GRAVITY MODEL ON A SINGLE COMMODITY: A REVIEW OF LITERATURE

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Abstract

Gravity model when applied on specific commodities offer novelty in terms of findings of the demand and supply factors of the specific commodities which are different from the aggregated trade flows. This article provides an extensive systematic review of the literature on the gravity model of trade on single commodities and highlights the research gap that exists for further research. The 'commodity-specific gravity model' is the pioneering model incorporating the characteristics closely related to the specific commodity studied. A significant number of studies of gravity model of specific commodities are focused on primary products, and the scope should be expanded to products in the secondary sector of economy. It is our view that the model can be used to examine the effects of free trade agreements, which may provide suggestion of beneficial trade policies for exporting and importing countries. Future studies can also explore on the methodological aspect of the gravity model, which is still relatively scarce.

Keywords gravity model, commodity-specific, review, trade flows, trade

INTRODUCTION

Gravity model is one of the most frequently applied models in the study of international trade following the seminal work by Tinbergen (1962) and Pöyhönen (1963). Later, Linneman (1966) provided a quantitative framework for the model. Tinbergen (1962) highlighted that the Gross National Product of exporting and importing countries and the distance between the countries as the main explanatory variables of gravity model. Traditionally, economists commonly applied the gravity model of trade to study aggregated trade flows

Hua and Porell (1979) and Kepaptsoglou, Karlaftis and Tsamboulas (2010) are among the limited published review articles on gravity model. Since these last two review articles, the literature on gravity model have experienced further development in terms of both the analysis of trade flows and methodological aspect of the model. However, the literature of gravity model applied on specific commodities have never been reviewed and this research gap deserves specific attention because the various studies offer novelty in finding the demand and supply factors of the specific commodities which are different from the aggregated trade flows. The methodological development of gravity model for specific commodities also differs from that of gravity model in general.

Hua and Porell (1979) reported that the lack of consensus on 'the' gravity model to be applied, in which authors have their own interpretation of 'the' standard gravity model, was a problem in the 1960s and 1970s studies. In another study, Kepaptsoglou et al. (2010), reviewed literature of gravity model from 2000-2010 and noted that past studies have either analysed policies and trade flows, or attempted to improve the performance of gravity models in estimating their parameters. However, it was further pointed out by Kepaptsoglou et al. (2010) that most studies

which analysed policies and flows still offer methodological novelties although it is not the main objective of those studies.

The objective of this article is to provide an extensive systematic review of the literature on the gravity model of trade on single commodities. This article also aims to highlight the research gap that exists that allow further research to be conducted in terms of gravity model on specific commodities. Karemera (1989) noted that none of the prior studies dealt with the disaggregation to single commodity levels. Furthermore, Kang (2003) noted that much can be learned from adopting a microeconomic perspective of international trade with a gravity model because of its high level of explanatory power of bilateral trade flows.

The remainder of the paper is organised as follows: the following section describes the procedures in selecting and reviewing literature for this review. This is followed by an overview of the different studies of gravity model explaining trade flows for single commodity. Next, the specification of gravity model on single commodity including the datasets is reviewed. In the following section, a discussion focusing on the issues of these studies is provided and gap for further research is analysed. Finally, the concluding remark ends this review paper.

REVIEW PROCEDURE

The following procedures are applied in preparing this review. Most of the literature reviewed consists of journal articles, followed by conference proceedings and the rest are made up of several selected doctoral dissertations. Selected doctoral dissertations have been included as the earliest known gravity model applied on one specific commodity is based on a doctoral dissertation by Karemera (1989), and it was further found that some doctoral dissertations provide some deeper insights into the topic. The procedure of selection is as follows:

i. The literature are sourced and gathered by using the combination of academic search engine and academic databases. The main sources are Google Scholar, ProQuest, Science Direct, Oxford Journal, Sage Publication, JStor and Emerald. Examples of keywords include gravity model, commodity-specific, commodity gravity model, disaggregated gravity model, gravity model of trade and single commodity gravity.

ii. All literature are selected based on the relevancy to the topic. Initially, the abstract is screened through before a more thorough reading on the full content is done. It is important to note that only literature with full text in the English language is considered.

iii. The time frame of the studies reviewed is from 1 January 1989 to 30 November 2015. The year 1989 is taken as the starting point as Karemera (1989) highlighted that none of the prior studies has dealt with aggregation to single commodity levels.

