A Pendulum Gravity Model of Outward FDI and Export

Abstract

The paper proposes a pendulum gravity model of outward FDI and export. Outward FDI and export can be complementary or substitute, depending on the development stages of outward FDI. The development of outward FDI is accompanied by advancements in productivity, technology and favorable transformations in factor endowment differences, which can be reflected in the ratio of export to outward FDI. At early stages of outward FDI undertakings, the ratio of export to outward FDI is greater or much greater than the world's average, outward FDI and export are conjectured to be complementary with our analytical framework. As outward FDI matures, the pendulum swings to the other side, i.e., the ratio of export to outward FDI becomes smaller than the world's average. Outward FDI and export turn into substitute then. Empirical results and findings from examining two panel data sets support our conjecture and the proposed model, which integrate the two seemingly opposing sets of literature.

Key words: pendulum gravity; outward FDI; export

1. Introduction

The relationship between FDI and trade has drawn intensive attention of many scholars, stretching back five decades and showing no signs of fading (Blonigen, 2001; Buckley & Casson, 1981; Chang & Gayle, 2009; Dunning, 1988; Helpman, Melitz, & Yeaple, 2004; Kojima, 1977; Lankhuizen, de Groot, & Linders, 2011; Mundell, 1957; Oberhofer & Pfaffermayr, 2012; Vernon, 1966). This paper concentrates on the relationship between export and outward FDI, where debate goes on with regard to substitution or complementation between them. It is argued that outward FDI substitutes export in many studies, including Vernon (1966), Buckely and Casson (1981), Gopinath, Pick and Vasavada (1999), among others. A few are by design for substitution, such as Oberhofer and Pfaffermayr (2012), Lankhuizen, de Groot and Linders (2011) and Chang and Gayle (2009). However, on the other hand, Kojima (1978a, b), Jacquemin (1989) and Patel and Pavitt (1991) hold the opposite views that outward FDI complements export.

The interaction between trade and FDI, especially the relationship between outward FDI and export, remains an unresolved issue. Insights into the trade-FDI relationship will contribute towards a better understanding of the process of internationalization and its potential impacts on economic growth. In particular, whether export and outward FDI complement or substitute with each other matters practically. Given a substitute relationship, firms or nations need to consider their international business strategies and overall objectives carefully. Advancement in one area too far may result in deterioration in another. Likewise, advancing on two fronts with a complementary relationship may be favorable on the one hand; it may meet with retaliations on the other, in terms of tariffs and barriers to entry. After all, how either relationship arises should be taken into a set of circumstances, which change over time. The issues may cause policy dilemmas or strategic dilemmas, which nations and firms have to face up. To provide a common platform for debate, we pose a unifying theory

in this paper that can accommodate both complements and substitutes, in a dynamic process along with development stages. This theory is then embedded in a pendulum gravity model for the examination of how trade and FDI interact with each other. It is conjectured that export and outward FDI can be complementary or substitute, depending on the stage of outward FDI, which is indicated by the position of a clock pendulum. The pendulum swings between the maximum angle right from vertical (say 3 o'clock), the primitive stage with zero outward FDI, and the maximum angle left from vertical (9 o'clock), the advanced mature stage of bulky outward FDI, passing through its resting equilibrium position (6 o'clock). It swings and accelerates towards the equilibrium position due to the force of gravity. The two alternating effects of complementation and substitution are vividly portrayed by, and integrated in, our model as shown in Figure 1. Export and outward FDI are complementary when the movement of the pendulum is accelerating from right to vertical, and they become substitute when the pendulum has passed 6 o'clock and swings leftward further.

{Figure 1 here}

Our pendulum gravity model differs from the conventional gravity model of trade and/or FDI. The latter is originally typified with the geographical distance, economic mass and spatial feature, which have been extended to include "distances" in and masses of technology, productivity, and institution and culture, among others. It will be seen later in Section 3 that our pendulum gravity model is a model of dynamic gravity – the pendulum moves while time is ticking, mimicking outward FDI that progresses through stages. It also caricatures the transformation of potential energy into kinetic energy in physics. In contrast, conventional gravity models are models of static gravity. Developing the pendulum gravity model, the present study is a response to the mixed results for the trade-FDI relationship documented in the literature. We propose that the relationship is dynamic and shifting, rather than static and fixed. It is a dynamic process that evolves in the trade-FDI relationship while outward FDI

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grows gradually. That is, our study is not another attempt to engage in the debate on the separate complementary effect or substitute effect or their static co-presence.

We then implement this pendulum gravity model empirically to establish how the complementary and substitute effect on export of outward FDI evolve at different stages of development. In this study, we have made two panels of exports and outward FDI in a balanced approach. The first panel is China, the largest developing country in the world, versus OECD countries that are more advanced than China. The second panel is the US, the world's largest economy as well as largest developed country, versus groups of developing economies. With the first panel, we have examined the panel data of exports and outward FDI flows from China to OECD countries, and *vice versa*. Likewise with the second panel, we have examined the panel data of exports and outward FDI flows from the US to the developing countries, and *vice versa*. Our results demonstrate that outward FDI complements export in the case of China as a beginner in outward FDI undertakings. Reversely, in the case of OECD as well-developed economies with many world-known MNCs, outward FDI substitutes export. Similarly, US outward FDI substitutes its exports to the developing countries, whereas outward FDI of the developing countries complements their exports to the US.

