GRAVITY MODEL TO UNDERSTAND CHINA INTERNATIONAL TRADE: A REVIEW LITERATURE

Ahmad Anwar
Corresponding author, Department of World Economy, Corvinus University of Budapest
aan.pop@gmail.com

Agung Wicaksono
Department of Political Science, Corvinus University of Budapest
agung.wicaksono@stud.uni-corvinus.hu

Abstract

Since its development, the gravity model of international trade has received some critics. However, there have been continuously studies using the model. This paper is a literature review by evaluating some scholarly works that analyse China's trajectory in doing its international trades. China is taken as a case study for the empirical course since the country has been maintaining its international trade with many countries. By doing so, this paper maintains that the gravity model still meets its relevance to understanding international trade patterns. It should also be noted that most studies use an augmented gravity model instead of the traditional one.

Keywords: gravity model, China, international trade

Introduction

In the current globalised world, countries have become more interdependent with each other This is characterised by – among others – economic interconnectivity in the forms of international trades (Ruggiero 2019). Economists have attempted to understand how international trade creates its patterns. One of the models is a gravity model that has been developed even several decades ago before the current massive globalisation.

The gravity model is a model to measure trade flows between countries on a macro basis. This model emphasises that international trade follows the principles of gravity as in physics. In this case, the volume of bilateral trade between two countries is influenced by their masses of the economy and the levels of trade barriers such as distance, tariffs, non-tariff, and information. The model was initially used to calculate international trades (Poyhonen 1963; Tinbergen 1962), and then several years later, some scholars managed to theocratise it for academia (Anderson 1979; Helpman and Krugman 1985).

Yet, the gravity model has also received some critics from many scholars. It is considered that the distance factor could lead to some misspecification and biases (Polak 1996). It has also been identified that its use could overestimate cost variables (Baldwin and Taglioni 2006). Other scholars assert that since the model accept the value of the intercept, it creates error to estimate the determinants of trade flows (Mele and Baistrocchi 2012). It has also been criticised for ignoring the product-level comparative advantage that forms the trade barrier effect in sector-level trade (French 2017).

Given the critics, this paper attempts to review some recent studies that employ the gravity model, especially empirical or case studies. There has been a general review about gravity model by Aguiar & Cossu (2019) as this paper has been inspired from it. To enrich the literature, this paper will add a specific case study related to China and international

trade. Choosing China as part of the subjects is due to the fact that the country has at least two features that could be associated with the gravity model: its massive economy and its trade with many countries across the globe.

First, China is considered the biggest economy. Its Gross Domestic Product (GDP) skyrocketed dramatically in the last decades. In 2020, the GDP was recorded at $14.7 trillion, the second-highest after the United States (US) (World Bank 2021). Second, in terms of trade, China performs international trade with almost all countries in the world. China also managed to create some free trade agreements with many countries in several regions (US Department of Commerce 2022). As such, taking China as an example in the study of the gravity model is reasonable.

This paper is a literature study to examine the development of the application of the gravity model. It is done by accessing EBSCO online database with the keywords: *China* and *gravity model*. we limit the literature published after 2010. This time frame is justified given the importance of China's economic milestone—its GDP ranking as the world's second largest economy in 2010, surpassing Japan's. Although some previous literature may still be useful in describing the gravity model of Chinese international trade, 2010 marked a new chapter in the country's economic history. Therefore, the literature evaluation concentrates on analysis published after 2010. The parameter is set to the subject of international trade. The search found hundreds journal articles and books. Yet, this paper will only review some selected articles from the results that have more relevancy.

This paper is structured as follow. After this introduction, the second part will discuss the basic idea of the gravity model. The third part examines China's economy to justify its importance in international trade. Subsequently, as the core of this paper, the fourth evaluate the selected scholarly works founded from the online database. Last but not least, the fifth part concludes.

Gravity Model

The gravity model comes initially from Newton's Gravity equation in physics to describe the relationship between two objects. It is explained that the gravitational attraction between two objects is proportional to the mass of each object and inversely proportional to the distance between the two. This idea was then developed and widely used in economics, especially international trade.