COMMODITY-SPECIFIC GRAVITY MODEL

The commodity-specific gravity model is the pioneering model first introduced by Koo and Karemera (1990) to study specific commodities by applying the gravity model. Koo and Karemera (1990) identified determinants of specific commodity trade flows on United States wheat trade by nine exporting countries and 34 importing countries from 1981-1987. Koo and Karemera (1990) replaced the commonly used Gross Domestic Product (GDP) variable to

represent income and instead used the total farm income. Koo and Karemera (1990) described total farm income variable as most closely related to farm production.

In another related study, Koo et al. (1994) identified and evaluated factors affecting volume and direction of meat trade flows, and noted that the commodity-specific gravity model can incorporate the unique characteristics and policies associated with trade flows of the specific commodity in exporting and importing countries. Koo et al. (1994) also used the total farm income to represent the income variable for the industry in this study. The commodity-specific gravity model can be distinguished from the general gravity model as it incorporates the characteristics closely related to the specific commodity studied, and the major change includes replacing GDP which is commonly used as income variable.

DATA AND METHODOLOGICAL ASPECTS

This section discusses the datasets used, the commonly used dependent and independent variables used in specific commodities gravity model and some of the methodological techniques used in estimating the gravity model for specific commodities. Some articles below may adopt Koo and Karemera (1990) commodity-specific gravity model where income and variables used are closely related to the industry studied, although not explicitly stated in the study.

Datasets

Panel data is the most commonly used dataset for gravity model for specific commodities studies as observed in Kepaptsoglou et al. (2010). Egger (2000) noted that panel data in gravity models allow relationships between the relevant variables over a longer period to be identified and panel approach is able to disentangle the time invariant country-specific effects. This is supported by Egger and Pfaffermayr (2003) who argued that the correct gravity specification is a three-way model (time-exporter-importer). Egger (2000) noted that usage of panel data allows researchers tocapture the relationships between the relevant variables over a longer period as well as the identification of the role of business cycle phenomenon.

One particular study by Rabbani et al. (2011) used time-series data, which is not very common. In using time-series data, testing has to be done to check on stationarity, autocorrelation and multicollinearity as explained (Rabbani et al., 2011). Rabbani et al. (2011) examined the determinants of catfish, basa and tra imports to the United States from Vietnam, China and Thailand. The availability of data for a time-series model remain a challenge for gravity model studies, which is one of the reasons of the scarcity of studies using time-series model, besides the strength of panel data as noted by Egger (2000) and Egger and Pfaffermayr (2003).

Common dependent and independent variables

a. *Dependent variables:* In terms of dependent variables (*y*), the trade flow (summation of export and import) of the specific commodities is the most common dependent variable used, followed by the exports and then the imports of the commodities. Taking into consideration that the pioneering studies of gravity model on specific commodities only began in 1990s, most of these studies have already applied the augmented gravity models where the models include

the demand and supply factors of the commodities and trade barriers impeding the trade of such commodities.

The dependent variables vary according to the type of commodities examined which is summarised in Table 1.

Table 1 Studies of specific commodities gravity model by type of commodities and trade flow analysed

Type of commodities	**Literature**
Trade flow of forest and wood products	Polaytov and Teeter (2007); Kangas and Niskanen (2003); Kang (2003)
Export of corns	Jayasinghe, Beghin and Moschini (2010)
Export of groundnuts	Xiong and Beghin (2012)
Export of rice	Ahmad and Garcia (2013); Bui and Chen (2015)
Trade flow and import of seafood	Rabbani, Dey and Singh (2011); Tran, Wilson and Hite (2012); He, Quagrainie and Wang (2013; Natale, Borrello and Motova (2015)
Export of orange	Kapuya (2015)
Export of used automobile	Pelletiere and Reinert (2003)

Authors' compilation from various sources

As the study on a particular commodity progresses, the use of dependent variables changes as well. For example, while Kangas and Niskanen (2003) only focused on the volume of exports of wood, Kang (2003) used the value and quantity of trade of wood products as dependent variables, while in a later study, Polyakov and Teeter (2007) used pulpwood trade, a sum of export and import of wood products.

b. *Independent variables:* The commonly tested demand and supply variables as the independent variables (x) are Gross Domestic Product (GDP), GDP per capita, income specific to the commodities, distance, FTAs, and tariff and non-tariff barriers.