The rest of the paper progresses as follows. The next section reviews the literature in the study of the relationships between export and outward FDI. Summarizing and reflecting on these empirical studies, pertinent hypotheses are put forward. A theoretical pendulum gravity model of outward FDI and export is accordingly proposed and illustrated in the third section. The fourth section presents the implementation and tests of the empirical model, including an introduction to data sets and choice of variables. The results are analyzed and discussed next. The final section concludes this study.

2. A brief review of studies in outward FDI-export relationships

A wide range of theoretical and empirical studies have investigated the relationships between FDI and trade in the last few decades. Many have focused on export and outward FDI. In theory, there can be two kinds of relationships between export and outward FDI: one is complementary and the other is substitute. Either has found empirical backings. As the literature is extensive and diverse, representative studies are summarized and presented in Table 1, indicating specifically whether they endorse a complementary or substitute relationship between export and outward FDI. Synthesizing the roles played by various factors under the given circumstances, reviews of literature in these two strands are therefore helpful for us to gain a broadened picture. This facilitates the development of unifying theories and models, such as that in the present study, which encompass the two seemingly opposite views.

{Table 1 here}

2.1. Substitution between FDI and export

The product life cycle model of Vernon (1966) views the life cycle of production in three stages, which evolve from introduction of a new product, through product maturity, and to product standardization. It is believed in this model that with the maturity of the product, the firm chooses producing the products in different places to achieve various objectives. The relationship between trade and FDI alternates with the phases of the cycle accordingly, which can be reflected in the internationalization process when extended into an international arena. According to internationalization process theory (Andersen, 1993; Buckley & Casson, 1976; Dunning, 1993; Hedlund & Kverneland, 1983), manufacturing firms are likely to undertake incremental steps to serve unknown foreign markets. They do so by exporting first, until sufficient experience is accumulated and necessary knowledge is acquired to operate a direct subsidiary overseas. This is because exporting requires less investment in sunk costs than FDI

and is the least risky mode of serving unknown markets. In this context, internationalization process theory postulates that FDI is a substitute for export only when higher fixed costs associated with foreign production can offset external transaction costs associated with export. FDI does not substitute export by the time when sufficient experience and knowledge are accumulated to operate a direct subsidiary, but higher fixed costs associated with foreign production have yet to offset external transaction costs.

Different from Vernon, Dunning's (1980; 1988; 1993) eclectic paradigm of international production combines three main factors in explaining international production: ownership factors (O) specific to firms, location factors (L) specific to home and host countries, and internalization factors (I) of firms. It is hence referred to as the OLI framework. The OLI paradigm suggests that firms tend to replace exports from the home country, or imports of the host country when they invest abroad. MNCs are exploiting their ownership advantages through controlling specific assets in facilitating their foreign subsidiaries to reduce costs and generate returns. Many large MNCs also invest in subsidiaries that produce intermediate products. These MNCs exploit the advantages accrued due to internalization and tend to replace exports of inputs from the home country. Analyzing inward FDI into Japan from 1989 to 1992, Kimino, Saal and Driffield (2007) have established that Japan's inward FDI is the substitution of source countries' exports. Exports and direct investments are alternative ways to serve foreign markets. They further indicate that multinational activities motivated by market penetration or barriers to trade tend to substitute for trade. Conversely, resource extraction and outsourcing FDI lead to an increased trade volume, thereby complementing trade.

The displacement of export by FDI due to a combination of location and ownership advantages under imperfect market conditions has been demonstrated in other studies (Adler & Stevens, 1974; Buckley & Casson, 1981; Chang & Gayle, 2009; Hirsch, 1976). Adler and

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Stevens (1974) have found that exports are substituted for by foreign sales of subsidiaries to varied degrees, when the products are perfect or partial substitutes under constant returns to scale. One of the most important location factors that act as an incentive for firms to invest abroad relates to lower costs of production (Dunning, 1988; Hirsch, 1976; Sharz, 2004). This could be due to the abundance of a factor in the foreign market, or tax incentives that make production cheaper. It is suggested that a firm's decision will have a pro-export bias in a high-cost host country and a pro-investment bias in a low-cost host country. However, the cost of production in the foreign market is not the only consideration. Buckley and Casson (1981) point out that a firm has also to take into consideration the other costs associated with marketing and transportation in serving foreign markets. These costs vary with the distances to different countries. The results in Arribas and Pérez (2011) indicate that the importance of distance has been increasing until the mid-1990s but has since returned to the levels of 30 years ago. Therefore, the role of distance they claim, on average, still exists. Chang and Gayle (2009) develop a model to show the trade-off between exports and FDI under market demand uncertainty when transportation or time costs are important. They conjecture that high transport costs and imperfect information about local market conditions may systematically trigger firms to undertake FDI. These costs also vary with the levels of tariffs. Daniels and Ruhr (2014) consider different transportation costs and found a substitute relationship between US FDI and trade flows consistent with a horizontal MNE activity. As the level of tariffs increases, costs of marketing increase relative to costs of production abroad, therefore firms are induced to invest abroad instead of exporting (Buckley & Casson, 1981; Hirsch, 1976; Horst, 1972a, b). Horst (1972a, b; 1977) focuses specifically on the effect of tariff levels on the relationship between trade and FDI. He believes that the tariff level of the host country determines the location choice of production. MNCs will switch from FDI to export at the point where marginal costs to produce fall to equal, or below,