The initial application of the model to scrutinise international trade was conducted by Tinbergen (1962) as well as Poyhonen (1963). They suggest bilateral trade flows between two countries have positive relations with the level of economy of both countries, and contrastingly have a negative correlation with the geographical distance between them. It was then developed in academia by Anderson and other scholars to create a solidity of the theoretical base (Anderson 1979; Bergstrand 1985; Helpman and Krugman 1985).

The traditional gravity model is illustrated as the following equation:

$$F_{ij} = G\frac{M_i^{\alpha} M_j^{\beta}}{D_{ij}^{\theta}}$$

F stands for the total volume of international trade. *i* and *j* represent country *i* and country *j*. *M* denotes the country's economic scale (given by its GDP). *D* represents the physical distance between both trading countries. While α, β, and θ are the equation's parameters, G stands for the constant. Hence, to be able to use regression, scholars usually convert the model into a linear equation as follows:

$$\ln F_{ij} = \beta_0 + \beta_1 \ln M_j + \beta_2 lnM_i + \beta_3 D_{ij} + \varepsilon_{ij}$$

This represents the logarithmic formulas and refers to regression coefficients. Meanwhile, ε illustrates the error residual. This equation is able to form a linear estimation of the international trade between the two countries.

How the model be used to analyse empirically will be the purpose of this paper. In this particular sense, the case will be China. Before we review some of the existing scholarly works about China using the gravity model, the next section will examine China economic profile, especially its international trade.

China's Economy and International Trade

China is one of the good examples of how a country gains advantages in economic globalisation. A country with a huge population, China even could boost its national economy in a rapid way. The world sees how this country in the last decades has been growing its economy on an average of ten per cent annually. It grew from one of the poorest countries to one of the largest economies in the world.

In terms of nominal GDP, China has been the world's second-biggest economy after the US. Nevertheless, in terms of the Purchasing Power Parity (PPP) per capita, it is the largest on the planet, estimated to be $27 trillion in 2021 (IMF 2022). The Chinese have also grown as the world's largest exporter of goods as well as manufacturing economy. In terms of imports, China is a net importer of services products. This economic trajectory cannot be separated from its open-door policy since the late 1970s and the fact that since 2001, Beijing has held a membership in the World Trade Organisation (WTO). Both make China possible to be a global player in trade and investment.

Not only that, China's immersion into the global economy has broadened to joining more regimes and partnerships. Numerous international economic organisations that involve almost every leading economy across the globe are participated by China. For example, China has memberships in the Asia-Pacific Economic Cooperation (APEC), G-20, G-5, IMF, Pacific Alliance (as an observer), ASEAN Plus Three (as a dialogue partner), and many others. As a result, China maintains trade partners with almost all countries. China's largest trading partners respectively are the US, the European Union (EU), Japan, South Korea, India, Taiwan, Australia, Vietnam, Malaysia, and Brazil.

Trade is one of the important aspects of the Chinese economic trajectory. The WTO in 2020 reported that China's exports and imports of goods in 2019 reached almost $2,500 billion and slightly more than $2,000 billion, respectively. Meanwhile, service exports in the same year reached $281.6 billion while the imports hit $497 billion. This figure represented a 19.5% increase in exports and an 18.7% increase in imports in that year. In the meantime, the World Bank reported that China's goods trade surplus increased from $395.1 to $425.2 billion between 2018-2019. China's overall trade balance, including services, also increased from $103 billion in 2018 to $164.1 billion in 2019.

Moreover, in 2013, China introduced the Belt and Road Initiative (BRI) as a broader economic cooperation scheme with other countries. The important feature is to enhance policy coordination to support free trade with the participating countries. Through the BRI, China attempts to leverage and sustain its economic growth (Huang 2016). By 2021, there are 139 participant countries from many regions spanning from Asia, Africa, Europe, Latin America, and the Caribbean. Including China, sixty-three per cent of the world's population lives within these countries, which account for forty per cent of global GDP (CFR 2021).

