regional trade flows for general products. Panel data approach was applied with different explanatory

variables and its impact was observed on exports. Recently, most studies<sup>[12,13]</sup> also examined the effects of currency union, common markets, free trade agreements on creation or diversion of trade. Other research studies have also observed the impact of different factors on trade policy implications. Studies also<sup>[14]</sup> investigated the impact of legal systems and governance on international trade. The results demonstrated that weak enforcement and corruption can increase risk in trade. Few researches<sup>[15]</sup> examined the impact of culture, language, and religion on bilateral trade. The findings suggest that cultural similarities are positively related to trade flows. Another significant area of research in gravity equations is gravity model and economic integration<sup>[16]</sup> There is extant literature being contributed to the subject of “Gravity Model”. Hence, it becomes an apparent problem in the literature of gravity models to demonstrate the development of research. Thus, there is a need for statistical analysis of the literature available concerning the subject of gravity model. To the best of our knowledge, there is a bibliometric review of gravity literature<sup>[17]</sup> covering the scientific development of the gravity model from 1980 to 2020.

Understanding this rapidly growing literature on gravity models is a difficult task when the same model with varied extensions and specification can be utilized in diverse areas such as trade, transportation, labour immigration. As a result, our bibliometric studies can be quite valuable for content that is always changing and evolving on the subject. Our research article also contributes to the existing literature by identifying emerging themes in the gravity model, analyzing research clusters, examining prolific authors, influential publication sources, defining intellectual structure of the research field and suggesting future research directions.

## MATERIALS AND METHODS

### Bibliometric Methods

Systematic Literature Reviews, Meta-Analysis, Bibliometric Analysis and Content Analysis are different types of quantitative and quantitative literature reviews.<sup>[18]</sup> Current study employs a blend of bibliometric methods (Journal quality analysis, Authors and Affiliation analysis, Citation Analysis) and Content Analysis (Thematic mapping of clusters) to explore the research questions of the research on Gravity Model of International Trade.

To define bibliometric methods precisely, it is designed to identify, describe and analyze the current published research. Using quantitative and transparent research review processes increases the authenticity and reliability of the results, along with reducing the subjective bias of any kind of literature reviews.<sup>[19,20]</sup> Bibliometrics is a supportive tool for network analysis and co-occurrences to identify similar research themes. The content and cluster analysis is helpful in exploring

the current research trends in the subject field by identifying the “hot-spots” and “Blind spots”.<sup>[21]</sup> Hot- Spots also called as developed areas and Blind-Spots called as developing subjects within the research area, if combined with other descriptive bibliometric techniques will suggest the future research directions.<sup>[22]</sup>

For data analysis and visualization, few software are available in the arena of literature review. VOS Viewer, Biblioshiny, Histcite, Bib excel, Publish and Gephi are some of the software used for comprehensive bibliometric analysis. Each software has different abilities and drawbacks.<sup>[23]</sup> Vos Viewer can use Scopus and Web of Science as the databases whereas Histcite considers databases from Web of Science only. Publish software accepts documents only from google scholar. Bib excel and Gephi are a little complex from a visualization perspective. Hence, authors have applied Bibliometrix package of R and VOS (Visualization of Similarities) software for bibliometric techniques,<sup>[24,25]</sup> we have applied bibliometric techniques on the literature of Gravity Model using citation analysis, co-occurrence analysis, keyword co-occurrences and co-citation analysis. This is followed by content analysis to explore recent trends and suggest research gaps based on our research questions.

### Data Extraction and Filtration

For every bibliometric analysis, there is a database. The two most commonly used databases for bibliometric review are Scopus and Clarivate Analytics' Web of Science (WoS).<sup>[26]</sup> The WoS covers 12000 journals which are only ISI Indexed, whereas Scopus includes 20000 peer-reviewed journals published by Elsevier, Emerald, sage, Taylor and Francis, Springer and Inderscience. Hence, Scopus is wider in scope than WoS. Authors have chosen Scopus as database for reviewing gravity model literature. Nonetheless, Scopus is widely used database for mapping smaller research fields<sup>[27]</sup> which is the case with gravity model of international trade. Hence, for the analysis of data and basic visualization, authors used Bibliometrix package in R and VOS Viewer version 1.6.17. First, we performed the analysis of annual scientific production, prolific authors, publication outlet analysis, global and local citation analysis. After that, co-citation analysis was used to develop intellectual structure of the field and evolution of related literature<sup>[28]</sup> For coupling, Louvain clustering algorithm and association normalization was used. This was followed by generation of related themes of literature for cluster formation and suggesting research gaps. To do so, we have adopted the scientific procedure commonly used for the systematic literature reviews, namely *assembling*, *arranging* and *assessing* of articles.<sup>[29]</sup>

### Arranging

Filtering Criteria: Subject Area, Document Type, Keywords, Source Type and Language

Year of Inclusion: Till “2020”

Subject Area: “Business Management and Accounting” “Econometrics” and “Finance”

Document Type: Only “Articles”

Publication Stage: “Final”

Language: “English”

Final Number of Articles: 604

### Assembling

Keywords Search: “Gravity Model” OR “Gravity Model of International Trade” AND “International Trade”

Database Used: Scopus

Search Result: 875 Documents

### Assessing

Bibliometric Techniques are applied namely:

Performance Analysis (Trend of publication, most influential journals, authors, institutions and countries)

Citation Analysis (Local and Global)

Keywords Co-Occurrence Analysis

Scientific Mapping & Content Analysis to explore research themes.