marginal profits. If the host country raises its tariff level, the price in the host country will also rise. Consequently, the import volume will be reduced and the MNC will expand the product scale in the host country to avoid high tariffs, and *vice versa*. Scrutinizing export volumes, taxation, and subsidiaries' production in different industries of US MNCs in Canada, Horst (1972b) shows that direct investment and trade substitute each other. In practice, high levels of tariffs are typically adopted by developing countries as an import-substitution policy to attract FDI. Tariffs are also imposed to discourage MNCs from exporting their product from their home country, but to encourage them to invest and produce in the host economy. High tariffs may also be supplemented by tax-incentives to further reduce the cost of FDI as compared to exporting. Therefore, low levels of market openness tend to make the relationship between trade and FDI substitute.

Another important factor that contributes to the relationship between outward FDI and export is research and development (R&D), or technology. It exerts effects directly on MNCs' production costs and productivity. Costs are incurred both due to direct investments in R&D, and due to the maintenance of proprietary on income-producing assets resulted from R&D. These help firms to create a unique differentiated product. In order to reap the benefits of R&D, firms are induced to internalize their ownership benefits (Buckley & Pearce, 1979; Gruber, Mehta, & Vernon, 1967). Research-intensive industries tend to be highly concentrated. There are several important reasons for firms with a high degree of R&D to internalize markets. Buckley and Pearce (1979) have identified the following five major considerations: a long gestation period for products with high R&D intensity, safeguarding monopoly over the product, public goods shared within the firm, exercising discriminatory pricing policy, and easy knowledge transfer within the firm. Thus high-tech firms are under pressure to invest in the host country to maintain market shares. Such an analytical

framework suggests that sales in the local market due to FDI are likely to grow at a higher rate than export, thus FDI tending to substitute for export.

Some recent empirical studies also support the substitution relationship between FDI and export based on factor endowment, productivity, comparative advantage and technology. Helpman *et al.* (2004) interpret how firms make up their mind when facing the choice between FDI and export, in view of productivity differences of firms. The most productive firms choose to invest in foreign markets while less productive firms choose to export, and FDI is more likely to substitute trade by firms with higher productivity. This idea is also supported by Kimura and Kiyota (2006). They suggest that the most productive firms engage in export and FDI, medium productive firms engage in either export or FDI, and the least productive firms neither export nor invest abroad. There is a difference between what is stipulated by Helpman *et al.* (2004) and that by Kimura and Kiyota (2006), though. The substitution of export by outward FDI is associated with the most productive firms in Helpman *et al.* (2004), while the substitution between export and outward FDI resides in medium productive firms in Kimura and Kiyota (2006). Extending the above analysis to a two-country scenario, whether outward FDI substitutes or complements export would depend on productivity differentials between the firms in the two countries.

It has been made clear that the studies advocating a substitute relationship between outward FDI and export are usually reflected by certain advantages possessed by a FDI source country over a FDI host country. These advantages include specifically technology and monopolistic power. MNCs are motivated to access more markets and gain higher market shares, to minimize unit R&D costs, to acquire cheap labor and natural resources, or to avoid high tariffs. Therefore, a substitute relationship between outward FDI and export is often observed where the home country is relatively developed and mature in outward FDI undertakings.

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2.2. Complementary relationship between FDI and export

Nevertheless, many other studies present a complementary relationship between FDI and trade. Schmitz and Helmberger (1970) have shown that FDI leads to increased exports of capital goods from the home country, when technologically advanced countries make investments in the primary sector of resource rich countries. The investment is made due to differences in factor endowments, demand habitat and production conditions. Such investment leads to a vertical integration of production between developed and developing countries, with the labor-intensive production taking place in developing countries and the capital-intensive production between developing and developed countries. This is known as international division of labor (IDL). FDI undertaken to exploit IDL and thereby vertical integrations of production leads to inter-industry trade between countries. IDL is helpful to explain the relationship between outward FDI and export, when FDI flows are from a developed country to a developing country. The developed country becomes a net exporter of capital-intensive intermediate products and a net importer of labor-intensive final products. Thus, international investment made in resource-based production leads to increased levels of trade, and is therefore trade creating in nature. This kind of probe also takes factor endowments and technology into consideration, which is similar to those theories that support a substitute relationship between export and outward FDI. However, it reaches a different deduction. In that sense, FDI will make developed countries become a net exporter of capital-intensive intermediate products; therefore, FDI complements export.