That tells the story of how big Chinese economy is. The country managed to grow and become a key economic partner for many countries. China joins many economic partnerships, cooperates with many countries for export and import, and gains returns for its national economy. Therefore, it is reasonable to pay attention to China when one studies the world economy, particularly international trade. Looking back to the gravity model in international trade introduced in the beginning, is the model appropriate to understand China's international trade? The next part will evaluate some of literature that successfully proves its relevancy.

Understanding China from Gravity Model

There have been many studies attempting to understand Chinese economic trajectory using the gravity model. As mentioned, there are dozens of articles, but this paper provides only the selected ones**.** The chosen articles reviewed in this section use the gravity model to investigate China trade potentials related to the BRI, effects of the Asean China Free Trade Area (ACFTA), as well as China's Foreign Direct Investment (FDI).

In terms of China trade potential, Yu, Zhao, Niu, & Lu (2020) examine the effect of the BRI on China's export performance. They analysis China's exports with 45 BRI countries and the world's top 30 trading countries from 2008-2016. Using the gravity model and the model of export potential measurement, they found that China's export potential to the BRI countries grew about 8% faster than non-BRI countries. At the same time, the figure shows stronger effects with countries in the ASEAN and West Asia. This is due to its distances and the countries' GDP in the two regions.

A similar study is also conducted by Jing, Zhihui, Jinhua, & Zhiyao (2020). They analyse the potential of trade in renewable energy products between BRI countries and China. They focus on products of solar, wind, hydro, bio, geothermal, and marine energy. They investigate data of 81 products that have been traded across 66 countries from 2007 to 2017. Espousing the gravity model, they maintain that the GDP of the importing country is the main factor influencing China to export renewable energy products. In this case, every per cent increase in a foreign country's GDP results in a 0.631% increase in China's exports of renewable energy products. Meanwhile, the distance between China and these countries has a negative correlation with China's exports of such products.

Regarding energy products, Leng, Shuai, Sun, Shi, & Wang (2020) further analyse China's potential export of energy products, particularly wind energy, to BRI countries. They examined data of 19 products from 65 countries from 2007–2017. They analyse using the gravity model by adding regression coefficients and residuals. Similar to the previous research, they found that trade in wind energy products between China and BRI countries has increased significantly. However, 81 per cent of the trade is focused mainly in Southeast, South, and West Asia. Exports of the products from China are affected by energy consumption and GDP of importing countries as well as by China's capacity in producing wind energy. On the other hand, the geographical distance between China and the partner countries is correlated negatively.

Meanwhile, China and Asean have been maintaining their economic cooperation. Foo, Lean, & Salim (2020) explore the potential effects of BRI on flows of trade between China and ASEAN. Using an extended gravity model, they examine data on exports, imports, GDP, GDP per capita, land border, common language, and the physical distance between Asean and China from 2000 to 2016. The main finding is that the BRI has

impacted positively on trade flows. The BRI dummy used in the equation has a significant effect at the 5 per cent level. In this case, the BRI does not only benefit Asean countries. The Initiative also gives advantages to other non-BRI countries due to a wider access to international trade. The authors project that trade between China and other non-BRI countries could increase by around 20% thanks to the implementation of the Initiative.

Since China and Asean have turned their economic cooperation into free trade, Jie & Zhihong (2020) examine the trade creation effects of ACFTA. The data analysed is about China's trade with 23 countries in Europe, South America, North America, Oceania, and Asia from 2010 to 2016 which all represent half of China's aggregate exports. Using the gravity model, they project that the GDP growth in partner countries would lead to the increase of trade flow. Hence, the ACFTA would intensify trade volume. When the GDP rises by one per cent, China's total trade would also rise and consequently, it affects the total trade positively even though the figure is not substantial. Meanwhile, the distance has negatively impacted the increase of trade flows. The farther the distance between the two, the fewer trade profits gained since transportation costs increase.