Reporting Mechanism: Figures, Tables and Words

First, we have developed a keyword search string to extract relevant documents from Scopus. We considered “Gravity Model” OR “Gravity Model of International Trade” AND “International Trade” for extracting relevant articles. The initial search resulted in 875 documents. Since the documents extracted can be from varied fields, a filtration process is required for appropriate documents for the study.

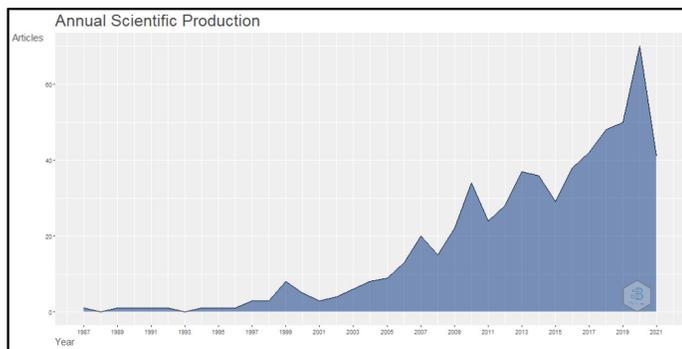
## SEARCH RESULTS

Using the “Title, Abstract, Keywords” search criterion, the preliminary search was attempted. Initial search resulted in 875 documents. During the filtration process, only “Articles” were selected as articles are subject to rigorous peer review and are accepted on the basis of high quality and uniqueness. This will enhance the authenticity and reliability of results. From the source type, only “Journal” was selected, and conference proceedings and books were ignored. All the

**Table 1: Descriptive Information of Articles of Gravity Model.**

Description	Results
Timespan	1987:2021
Sources (Journals, Books, etc)	289
Documents	604
Average years from publication	7.24
Average citations per documents	18.91
Average citations per year per doc	1.904
References	10131

Source: The Authors

**Figure 1:** Publication Trend in the Area of Gravity Model.

recommendations are in line with existing studies.<sup>[29]</sup> Further research areas of decision sciences are included along with Business, Management, Accounting, Econometrics and Finance. Lastly, only English language documents were selected to enhance the comprehension and readability. After filtration, only documents were selected for second stage.

In the second stage, the abstracts and titles of the documents were thoroughly read, and duplicates were removed. All the other documents which were not appropriate for Gravity Model of international trade were also ignored. Total number of articles selected for the bibliometric study is 604.

### Main Information

After the documents to be analyzed for bibliometric review, the main and descriptive information of all articles is extracted. Table 1 reveals that the Gravity Model of International Trade related articles are included from 1987 onwards. Total journal sources are 289 for 604 total articles. Average citation per document is 18.91 signifying the quality of every document selected.

### Annual Scientific Production of Articles

Figure 1 displays the chronological trend in the number of articles published in the area of gravity model related to international trade since 1987. It is clearly visible that research articles were stagnant over a few years till 1996. After that, research articles were increasing on a year-to-year basis.

Annual growth rate of articles was reported to be 12.31%. The number of articles in the area of gravity model gained its momentum in 2005 -2015 when the gravity model was more developed to minimize the estimation biases and was used as a prime tool for the empirical analysis of the bilateral trade flows.

### Journal Quality Analysis

The journals that publish the highest number of articles in a particular research field are regarded as “core journals”.<sup>[30]</sup> It is important to know and assess the core journals for the academicians to know the scope of that particular source and conduct literature review. Table 2 represents the contribution of locally cited top 10 journals in the subject of the Gravity Model of International Trade. It shows that *Journal of International Economics* (published by Elsevier) is the leading journal with maximum publications of 374. It can be seen that 61.9% of total articles are published in the *Journal of International Economics*. This is followed by the *American Economic Review* with 355 documents. For easy access to readers, web links of top 10 journals are also mentioned in the given table. The publications in other journals range from 70 to 182.

**Table 2: Top 10 Journals Publishing research in the area of Gravity Model of International Trade.**

Source	Weblink/Publisher	No. of Documents
<i>Journal of International Economics</i>	<a href="https://www.sciencedirect.com/journal/journal-of-international-economics">https://www.sciencedirect.com/journal/journal-of-international-economics</a>	374
<i>American Economic Review</i>	<a href="https://www.aeaweb.org/journals/aer">https://www.aeaweb.org/journals/aer</a>	355
<i>Review of Economics and Statistics</i>	<a href="https://direct.mit.edu/rest">https://direct.mit.edu/rest</a>	182
<i>The World Economy</i>	<a href="https://onlinelibrary.wiley.com/journal/14679701">https://onlinelibrary.wiley.com/journal/14679701</a>	156
<i>Econometrica</i>	<a href="https://onlinelibrary.wiley.com/journal/14680262">https://onlinelibrary.wiley.com/journal/14680262</a>	112
<i>European Economic Review</i>	<a href="https://www.journals.elsevier.com/european-economic-review">https://www.journals.elsevier.com/european-economic-review</a>	112
<i>The American Economic Review</i>	<a href="https://www.aeaweb.org/journals/aer">https://www.aeaweb.org/journals/aer</a>	112
<i>The Review of Economics and Statistics</i>	<a href="https://direct.mit.edu/rest">https://direct.mit.edu/rest</a>	112
<i>Economics Letters</i>	<a href="https://www.journals.elsevier.com/economics-letters">https://www.journals.elsevier.com/economics-letters</a>	89
<i>Journal of Development Economics</i>	<a href="https://www.sciencedirect.com/journal/journal-of-development-economics">https://www.sciencedirect.com/journal/journal-of-development-economics</a>	70