As one of the leading international economists, Kojima supports a complementary relationship between trade and FDI in a different and rational way. He puts forward the theory of comparative advantage to investment in the mid-1970s by examining trade and FDI between the US and Japan (Kojima, 1977). His approach is based on the theory of comparative advantages as the fundamental, further taking IDL into account. It is shown that

FDI going from a comparatively disadvantageous industry in the investing country, which is potentially a comparatively advantageous industry in the host country, will promote an upgrading of industrial structure on both sides and thus accelerate trade between the two countries. When investments are made in sectors in which the home country has a comparative advantage, export and FDI will be substitutes. Making direct investment abroad would create competitive production against its own exportables when the investing country has a comparative advantage in a product, hence destroying trade (Kojima, 1978a). Kojima (1978b) applies this distinction to Japanese and US investments. He shows that Japanese FDI is trade creating as it is invested in sectors in which it has a comparative disadvantage. In contrast, US FDI tends to compete with its own export because its investments are made in sectors in which US has a comparative advantage. Kojima's findings reject the essentiality of monopolistic advantages. These findings are mostly applicable to medium-sized and small enterprises. Kojima's theory has been confirmed by many empirical studies, especially when the country of interest is Japan.

Specifically, Yamawaki (1991) examines the effects of Japanese FDI on its exports, using a cross-section analysis of 44 Japanese manufacturing subsidiaries in the US in 1986. Regression estimates have shown that Japanese investments in distributional activities have enhanced Japanese exports to the US. Empirical analysis by Head and Reis (2001) corroborates Yamawaki's results. Their investigation of 932 Japanese manufacturing firms over 25 years (1966-1990) shows that, at the aggregate level, FDI in both manufacturing and distribution facilities has led to increased exports from Japan. Pantulu and Poon (2003) examine the US and Japanese outward FDI to 29 and 32 countries respectively for the period between 1996 and 1999. Their results indicate that the complementary effect of outward FDI on exports dominates on the whole. Further, the trading creating effect of outward FDI is stronger with shorter the geographical distance. That is, the trading creating effect of US FDI

is the highest with Canada; while the trading creating effect of Japanese FDI is the highest with Malaysia and Thailand.

Studies on other countries also support a complementary relationship between outward FDI and export. For example, examinations of Taiwanese FDI in four ASEAN countries (Indonesia, Malaysia, the Philippines and Thailand) have also exhibited a complementary relationship (Lin, 1995). Alguacil and Orts (1999) have found that, controlling for relative market size and prices, time series analysis of outward FDI and export from Spain between 1970 and 1992 indicates a positive long-run causality of outward FDI to export. Camarero and Tamarit (2004) show a general complementary relationship between FDI and trade for 13 countries, including 11 EU member countries plus US and Japan, from 1981 to 1998. Görg and Labonte (2012) maintain that the 107 countries that implemented trade protection measures are associated with about 40 to 80 per cent lower FDI inflows since the start of the crisis in 2008. Their results suggest that trade and FDI are moving toward the same direction during the 2006-2009 period. In other words, trade liberalization and FDI can be potentially in a complementary relationship. Cardamone and Scoppola (2012) investigate the impact of preferential trade agreements (PTAs) on the patterns of outward stocks of EU FDI. They use a sample of 173 host countries and the EU as the home country covering the period 1995-2005. They have found that a high EU tariff tends to discourage EU outward FDI. In other words, a low tariff based on PTAs encourages EU outward FDI.

2.3 Mixed results for FDI and export relationships

A number of studies support a contingent view, which suggests that FDI-export relations may present different patterns subject to specific conditions. For example, Amiti and Wakelin (2003) pay attention to the effect of cost of FDI on exports. They look at bilateral trade flows between 36 counties, including both OECD and developing countries, for the period from

1986 to 1994. Their findings suggest investment liberalization stimulates exports when countries differ in relative factor endowments and trade costs are low, whereas investment liberalization reduces exports when countries are similar in terms of relative factor endowments and size, and trade costs are moderate to high. Another example is from Herander and Kamp (2003). They look at information asymmetry problems faced by foreign firms. To handle the lack of full information on the cost structure, foreign firms may have three options: no entry, enter via export and incur the costs of a tariff, and enter via FDI and avoid the tariff. They have found that when entry mode is altered, other standard full-information effects of trade policy may also no longer hold. The study by Braunerhjelm, Oxelheim, and Thulin (2005) highlight issues regarding different types of direct investment. They argue that a complementary relationship can be expected to prevail in vertically integrated industries, whereas a substitute relationship can be expected in horizontally organised production. An uncertainty model by Chang and Gayle (2009) highlights the impact of demand volatility. They argue the FDI-export relationship might be "either-or". Using a panel of US firms' sales to 56 countries between 1999 and 2004, they find whether a firm chooses to serve foreign markets by exports or via FDI may depend on demand volatility along with other well-known determinants such as size of market demand and trade costs. Drawing on Helpman *et al.* (2004)'s study, Oberhofer and Pfaffermayr (2012) analyze European companies' probability of using export or FDI strategy based on a bivariate probit model. Their empirical evidence indicates that more productive firms less probably use the export strategy to serve foreign markets. They also found that a considerable number of companies actually use a combination of both the strategies to serve foreign markets.