c. *Income specific to the commodities:* This was first introduced in commodity-specific gravity model in Koo and Karamera (1990), and was observed to be used in Koo et al. (1994), Polyakov and Teeter (2007), Jayasinghe et al. (2010). Other studies while analysing the trade flows of specific commodities still applied the commonly used income variable such as GDP. Income usually has a positive relationship with the dependent variable.

d. *Distance:* Distance is a key variable as specified in Tinbergen (1962) model and hence appears in all the studies reviewed. It is usually found that distance has a negative relationship with trade flows, as the further the distance between countries, the higher the transportation cost is. However, whilst distance is an important variable in gravity model of trade, He et al. (2013) omitted the variable because of multicollinearity a rising from the differences in distance between the four importing countries (China, Thailand, Vietnam, Indonesia) are relatively small.

e. *Free trade agreements (FTA):* The trade memberships and FTAs that have been analysed are European Union (EU), Southern African Development Community (SADC), North American Free Trade Agreement (NAFTA), Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC), Andean states and Mercosur. In terms of free trade agreements (FTAs) for specific commodity gravity model, such as by Dascal, Mattas and Tzouvelekas (2002), Kang (2003), Eita and Jordaan (2007), Cardamone (2011), and Jayasinghe and Sarker (2008), the studies largely agreed that FTAs increases trade among the FTA members. Eita and Jordaan (2007) found that membership of Southern African

Development Community (SADC) and being part of Africa are associated with an increase in exports of metal products.

Dascal et al. (2002) analyzed the main factors affecting the trade flows of wine in the European Union (EU) and it was shown that EU integration enhanced trade among members, even in its early days. Cardamone (2011) analyse the effect on trade over the period 2001–2004 of FTAs granted by the EU to developing countries for specific agricultural products of grapes, apples and oranges and found that FTAs appear effective in expanding EU-bound exports from eligible countries for all fruits except oranges. Jayasinghe and Sarker (2008) analysed the effects of North American Free Trade Agreement (NAFTA) on trade in selected agrifood products and found that the share of intraregional trade is growing within NAFTA but also reduced the degree of openness to trade with non-members.

f. *Trade barriers and policies:* Pelletiere and Reinert (2003) developed an ordinal scale for protectionist policies and analysed the trade flows using gravity model and probit estimation, and found that restrictions on used automobile imports reduce the welfare-enhancing global trade of used automobiles. Importantly, the ordinal scale for protection revealed this result while a dummy variable for protection policy will not have a significant result. Meanwhile, Kapuya (2015) measured the trade effects of technical barriers in South Africa's 33 major markets for oranges and found that reducing technical barriers has a fairly significant impact on South Africa's other major markets for the citrus product.

Jayasinghe, Beghin and Moschini (2010), Tran et al. (2012) and Xiong and Beghin (2012) focused on the variable of regulation in gravity model of specific products. Jayasinghe et al. (2010) found that sanitary and phytosanitary (SPS) regulations, tariff and distance as trade cost have negative effect on the export of US corn seed export demand. Tran et al. (2012) found that continually tightening of seafood safety standards has had a negative impact on exporting countries.

Xiong and Beghin (2012) examined the ex-post examination of the harmonization and tightening of European Union maximum residual limits (MRL) on aflatoxins effects on African exports of groundnut products and found that MRL has no significant effect on export of groundnuts from Africa; instead the trade potential is constrained by inability to supply domestically.

The variables discussed here are not exhaustive and there are other variables such as population, exchange rate, common borders and common language which appears in several studies of gravity model for specific commodities.

Methodological Aspects

In general, it is observed that gravity model on specific commodities experienced slower methodological development compared to the general gravity model. The Ordinary Least Squares (OLS) method remains the most commonly applied estimation technique even 54 years after the model was first introduced by Tinbergen (1962). This is the same case for gravity models on specific commodities. Other applied estimation techniques are fixed effect, and random effect estimations, generalised least square, truncated OLS, non-linear least squares and fixed gravity coefficient model. Most of the estimation techniques are applied to compare the robustness and empirical performance with the OLS which was the most common method

to estimate gravity models. Most studies recorded that the alternative method have certain merit compared to OLS but as Santos Silva and Tenreyo (2006) highlighted there can be no estimator can always outperform its competitors.