Source: The Authors

### Production Analysis of Influential Countries

A total of 97 countries have published 604 articles on the Gravity Model of International Trade during the period of 1987 to 2021. Countries are ranked from high to low on the basis of total publications for each country. Table 3 demonstrates the statistics of top countries publishing research in the field of gravity model. It can be seen that the United States has published a total of 125 articles (20.69% of total articles). Followed by the USA, Germany has a total of 69 publications. Spain, China and Australia are amongst the influential nations. Based on citations, the United States, Germany and the United Kingdom are leading nations with 4744, 1423 and 1031 total citations. Figure 2 depicts the country's collaboration for undertaking research in the current subject. It is visible that Germany and Spain have the highest frequency of research collaboration. This is followed by the USA, Canada and Australia. This signifies that developed nations are doing most productive research in the area of bilateral trade models.

### Most Productive Institutions

A total of 1024 Organizations worldwide, have contributed to the relevant research for scholarly publications. Table 4 depicts the statistics of most productive organizations. *Dogus University, Department of Industrial Engineering Istanbul, Turkey* is on the top with 7 articles. This is followed by University of Agriculture, Slovakia with 5 articles. Other affiliations from Spain, Netherlands, Italy and USA have conducted significant research on the gravity model of international trade.

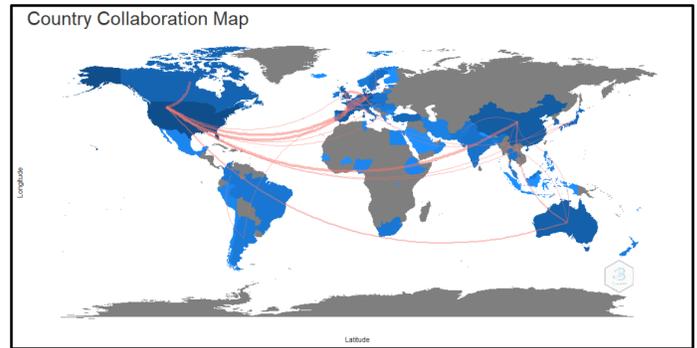
### Prolific Authors

Table 5 represents the leading top 10 authors publishing articles in the area of gravity model, specifically in International Trade. It is clearly visible that Inma Martinez-Zarzoso and Mario Larch are influential authors with maximum publications. The research profile of all the top influential authors is mentioned

**Table 3: Countries' Publication and Citation Statistics.**

Countries	Total Publications	Total Citations
United States	125	4744
Germany	69	1423
Spain	45	795
China	34	483
Australia	32	289
United Kingdom	30	1031
France	23	398
Canada	20	455
Italy	19	801
South Korea	19	301

Source: The Authors



**Figure 2:** The Country Collaboration Map for Gravity Model Research.

**Table 4: Statistics of Most Influential Organizations Worldwide.**

Sl. no	Affiliation	No. of Articles
1.	Dogus University, Department of Industrial Engineering, Turkey	7
2.	Department of Economic Policy, Slovak University of Agriculture, Slovakia	5
3.	International Monetary Fund, United States	5
4.	The Bucharest Academy of Economic Studies, Romania	5
5.	Utrecht School of Economics, Utrecht University, Netherlands	5
6.	Peoples' Friendship University of Russia, Russia	4
7.	L R Klein Institute for Economic Forecasts, Spain	4
8.	Department of Agricultural Forest and Food Sciences, University of Turin, Italy	4
9.	Rudn University, Moscow Russian Federation	4
10.	School of Economics and Business, Kaunas University of Technology, Lithuania	4

Source: The Authors

in Table 5 for further readings on research conducted by the eminent authors.

### Citation Analysis

Citation Analysis is conducted to identify the most cited papers in a given subject field of research. If an article receives the highest number of citations, it is considered to be the most influential article on a specific topic of research as compared to other less cited papers. There are two types of citations, Global citations and Local citations. Global citations refer to the citations received to an article without any filtration criteria like discipline.<sup>[31]</sup> The most cited article in terms of global citations are shown in Table 6. Article titled "Do We Really Know That the WTO Increases Trade?" has received the maximum citations (n= 633). This is followed by "Insecurity and the pattern of Trade: An Empirical Investigation" with a citation score of 426. In the highest cited paper the author has try to estimate the effect of multilateral trade agreements like the World Trade Organization (WTO), its predecessor