Several studies have explored conditions under which OFDI and export relate in China. For example, Liu, Wang, and Wei (2001) investigate the causal relationship between FDI and trade (exports and imports). Based on a panel of bilateral data for China and 19 home

countries/regions over the period 1984–1998, they have two main findings: the growth of China's imports causes the growth in inward FDI from a home country/region, which, in turn, causes the growth of exports from China to the home country/region. However, they were unable to consider China's outward FDI, constrained by their time period and span. Similarly, the study by Li and Zhang (2008) explores the development path of China through a "catch-up process". They argue that the label of export-led model of China may not reflect the real picture as imports underwent dramatic increases during their respective growth periods. They found that FDI has played a pivotal role in its economic growth and has major presence in international trade. Recently, Zhao, Liu, and Zhao (2010) examine the effect of China's OFDI on growth in its own productivity. They argue specific reasons for this growth, namely, R&D, technology sourcing and improvements in efficiency. Their analysis of Chinese outward FDI in eight developed countries during the period 1991 to 2007 shows that Chinese outward FDI has had beneficial spill-over effects in improving total factor productivity growth over the period of the study.

In summary, a variety of factors influence the relationship between outward FDI and export to different degrees. Productivity, technology, and factor endowment differences are identified to be the most crucial ones among them, which reflect the maturity in outward FDI and the economic distance between participating countries. Investment flows from relatively advanced countries to less experienced countries tend to substitute the home country's export, in terms of maturity in FDI. On the contrary, FDI flows from less experienced countries to countries with an edge in technology and productivity would complement the home country's export. Economic distances play a similar role in shaping the relationship between outward FDI and export as advancements in productivity and technology. The trajectories in outward FDI and export are therefore featured by accelerated increases in outward FDI accompanied by increasing export initially; steady increases in outward FDI accompanied by increasing

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export next; increasing outward FDI accompanied by still increasing but decelerating export thereafter; decreasing export lastly when growing outward FDI entering into the mature stage. The assumed trajectories of export-outward FDI relationships are in line with investment development path (IDP). In this respect, Dunning (1981) suggests that there is a systematic relationship between the determinants of FDI flows and the stage and structure of a country's economic development. In addition, Narula and Dunning (2000) develop IDP in relation to developing economies. They suggest that the primary relationships are consisted of five stages. At stage 1 a country has little or no inward FDI, then have growing inward FDI and little outward FDI at stage 2, and move to a rising inward FDI and rising outward FDI at stage 3, and to be with stronger outward FDI than inward FDI at stage 4 with some fluctuations between the two at stage 5. Using annual data for the period 1979 to 2005, Marton and McCarthy (2007) demonstrate the form of the IDP for China. They conclude that China has entered stage 3 of the path postulated by the IDP theory.

Beyond the cycle, export volumes fluctuate, accompanied by fluctuating outward FDI in opposite directions. Figure 2 portrays such trajectories in outward FDI and export. The left vertical axis is for export and the right vertical axis is for outward FDI.

{Figure 2 here}

The above trajectories are brought about by advancements in productivity and technology and favorable transformations in factor endowment differences. Such trajectories reveal and exhibit a falling export to outward FDI ratio with gradual maturity in outward FDI. Therefore, the ratio of export to outward FDI becomes a central indicator when we consider the effects exerted on export by outward FDI. It is a unifying factor that integrates many of the above reviewed and identified factors that influence export-outward FDI relationships in a dynamic alternate fashion, evolving over time and swinging between complementation and substitution. A similar approach has been taken by other studies such as Chang and Gayle

(2009). The next section develops a pendulum gravity model of outward FDI and export along this line of inquiry. It can be demonstrated that evolving export-outward FDI relationships from complementation to substitution bestow an optimal trajectory for the production function for overseas and domestic production and sales. The production function, featured by a pendulum gravity model, is maximized on the optimal trajectory at various development stages of outward FDI, progressing with a falling export to outward FDI ratio.

3.   A pendulum gravity model of outward FDI and export

This section outlines the development of a pendulum gravity model of outward FDI and export, with which a dynamic process evolves in the trade-FDI relationship while outward FDI grows gradually. The model entitles a three-fold hypothesis test, following the discussion, reflection and synthesis in the previous sections:

> **Hypothesis 1:** The relationship between export and outward FDI, being complementary or substitute, depends on the stages of outward FDI as reflected by export to outward FDI ratios.