On the same concern to the free trade, Yang & Martinez-Zarzoso (2014) study the impact of the ACFTA on exports, focusing on trade creation and diversion effects. They use aggregated and disaggregated export data of 31 countries - including China, ten Asean countries, and China's top 20 trading partners from 1995 to 2010. The dataset is related to agricultural, manufactured, chemical, machinery and transport equipment products. They argue that ACFTA has a positive effect on overall trade as it removes or at least reduces tariff barriers which, in turn, increases the total trade volume. This is also beneficial not only among ACFTA member countries but also between ACFTA member countries and non-member countries. There was also a significant increase in exports of manufactured goods and chemical products. The same way also happens, albeit in small quantities, to agricultural goods and machinery, as well as transportation products.

Relating to the ACFTA, Schaak (2016) more focuses explicitly on trades of dairy products by questioning whether ACFTA has impacts on international trade of such products. Schaak uses the gravity model and pseudo maximum likelihood (PML) to understand trade creation and diversion effects. He utilises data about disaggregate bilateral trades of 36 countries from 1995 to 2013, focusing on three dairy product groups (milk & cream, butter & fats/oils derived from milk, and cheese & curd). He concludes that ACFTA certainly leads to noteworthy trade creation. Nonetheless, in terms of dairy products, it also creates import diversion and export diversion effects. Hence, since it constitutes a negative net trade creation effect, the FTA should be critically evaluated.

What is the effect of ACFTA on China-Asean trade flows? Sheng, Tang, & Xu (2014) attempts to answer this question by specifically analysing total exports and imports in the trade of parts and components (non-final goods). The dataset is obtained from 76,417 observations of 117 countries from 1980 to 2008. Using an augmented gravity model, they confirm that ACFTA has much broader impacts on bilateral trade between the two parties than what the traditional gravity model suggests. The intensification is focused on countries in Southeast Asia that have close industrial relations with China. More specifically, the trade creation between both parties has also a positive spillover to other countries globally. This is because the other countries outside of ACFTA are involved in the production chain. Moreover, trade creation is more likely dominating the trade diversion because trade in parts and

components tend to be corresponding among the participant countries.

In a different locus, Irshad, Xin, Shahriar, & Arshad (2018) attempt to explain China's trade pattern with OPEC. The data used are bilateral trade data between 14 OPEC member countries with China from 1990 to 2016. They investigate the factors of GDP (including the total per capita and the per capita differences between them), China's trade openness, bilateral exchange rates, geographical distance, and WTO membership. Using the gravity estimation panel, they found that growing GDP and GDP per capita would increase trade flows between OPEC members and China. The openness level and WTO membership have a positive impact on the volume of bilateral trade, and the trade distance has a negative impact. In addition, the depreciation of the bilateral exchange rate also has a negative effect on the trade volume between them.

Apart from the above-mentioned studies, the gravity model is interestingly also used to analyse a pattern of China outward investment. Using an augmented gravity model, Chang (2014) investigates determinant factors behind China's Outward FDI (OFDI) in various regions or countries. He uses data from 138 countries from the period of 2003 to 2009. Chang argues that China's GDP has impacted positively and significantly on China's outward investment motivation, while distance does not substantially contribute to China's OFDI. China's currency appreciation strategy does not really result in the decline of its outward investment.

Conclusion

Many attempts have been successfully done by scholars to employ the gravity model in examining China global economic profile. In the case of China in international trade, some scholars use the basic gravity model while others employ the extended model. Other scholars even combine the model with other models of analysis. We could also take note that mainly the studies are concerned with the BRI as China recent foreign (economic) policy.

The literature managed to analyse the potentials of bilateral trade empirically on China. Some scholars also address specific trade sectors done by China, such as trade on dairy products, renewable energies, and components (non-finished) products. Even some of them could use an augmented gravity model to analyse China's outward FDI.

Hence, although many studies criticise it, the gravity model is proven relevant for analysing a big economy like China. Indeed, we should admit that most scholars advance or augment the model. Only several employ the traditional model. For specific issues, the scholars would use the augmented model or combine it with other equations or models.

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