**Table 5: Prolific Authors Publishing Research in Gravity Model of International Trade.**

Authors	Author Affiliation	Publications	Google Scholar Link
Inma Martinez-Zarzoso	University of Goettingen, Germany	11	<a href="https://scholar.google.co.in/citations?user=q7YYykAAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.co.in/citations?user=q7YYykAAAAJ&amp;hl=en&amp;oi=sra</a>
Mario Larch	University of Bayreuth, Germany	6	<a href="https://scholar.google.co.in/citations?user=ZGWuX2sAAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.co.in/citations?user=ZGWuX2sAAAAJ&amp;hl=en&amp;oi=sra</a>
Vicente Pinilla	University of Zaragoza, Spain	6	<a href="https://scholar.google.com/citations?user=PHx9OQoAAAAJ&amp;hl=en">https://scholar.google.com/citations?user=PHx9OQoAAAAJ&amp;hl=en</a>
Yoto V. Yotov	DREXEL University, USA	6	<a href="https://scholar.google.com/citations?hl=en&amp;user=o9KM0zsAAAAJ">https://scholar.google.com/citations?hl=en&amp;user=o9KM0zsAAAAJ</a>
Tristan Kohl	University of Groningen, Netherlands	5	<a href="https://scholar.google.com/citations?user=InDL278AAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.com/citations?user=InDL278AAAAJ&amp;hl=en&amp;oi=sra</a>
Volker Nitsch	The Technical University of Darmstadt, Germany	5	<a href="https://scholar.google.com/citations?user=8uJqkMgAAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.com/citations?user=8uJqkMgAAAAJ&amp;hl=en&amp;oi=sra</a>
Andrew K Rose	University of California, USA	5	<a href="https://scholar.google.com/citations?user=XhpyWAMAAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.com/citations?user=XhpyWAMAAAAJ&amp;hl=en&amp;oi=sra</a>
Peter H. Egger	ETH Zürich University, Switzerland	4	<a href="https://scholar.google.com/citations?user=Lc6rZrgAAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.com/citations?user=Lc6rZrgAAAAJ&amp;hl=en&amp;oi=sra</a>
Gabriel Felbermayr	University of Kiel, Germany	4	<a href="https://scholar.google.com/citations?user=Z25Q51wAAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.com/citations?user=Z25Q51wAAAAJ&amp;hl=en&amp;oi=sra</a>
Jarko Fidrmuc	Zeppelin University, Germany	4	<a href="https://scholar.google.com/citations?user=wOi5anQAAAAJ&amp;hl=en&amp;oi=sra">https://scholar.google.com/citations?user=wOi5anQAAAAJ&amp;hl=en&amp;oi=sra</a>

Source: The Authors

**Table 6: Top 10 Globally Cited Articles in the subject of “Gravity Model of International Trade”**

Article Title	Author(s)	Journal	Total Citations	TC per Year
Do We Really Know That the WTO Increases Trade?	Rose (2004)	The American Economic Review	633	35.1667
Insecurity and The Pattern of Trade: An Empirical Investigation	Anderson and Marcouiller (2002)	The Review of Economics and Statistics	426	21.3
The WTO Promotes Trade, Strongly but Unevenly[32]	Subramanian and Wei (2007)	Journal of International Economics	311	20.7333
The Design of International Trade Agreements: Introducing A New Dataset	Dür <i>et al.</i> , (2013)	The Review of International Organizations,	240	30
The Political Determinants of International Trade: The Major Powers, 1907-90	Morrow <i>et al.</i> , (1998)	American Political Science Review	224	9.3333
The World Trade Network	Benedictis and Tajoli (2011)	The World Economy	203	18.4545
National Borders and International Trade: Evidence from The European Union.[33]	Nitsch (2000)	Canadian Journal of Economics	198	9
On the Green and Innovative Side of Trade Competitiveness? The Impact of Environmental Policies and Innovation on EU Exports.	Costantini and Mazzanti (2012)	Research Policy	194	19.4
The Gravity Equation in International Trade in Services	Kimura and Lee (2006)	Review of World Economics	188	11.75
Language and Foreign Trade	Melitz (2008)	European Economic Review	186	13.28

Source: The Authors

General Agreement on Tariffs and Trade (GATT) and the Generalized System of Preferences (GSP) on international trade. In the second most cited paper on the gravity model authors conclude that the relative import demand is a function of level of income, per-capita income, Institutional quality, shared border, a shared language, distance, tariff if applicable and the overall traded goods price index.

Local Citations are received from the particular corpus of area of study. This implies that local citations are received from the study area of “Gravity Model”. From the Table 7, it can be seen that an article by AK Rose, “*Do We Really Know That the WTO Increases Trade?*” has received maximum citations of 21. This is followed by the highly cited articles describing the gravity model.

### Keywords Co-Occurrence Analysis

The rationale behind the analysis of keywords occurrence is that the author’s keywords gives a glimpse of the article content<sup>[40]</sup> Keyword’s co-occurrence occurs when two keywords are cited together in an article. This indicates that a kind of relationship exists between two concepts. Scientometric researchers usually apply keyword occurrences to quantify the performance and measure innovations and information flows.<sup>[41]</sup> Authors in the current research performed keyword analysis to explore the emerging and unexplored field in the gravity model of international trade. Table 8 lists the most occurring keywords. *Gravity Model* is the frequently occurred keyword with 264 occurrences. The result is logical as the gravity model is the central theme of any kind of research on the gravity model of international trade.