The development of outward FDI is accompanied by advancements in productivity and technology and favorable transformations in factor endowment differences reflected by a falling export to outward FDI ratio with gradual maturity in outward FDI. Unifying and integrating many of the identified factors that influence export-outward FDI relationships, the ratio of export to outward FDI becomes a central indicator for the export-outward FDI relationship to evolve from complementation to substitution, as well as the degrees of complementation and substitution. Moreover, developed economies have entered a mature stage of outward FDI undertakings with a below world average ratio of export to outward FDI, a substitute relationship between outward FDI and export is expected. Therefore:

Hypothesis 1a: FDI from developed mature economies to developing countries has a negative impact on the exports by the former.

Developing countries are less experienced in outward FDI with an above, or much above world average ratio of export to outward FDI. FDI from developing countries to countries with an edge in technology and productivity would complement the home country's export. Consequently:

Hypothesis 1b: FDI from developing countries, who are less experienced in outward FDI, to developed countries, who have entered the mature stage of outward FDI, promote the former's exports.

3.1. The model

Let us consider an augmented Cobb-Douglas function for proceeds from overseas and domestic production and sales:

$$Q(OSPS_t, DPS_t) = k \cdot OSPS_t^{\beta} \cdot DPS_t^{(1-\beta)} \tag{1}$$

where $k > 0$ and $0 < \beta < 1$ are constant, $OSPS_t$ is overseas production and sales, and DPS_t is domestic production and sales. Further, overseas production and sales consist of two elements: outward FDI and export. While the elasticity of substitution between overseas and domestic production and sales is constant, the elasticity of substitution between outward FDI and export is not. The latter takes into account the effect of pendulum gravity that swings between the two overseas undertakings. When outward FDI is negligibly small, it does not substitute export; it may instead go with export in a learning and catch-up process. Outward FDI exerts a gradually increasing substitution effect or decreasing complementation effect on export as it becomes substantial. These are reflected in the varying marginal rates of technical substitution (MRTS) that our model is able to produce, which can be either positive

(substitute) or negative (complementary). A proceeds function adjusted by pendulum gravity

for overseas activity, featured by a non-constant elasticity of substitution, is then derived:

$$Q\left(XP_t, OFDI_t, DPS_t\right) = k \cdot OSPS_t^{\beta} \cdot DPS_t^{(1-\beta)}$$
$$= k \cdot XP_t^{\beta\alpha_{gt}} \cdot OFDI_t^{\beta\left(1-\alpha_{gt}\right)} \cdot DPS_t^{(1-\beta)} \tag{2}$$

where XP_t is export and $OFDI_t$ is outward FDI. The pendulum gravity weight is given as:

$$\alpha_{gt} = \frac{\gamma OFDI_t}{XP_t + \gamma OFDI_t} \tag{3}$$

γ is chosen as the ratio of world total export to total outward FDI or a function of the ratio.

$\alpha_{gt} \approx 0.5$ when outward FDI (γ adjusted) and export have a comparable size. The pendulum

swings between 3 o'clock ($\alpha_{gt} = 0$) and 9 o'clock ($\alpha_{gt} = 1$) and with a tendency to move

towards 6 o'clock ($\alpha_{gt} = 0.5$) from either side. The pendulum swings and accelerates from the

maximum right angle (3 o'clock) where $\alpha_{gt} = 0$ towards vertical (6 o'clock) where $\alpha_{gt} = 0.5$;

the pendulum then swings and decelerates from vertical towards the maximum left angle (9

o'clock) where $\alpha_{gt} = 1$. $\alpha_{gt} = 0$ represents the primitive stage with zero outward FDI, and

$\alpha_{gt} = 1$ represents the advanced mature stage of bulky outward FDI. $\alpha_{gt} = 0.5$ is the

equilibrium position and also the turning point when the complementary relationship between

export and outward FDI is being turned into a substitute relationship between them. The

complementary effect becomes weaker and weaker when the pendulum moves closer to the

vertical line from the right side; and the substitute effect is also weak when the pendulum has

just passed the vertical line to the left. At this stage around the equilibrium position, either the

complementary effect or the substitute effect can be ambiguous, offering explanations to a

mixture of findings in the empirical literature. Equation (2), together with equation (3),

suggests that when export is much larger than outward FDI (α_{gt} is close to being 0), the

marginal contribution of export is very small. Increasing outward FDI may not reduce the

marginal contribution of export; it may help raise the marginal contribution of export. When the pendulum swings to the other side, the opposite phenomenon emerges.

Now let us work out the MRTS between the three activities. Note that three factors can't substitute each other in turn. i.e., if domestic production substitutes export and outward FDI, then export and outward FDI won't be able to substitute each other, they have to be complementary. Likewise, when export and outward FDI substitute each other, domestic production must be complementary with either export or outward FDI.