In recent years, the Poisson pseudo-maximum-likelihood (PPML) method has gained attention and is also applied in the studies of gravity model for specific commodities. The Poisson pseudo-maximum-likelihood (PPML) estimation for gravity model of trade which was introduced by Santos Silva and Tenreyo (2006) has been shown to be robust to various heteroskedastic patterns with the assumption of conditional variance of the dependent variable proportional to its conditional mean. However, only a handful of studies (Jayasinghe et al., 2010; Wilson and Bray, 2010; Cardomone, 2011; Xiong and Beghin, 2012; and Tran et al., 2012) has applied PPML on specific commodities.

RESEARCH ISSUES AND GAPS FOR FUTURE RESEARCH

Firstly, the commodities covered varies from wheat, meat, wood and forest products, rice, metal, vegetable and fruits, seafood, groundnut, and used automobile. However, it is observed that a significant number of studies of gravity model of specific commodities are very focused on primary products. The gap for products to be examined remains large, and can be expanded to products in the secondary sector of economy.

Another important issue on the gravity model for specific commodities is the scope and extent of the commodities examined to be considered a specific commodity. It seems that there has been little discussion on this. Some studies focus specifically on one single commodity such as Koo and Karemera (1990) on wheat, Koo et al. (1994) on meat, while others such as Kangas and Niskanen (2003), investigated a group of forest products. It also seems that studies which analysed seafood trade such Wilson and Bray (2010), Rabbani et al. (2011), Tran et al. (2012), and Natale et al. (2015) usually examined several groups (or types) of seafood together. Among the literature reviewed, there has been no consensus on how specific should the commodity analysed be specified. While more recent studies have specified the Harmonised System (HS) code(s) used in the studies, not all studies report the HS codes used. In fact, if HS codes are used to specify the commodities, the digits of specification also remain an issue whether should it be specific to two digits, four digits, six digits or beyond. These issues provide gaps for further empirical research to answer.

On economic co-operations, some studies focused more on the memberships of geographical associations rather than regional FTAs. Studies that focused on regional FTAs includes Koo and Karamera (1990), Koo et al. (1994), Kang (2003) and Jayasinghe and Sarker (2008). On the other hand, studies in this field that are more focused on the regional geographical membership or association are Kangas and Niskanen (2003), Eita and Jordaan (2007) and Kapuya (2015). The World Trade Organisation reported that as of February 2016, there are 267 FTAs in effect. Given the high number of FTAs in effect against the currently studied FTAs in terms of specific commodities, further studies can be focused on examining the effects of FTAs, and may provide suggestion on beneficial trade policies for exporting and importing countries.

In addition, few studies attempted to improve the methodological aspect of the gravity model, while more are focused to study the effect of trade flows using gravity model. The few studies that aim to improve the methodological aspects are studies such as Polaytov and Teeter (2007)

and Tran et al. (2012). It can be inferred that there are more general gravity model studies that are continuously improving the econometric estimation of gravity model compared to gravity model for specific commodities. For example, PPML which was introduced in 2006 was only adopted in studies for specific commodities in Jayasinghe et al. (2010), a lag of four years to be adopted in specific commodities gravity model.

CONCLUDING REMARK AND OUTLOOK

Gravity model remains one of the most commonly applied models to examine factors affecting demand and supply of goodsin international economics since it was first introduced. The authors note that categorising gravity model into specific commodities studies is not common, unless explicitly highlighted by the commodity-specific gravity model studies such as Koo and Karemera (1990) and Karemera et al. (1994). However, the increase in the number of literature in this field of gravity model has made it increasingly important to highlight the developments and the research gaps that deserves more attention in future studies.

This review has shown that in terms of methodological development, although numerous methodological techniques such as NLS and PPML have been adopted, more can be done in terms of exploring various other empirical techniques to improve the methodological development of gravity model for specific commodities. However, the commonly used traditional techniques such as OLS are unlikely to be neglected yet as over the years it has shown results with high explanatory power.

It is also observed that a significant number of studies of gravity model of specific commodities are focused on primary products, and further research can be focused on other products, including those in the secondary sector of the economy. In terms of FTAs, currently available studies focused on only a handful of FTAs, hence, further studies may further explore the effects of other FTAs which may provide further insights into a more comprehensive economic effect of FTAs, especially those applied in other regions of the world. While gravity models in examining specific commodities are able to provide more focused findings and results of the demand and supply factors of the specific commodities, its results are also limited to the specific commodity only, and may not reflect the full ecosystem of trade flow being examined. Hence, in terms of this limitation, accompanying macroeconomic results should be reviewed together as a whole to facilitate rational and optimal policymaking decisions that may benefits the stakeholders of the specific commodity and the economy as a whole.

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