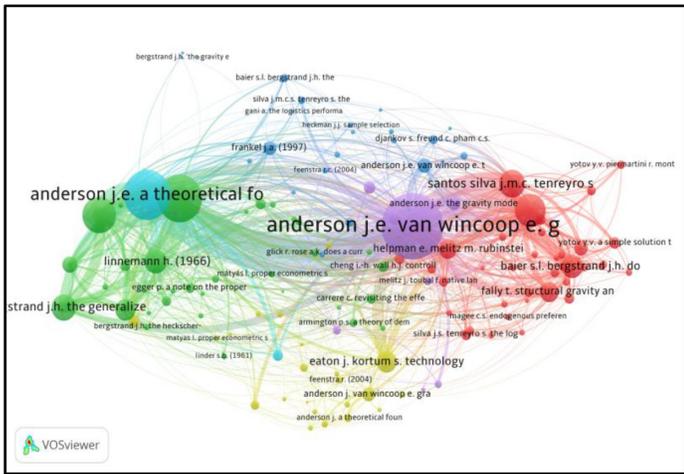


Figure 4: Visualization of Co-Citation Analysis.

variety of goods and factors crossing the regional barrier.<sup>[45]</sup> Table 9 encapsulates the top five documents based on page rank and covers the foundation structure of the gravity model. A research was conducted on the theoretical foundation of gravity model and found that it is a reduced form of a partial equilibrium subsystem of a general model with nationally differentiated products.<sup>[46]</sup> Notably, the studies have been conducted on the econometrics of gravity equation to disentangle country specific and time effects. It has been found that country and time effects should be fixed.<sup>[47]</sup>

**Cluster 2 Estimation Biases of Gravity Equation**

After thorough reading of documents in Cluster 2, we find majority documents focused on estimation and interpretation of gravity equations. Table 10 lists the top 5 articles based on page-rank from this cluster. Several authors<sup>[49]</sup> argue that there are several theory consistent methods of estimation in place, but there cannot be sole reliance against one. Thereby authors proposed a toolkit approach for selecting an estimation method for gravity equation. Some authors<sup>[50]</sup> provided estimates of the size of biases through currency union trade effect. It was reported that time varying country dummies can be dealt with time invariant pair dummies. Researchers have estimated different log-linear and generalized linear gravity models to examine the biases of the equation.<sup>[51]</sup> There are different approaches to estimate gravity equations which can be reduced form or structural form. A research<sup>[52]</sup> suggested Poisson Pseudo-Maximum Likelihood estimator with fixed effects in the estimation of model.

**Cluster 3 Factors Influencing Cross Border Trade- An Application of Gravity Model**

Over the years, several economists and researchers have been estimating gravity models to extract the factors affecting cross-border trade. Table 11 lists the top five documents ranked on the basis of page-rank in the third cluster. Frankel and

Table 9: Cluster 1 Theoretical Foundation.

Title	Author's detail	Journal	Page rank
Shaping the world economy; suggestions for an international economic policy	(Tinbergen, 1962)	The Economic Journal	0.038087
A Theoretical Foundation for the Gravity Equation	(Anderson, 1979)	The American Economic Review	0.034189
The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence	(Bergstrand, 1985)	The Review of Economics and Statistics	0.030058
An Econometric Study of International Trade Flows	Linnemann (1966)	Oxford University Press	0.02081
The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade <sup>[48]</sup>	(Bergstrand, 1989)	The Review of Economics and Statistics	0.016779

Source: The Authors

Table 10: Cluster 2- Estimation Biases of Gravity Equation.

Title	Author's detail	Journal	Page rank
Gravity Equations: Workhorse, Toolkit, and Cookbook	(Head and Mayer, 2014)	Handbook of International Economics	0.023594
The Log of Gravity <sup>[53]</sup>	(Santos Silva and Tenreyro, 2006)	The Review of Economics and Statistics	0.021248
Do free trade agreements actually increase members' international trade?	(Baier and Bergstrand, 2007)	Journal of International Business	0.019743
Structural gravity and fixed effects	(Fally, 2015)	Journal of International Economics	0.015931
On the widely differing effects of free trade agreements: Lessons from twenty years of trade integration <sup>[54]</sup>	(Baier et al., 2019)	Journal of International Economics	0.010491

Source: The Authors

Romer, (1999) investigates the problem of effects on trade by addressing the component of trade that is due to geographic factors. It was found that geographical characteristics have important effects on trade. Evidence has also shown that border and distance impede trade because of presence of tariffs and transport costs.<sup>[55]</sup> Apart from borders and distances, there are other factors which may impact trade. Infrastructure can be regarded as an important factor in determining transport

**Table 11: Cluster 3- Factors Influencing Cross Border Trade- An Application of Gravity Model.**

Title	Author's detail	Journal	Page rank
Does Trade Cause Growth? <sup>[58]</sup>	(J. A. Frankel and Romer, 1999)	American Economic Review	0.004227
Insecurity and the Pattern of Trade: An Empirical Investigation	(Anderson and Marcouiller, 2002)	The Review of Economics and Statistics	0.004697
National Borders Matter: Canada-U.S. Regional Trade Patterns <sup>[59]</sup>	(McCallum, 1995)	American Economic Review	0.003733
Time as a Trade Barrier <sup>[60]</sup>	(Hummels and Schaur, 2013)	American Economic Review	0.003261
Networks versus markets in international trade <sup>[61]</sup>	(Rauch, 1999)	Journal of International Economics	0.003126