Partial derivatives of the production function with respect to export, outward FDI and domestic production and sales follow. The first is partial derivative of the production function for export:

$$
\begin{aligned}
\frac{\partial Q}{\partial XP_t} &= k\,\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\,XP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}-1\right)}OFDI_t^{\left(\frac{\gamma XP_t}{XP_t+\gamma OFDI_t}\right)}DPS_t^{(1-\beta)}\\
&\quad -kXP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}OFDI_t^{\left(\frac{\beta XP_t}{XP_t+\gamma OFDI_t}\right)}Ln\!\left(XP_t\right)\frac{\beta\gamma OFDI_t}{\left(XP_t+\gamma OFDI_t\right)^2}DPS_t^{(1-\beta)}\\
&\quad +kXP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}OFDI_t^{\left(\frac{\beta XP_t}{XP_t+\gamma OFDI_t}\right)}Ln\!\left(OFDI_t\right)\frac{\beta\gamma OFDI_t}{\left(XP_t+\gamma OFDI_t\right)^2}DPS_t^{(1-\beta)} \quad\quad (4)\\
&= kXP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}OFDI_t^{\left(\frac{\beta XP_t}{XP_t+\gamma OFDI_t}\right)}\frac{\beta\gamma OFDI_t}{\left(XP_t+\gamma OFDI_t\right)^2}DPS_t^{(1-\beta)}\\
&\quad \cdot\left[\frac{XP_t+\gamma OFDI_t}{XP_t}-Ln\!\left(XP_t\right)+Ln\!\left(OFDI_t\right)\right]
\end{aligned}
$$

Partial derivative of the production function for outward FDI is:

$$\frac{\partial Q}{\partial OFDI_t} = kXP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}\frac{\beta XP_t}{XP_t+\gamma OFDI_t}OFDI_t^{\left(\frac{\beta XP_t}{XP_t+\gamma OFDI_t}-1\right)}DPS_t^{(1-\beta)}$$

$$+kXP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}Ln(XP_t)\frac{\beta\gamma XP_t}{\left(XP_t+\gamma OFDI_t\right)^2}OFDI_t^{\left(\frac{\beta XP_t}{XP_t+\gamma OFDI_t}\right)}DPS_t^{(1-\beta)}$$

$$-kXP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}OFDI_t^{\left(\frac{\beta XP_t}{XP_t+\gamma OFDI_t}\right)}Ln(OFDI_t)\frac{\beta\gamma XP_t}{\left(XP_t+\gamma OFDI_t\right)^2}DPS_t^{(1-\beta)} \qquad (5)$$

$$=kXP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}OFDI_t^{\left(\frac{\beta XP_t}{XP_t+\gamma OFDI_t}\right)}\frac{\beta\lambda XP_t}{\left(XP_t+\gamma OFDI_t\right)^2}DPS_t^{(1-\beta)}$$

$$\cdot\left[\frac{XP_t+\gamma OFDI_t}{\gamma OFDI_t}+Ln(XP_t)-Ln(OFDI_t)\right]$$

While partial derivative of the production function for domestic production and sales is:

$$\frac{\partial Q}{\partial DPS_t}=k(1-\beta)XP_t^{\left(\frac{\beta\gamma OFDI_t}{XP_t+\gamma OFDI_t}\right)}OFDI_t^{\left(\frac{\gamma XP_t}{XP_t+\gamma OFDI_t}\right)}DPS_t^{(-\beta)} \qquad (6)$$

For a three factor model, MRTS between any two factors is derived with the third factor being assumed constant, which can be plotted with a 2-dimensional isoquant curve. A 2-dimensional isoquant curve for exports and outward FDI, or MRTS between export and outward FDI then is:

$$MRTS_{OFDI,XP}=-\frac{dOFDI_t}{dXP_t}=\frac{\partial Q/\partial XP_t}{\partial Q/\partial OFDI_t}$$

$$=\frac{OFDI_t}{XP_t}\cdot\frac{\dfrac{XP_t+\gamma OFDI_t}{XP_t}-Ln(XP_t)+Ln(OFDI_t)}{\dfrac{XP_t+\gamma OFDI_t}{\gamma OFDI_t}+Ln(XP_t)-Ln(OFDI_t)} \qquad (7)$$

$$=\frac{OFDI_t}{XP_t}\cdot\frac{\dfrac{XP_t+\gamma OFDI_t}{XP_t}+Ln\left(\dfrac{OFDI_t}{XP_t}\right)}{\dfrac{XP_t+\gamma OFDI_t}{\gamma OFDI_t}-Ln\left(\dfrac{OFDI_t}{XP_t}\right)}$$

Depending on the development stage of individual countries' outward FDI measured by the ratio of export to outward FDI, the value of $MRTS_{OFDI,XP}$ in equation (7) can be positive (substitute) or negative (complementary).

According to the world's outward FDI flow and export data, export volume has been 15-20 times of the outward FDI flow figure – the average ratio being 22 from 1980 to 2011 and 12 since the new millennium. The lowest ratio of 6.46 is found in 2000 and the highest and unusual high ratio of 80.92 is documented in 1982, with the majority being well below 30. So the denominator in equation (7), $\frac{XP_t + \gamma OFDI_t}{\gamma OFDI_t} - Ln\left(\frac{OFDI_t}{XP_t}\right)$, is always positive in this range.