Source: The Authors

**Table 12: Cluster 4- Trade Flows and Trade Costs.**

Title	Author's detail	Journal	Page rank
Economic integration agreements, border effects, and distance elasticities in the gravity equation <sup>[65]</sup>	(Bergstrand et al., 2015)	European Economic Review	0.013287
Technology, Geography, and Trade	(Eaton and Kortum, 2002)	Econometrica	0.012744
Estimating Trade Flows: Trading Partners and Trading Volumes <sup>[66]</sup>	(Helpman et al., 2008)	The Quarterly Journal of Economics	0.011763
Trade Cost	(Anderson and Van Wincoop, 2003)	Journal of Economic Literature	0.008735
Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation <sup>[67]</sup>	(Baier and Bergstrand, 2009)	Journal of International Economics	0.00503

Source: The Authors

costs. Few studies<sup>[56]</sup> Limão and Venables, (2001) confirm the role of infrastructure in the elasticity of trade flows. It was also indicated that low levels of African trade can be attributed to poor infrastructure. Several studies suggest that common currencies can be an influential aspect of trade. A research<sup>[57]</sup> studies data of 200 countries and quantified the effect of common currency on trade. There was no evidence of trade diversions reported.

#### Cluster 4 Trade Flows and Trade Costs

There are a lot of differences and variations across the countries in terms of trade. This also makes economic sense

as it facilitates trade. One research<sup>[62]</sup> quantified a Ricardian model of international trade with incorporating geography as a factor. Findings reveal that geographical barriers reflect impediments to trade such as tariffs, quotas and transport costs. Table 12 lists the top documents ranked on the page-rank which revolves around the theme of transport costs and cross-border trade assessed through gravity equations. Researchers have also thrown some light on the measurement of trade costs involved. Partial data infers the implicit trade costs. Ad-Valorem tax is another explicit cost leading to higher trade costs in poor countries<sup>[63]</sup> Few studies<sup>[61]</sup> revealed a relationship between trade flows, incomes and costs with the Monte Carlo simulations. Results show that size of the countries relative to the bilateral trade is the key factor explaining the approximation errors. By applying the gravity regression model, it is found that tariff and non-tariff costs are significant explanations for trade restrictiveness in low-income countries<sup>[64]</sup> (Hoekman and Nicita, 2011). Steps taken to improve logistics; infrastructure may facilitate positive effects on the country's trade.

## CONCLUSION

In this research study undertaken, of the studies published in Scopus on "Gravity Model" during 1987 and 2021 were confined to those connected to international trade, and the keyword "gravity model" was made sure to appear in the titles, summaries, or key words of these studies. The results were assessed under the headings of research development, most productive and most cited authors, most productive journals, most productive nations, and distribution of the most cited publications per year, collaborative country studies, bibliographic match, and word analysis. The studies were also thoroughly analyzed, and clusters were formed to reveal various cluster themes in the area of Gravity Model of International Trade.

The current study shows that research on this area remained stable from 1887 to 1996, but that it began to pick up steam from 2005 onwards. According to our findings, 2019 was the most productive year for research on gravity models in international trade. It has been realized that the objective of sustainable development is positively related to international trade and free trade agreements. It was observed that trade internationalization can act as an effective tool for long term development. Researchers and Academicians across the globe focused on the importance of international trade and led to increase in the publications in this domain. The *United States*, *Germany*, *Spain*, and *China* are the most productive countries in terms of modern research production, whereas the *United States*, *Germany*, and the *United Kingdom* are the top three countries in terms of citation analysis. *Germany* and *Spain* are the countries with the most frequent research collaborations.

*Journal of International Economics*, *American Economic Review*, and *Review of Economics and Statistics* are the most productive publication outlets for publishing research on the gravity model of international trade. Dogus University, Department of Industrial Engineering in Istanbul, Turkey, was found to be the most productive institution, and Inma Martinez-Zarzoso (University of Goettingen, Germany) was discovered to be the most prolific author in the subject. “Gravity Model” and “International Trade” were found to be the frequently occurring keywords to explore the research studies on Gravity Model of International Trade. *Estimation of trade variables and projections* are the most popular areas of subject specification, while *estimation of economic integration*, *Extensive and Intensive Margin*, and *Logistics Performance Index* receive less attention. The limitation of the study is the fact that data is only gathered from Scopus, and it is examined using only a VOS viewer.

### Forging the Way Forward

This bibliometric analysis provides a glimpse of research articles on gravity models of international trade from around the world. However, the study was limited to the Scopus database, the findings cannot be generalized. It hasn't considered manuscripts from other databases or indexes, such as Web of Science. In order to attain generalizations, future studies will need to include papers from other high-quality databases. Future researchers also need to focus the use of gravity models in the area of estimation of economic integration, Extensive and Intensive Margin, and Logistics Performance Index receive less attention.

### Managerial Implications

The aim of this research was to look at research trends on gravity models of international trade during the last 21 years from a variety of angles. Academics and policymakers both will benefit from the outcomes of bibliometric analysis. The current exploration has identified the gravity model's research gaps. These research gaps can be utilized by researchers for furthering this research subject as per their own interests and research implications. This research can assist both educational institutions and academicians in developing crucial strategies for publishing such research in order to increase its visibility and influence. By studying current research trends on gravity models, Academicians will be able to collaborate with other researchers based on the quality of research conducted by other countries and institutes.

### CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

### REFERENCES

- Anderson JE, Van Wincoop E. Gravity with gravitas: A solution to the border puzzle. *American Economic Review*. 2003;93(1):170-92.

- Bergstrand JH. The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence. *Rev Econ Stat*. 1985;67(93):474-81.
- Bikker JA. Measuring Performance of Banks: An Assessment. *Journal of Applied Business and Economics*. 2010;11(4):141-59.
- Bikker JA. An International Trade Flow Model with Substitution: An Extension of the Gravity Model. *Kyklos*. 1987;40(3):315-37.
- Anderson JE. A theoretical foundation for the gravity equation. *American Economic Review*. 1979;69(1):106-16.
- Deardorff A. Determinants of bilateral trade: Does gravity work in a neoclassical world? *The Regionalization of the World Economy*. 1998;7-22.
- Metin I, Tepe G. Gravity model: A bibliometric analysis and detailed overview. *International Journal of Business and Society*. 2021;22(1):365-81.
- Tinbergen J. Shaping the world economy; suggestions for an international economic policy. 1962.
- Breuss F, Egger P. How reliable are estimations of East-West trade potentials based on cross-section gravity analyses? *Empirica*. 1999;26(2):81-94.
- Filippini C, Molini V. The determinants of East Asian trade flows: A gravity equation approach. *J Asian Econ*. 2003;14(5):695-711.
- Lampe M. Bilateral trade flows in Europe, 1857-1875: A new dataset. Vol. 26, *Research in Economic History*. 2008.
- Arghyrou MG. EU participation and the external trade of Greece: An appraisal of the evidence. *Appl Econ*. 2000;32(2):151-9.
- Baier SL, Bergstrand JH. Do free trade agreements actually increase members' international trade? *J Int Econ*. 2007;71(1):72-95.
- Anderson JE, Marcouiller D. Insecurity and the pattern of trade: An empirical investigation. *Review of Economics and Statistics*. 2002;84(2):342-52.
- Linders GJ, Slangen A, de Groot HLF, Beugelsdijk S. Cultural and Institutional Determinants of Bilateral Trade Flows. *SSRN Electronic Journal*. 2011;
- Cheng IH, Wall HJ. Controlling for Heterogeneity in Gravity Models of Trade and Integration. *Review*. 2005;87(1).
- Metin I, Tepe G. Gravity model: A bibliometric analysis and detailed overview. *International Journal of Business and Society*. 2021;22(1):365-81.
- Gaur A, Kumar M. A systematic approach to conducting review studies: An assessment of content analysis in 25 years of IB research. *Journal of World Business*. 2018;53(2):280-9.
- Madititi DR, Munim ZH, Schramm HJ, Kummer S. A review of green supply chain management: From bibliometric analysis to a conceptual framework and future research directions. Vol. 139, *Resources, Conservation and Recycling*. 2018;139:150-62.
- Zupic I, Cater T. Bibliometric Methods in Management and Organization. *Organ Res Methods*. 2015;18(3):429-72.
- Sassmannshausen SP, Volkman C. The Scientometrics of Social Entrepreneurship and Its Establishment as an Academic Field. *Journal of Small Business Management*. 2018;56(2):251-73.
- Gaur A, Kumar M. A systematic approach to conducting review studies: An assessment of content analysis in 25 years of IB research. *Journal of World Business*. 2018;53(2):280-9.
- Persson O, Danell R, Schneider JW. How to use Bibexcel for various types of bibliometric analysis. Celebrating scholarly communication studies: A Festschrift for Olle Persson at his 60<sup>th</sup> Birthday. 2009;5:9-24.
- Fahimnia B, Sarkis J, Davarzani H. Green supply chain management: A review and bibliometric analysis. *Int J Prod Econ*. 2015;162:101-14.
- Xu X, Chen X, Jia F, Brown S, Gong Y, Xu Y. Supply chain finance: A systematic literature review and bibliometric analysis. *International Journal of Production Economics*. 2018;204:160-73.
- Aria M, Cuccurullo C. bibliometrix: An R-tool for comprehensive science mapping analysis. *J Informetr*. 2017;11(4).
- Zupic I, Cater T. Bibliometric Methods in Management and Organization. *Organ Res Methods*. 2015;18(3):429-72.
- Elango B. A Bibliometric Analysis of Franchising Research (1988–2017). *Journal of Entrepreneurship*. 2019;28(2):223-49.
- Paul J, Lim WM, O'Cass A, Hao AW, Bresciani S. Scientific procedures and rationales for systematic literature reviews (SPAR-4-SLR). *Int J Consum Stud*. 2021;45(4):01-6.
- Ali A, Hakak IA, Amin F. Assessing the Coronavirus Research Output: A Bibliometric Analysis. *Global Business Review*. 2020.
- Kent Baker H, Pandey N, Kumar S, Haldar A. A bibliometric analysis of board diversity: Current status, development, and future research directions. *J Bus Res*. 2020;108:232-46.
- Subramanian A, Wei SJ. The WTO promotes trade, strongly but unevenly. *J Int Econ*. 2007;72(1):151-75.
- Nitsch V. National borders and international trade: Evidence from the European Union. *Canadian Journal of Economics*. 2000;33(4):1091-105.
- Rose AK. Do we really know that the WTO increases trade? *American Economic Review*. 2004;94(1):98-114.
- Glick R, Rose AK. Currency unions and trade: A post-EMU reassessment. *Eur Econ Rev*. 2016;87:78-91.

36. Martí L, Puertas R, García L. The importance of the Logistics Performance Index in international trade. *Appl Econ*. 2014;46(24):2982-92.
37. Kohl T. Do we really know that trade agreements increase trade? *Review of World Economics*. 2014;150(3):443-69.
38. Gómez-Herrera E. Comparing alternative methods to estimate gravity models of bilateral trade. *Empir Econ*. 2013;44(3):1087-111.
39. Kimura F, Lee HH. The gravity equation in international trade in services. *Review of World Economics*. 2006;142(1):92-121.
40. Comerio N, Strozzi F. Tourism and its economic impact: A literature review using bibliometric tools. *Tourism Economics*. 2019;25(1):109-31.
41. Kent Baker H, Pandey N, Kumar S, Halder A. A bibliometric analysis of board diversity: Current status, development, and future research directions. *J Bus Res*. 2020;108:232-46.
42. Small H. Co-citation in the scientific literature: A new measure of the relationship between two documents. *Journal of the American Society for Information Science*. 1973;24(4):265-9.
43. Rossetto DE, Bernardes RC, Borini FM, Gattaz CC. Structure and evolution of innovation research in the last 60 years: Review and future trends in the field of business through the citations and co-citations analysis. Vol. 115, *Scientometrics*. 2018;115(3):1329-63.
44. Hjørland B. Citation analysis: A social and dynamic approach to knowledge organization. *Inf Process Manag*. 2013;49(6):1313-25.
45. Anderson JE. A theoretical foundation for the gravity equation. *American Economic Review*. 1979;69(1):106-16.
46. Bergstrand JH. The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence. *Rev Econ Stat*. 1985;67(3):474-81.
47. Egger P. A note on the proper econometric specification of the gravity equation. *Econ Lett*. 2000;66(1):25-31.
48. Bergstrand JH. The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade. *Rev Econ Stat*. 1989;71(1):143-53.
49. Head K, Mayer T. Gravity Equations: Workhorse, Toolkit, and Cookbook. In: *Handbook of International Economics*. 2014;4:131-195.
50. Baldwin R, Taglioni D. Gravity for Dummies and Dummies for Gravity Equations. *Centre for Economic Policy Research Discussion Paper*. 2006;(5850).
51. Egger PH, Tarlea F. Multi-way clustering estimation of standard errors in gravity models. *Econ Lett*. 2015;134:144-7.
52. Fally T. Structural gravity and fixed effects. *J Int Econ*. 2015;97(1):76-85.
53. Santos Silva JMC, Tenreyro S. The log of gravity. *Review of Economics and Statistics*. 2006;88(4):641-58.
54. Baier SL, Yotov YV, Zylkin T. On the widely differing effects of free trade agreements: Lessons from twenty years of trade integration. *J Int Econ*. 2019;116:206-26.
55. Head K, Mayer T. What separates us? Sources of resistance to globalization. *Canadian Journal of Economics*. 2013;46(4):1196-231.
56. Limão N, Venables AJ. Infrastructure, geographical disadvantage, transport costs, and trade. *World Bank Economic Review*. 2001;15(3):451-79.
57. Frankel J, Rose A. An estimate of the effect of common currencies on trade and income. *Quarterly Journal of Economics*. 2002;117(2):437-66.
58. Frankel JA, Romer D. Does trade cause growth? *American Economic Review*. 1999;89(3).
59. McCallum J. National Borders Matter: Canada-U.S. Regional Trade Patterns. *Am Econ Rev*. 1995;85(3):615-23.
60. Hummels DL, Schaur G. Time as a trade barrier. *American Economic Review*. 2013;103(7):2935-59.
61. Rauch JE. Networks versus markets in international trade. *J Int Econ*. 1999;48(1):7-35.
62. Eaton B, Kortum S. Technology, geography, and trade. *Econometrica*. 2002;70(5):1741-79.
63. Anderson JE, Van Wincoop E. Gravity with gravitas: A solution to the border puzzle. *American Economic Review*. 2003;93(1):170-92.
64. Hoekman B, Nicita A. Trade policy, trade costs, and developing country trade. *World Dev*. 2011;39(12):2069-79.
65. Bergstrand JH, Larch M, Yotov Y V. Economic integration agreements, border effects, and distance elasticities in the gravity equation. *Eur Econ Rev*. 2015;78:307-27.
66. Helpman E, Melitz M, Rubinstein Y. Estimating trade flows: Trading partners and trading volumes. *Quarterly Journal of Economics*. 2008;123(2).
67. Baier SL, Bergstrand JH. Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation. *J Int Econ*. 2009;77(1):77-85.