The sign of MRTS is then decided by the sign of the numerator in equation (7), $\frac{XP_t + \gamma OFDI_t}{XP_t} + Ln\left(\frac{OFDI_t}{XP_t}\right)$. MRTS is positive when $\frac{XP_t + \gamma OFDI_t}{XP_t} + Ln\left(\frac{OFDI_t}{XP_t}\right) > 0$ (substitute), which happens when outward FDI (γ adjusted) and export have a comparable size. MRTS is negative when $\frac{XP_t + \gamma OFDI_t}{XP_t} + Ln\left(\frac{OFDI_t}{XP_t}\right) < 0$ (complimentary, actually), which happens when outward FDI is much smaller than export. The rate becomes the marginal rate of technical complementation (MRTC) instead.

{Figure 3 here}

Figure 3 plots MRTS with γ being set at 20, in line with the average export to outward FDI ratio. The horizontal axis is the ratio of export to outward FDI in reverse order, matching the time sequence of outward FDI development; and the vertical axis is MRTS. The part of MRTS above the horizontal axis is positive and shows the extent of the substitute effect; the part of MRTS below the horizontal line is negative, is MRTC and displays the extent of the complementary effect. Panel A exhibits MRTS with the export to outward FDI ratio ranging from 6 to 65. It is observed that export and outward FDI substitute each other when outward FDI becomes large and is in a comparable range (γ adjusted) of export – when outward FDI is greater than 12th of export volume. For example, the curve shows that a one percent increase in outward FDI would result in a 0.05 percent fall in export for example at the ratio of 8.

Exports and outward FDI become complimentary when outward FDI is comparably small – smaller than 13th of export volume. Panel B expands the complementation part of the graph, as MRTC figures are small, less than 0.011 in absolute values. It shows, for example, a one percent increase in outward FDI leads to a 0.01 percent increase in export at the ratio of 24. Small MRTC figures should not be interpreted as a weak effect, however. Note that the export to outward FDI ratio can be as high as 50-60 at the stage when they are complementary, so a one percent increase in export leading to a 0.02 percent increase in outward FDI is a considerable effect. Moreover, it can be observed that the negative part of MRTS, or MRTC, is not a monotonic function of the export to outward FDI ratio. When outward FDI is significantly smaller than exports, complimentary though, the complementation effect is insignificant. The complementation effect becomes stronger gradually with the steady increase in outward FDI and continued increases in exports. The complementation effect is the highest when the ratio is 24. Further increase in outward FDI leads to reduced complementation with exports, and then increasing substitution with export. This varying complementation pattern produced by our model matches our theoretical trajectories in export and outward FDI well.

Next, MRTS for exports and domestic production and sales is:

$$
\begin{aligned}
MRTS_{DPS,XP} &= -\frac{dDPS_t}{dOFDI_t} = \frac{\partial Q/\partial XP_t}{\partial Q/\partial DPS_t} \\
&= \frac{\beta\gamma OFDI_t \cdot DPS_t}{(1-\beta)(XP_t+\gamma OFDI_t)^2} \cdot \left[\frac{XP_t+\gamma OFDI_t}{XP_t} + Ln\left(\frac{OFDI_t}{XP_t}\right)\right]
\end{aligned}
\tag{8}
$$

and MRTS for outward FDI and domestic production and sales is:

$$
\begin{aligned}
MRTS_{DPS,OFDI} &= -\frac{dDPS_t}{dOFDI_t} = \frac{\partial Q/\partial OFDI_t}{\partial Q/\partial DPS_t} \\
&= \frac{\beta\gamma XP_t \cdot DPS_t}{(1-\beta)(XP_t+\gamma OFDI_t)^2} \cdot \left[\frac{XP_t+\gamma OFDI_t}{\gamma OFDI_t} - Ln\left(\frac{OFDI_t}{XP_t}\right)\right]
\end{aligned}
\tag{9}
$$

The earlier analysis for equation (7) suggests that $\frac{XP_t + \gamma OFDI_t}{\gamma OFDI_t} - Ln\left(\frac{OFDI_t}{XP_t}\right)$ is always

positive, given an export to outward FDI ratio that is much greater than one.

$\frac{XP_t + \gamma OFDI_t}{XP_t} + Ln\left(\frac{OFDI_t}{XP_t}\right)$ is negative when export is much greater than outward FDI and

positive when they have a comparable size (γ adjusted). Therefore, outward FDI and

domestic production and sales are always substitute. Export and domestic production and

sales are complementary when outward FDI is considerably small (γ adjusted). As three

factors or activities can't be all substitute or complementary, let us look into the situation in

detail. Suppose there is an increase in outward FDI at this stage, then export would increase

given a complementary relationship between them. The increase in outward FDI results in a

decrease in domestic production and sales while the increase in export results in an increase

in domestic production and sales. However, the MRTS between outward FDI and domestic

production and sales is much greater than the MRTC (in absolute value) between export and

domestic production and sales. So, overall overseas activities, which include outward FDI

and export, substitute domestic activities. Export and domestic production and sales are

substitute when outward FDI and export have a comparable size (γ adjusted). Suppose there

is an increase in outward FDI at this advanced stage of outward FDI activity, then export

would decrease given a substitute relationship between them. The increase in outward FDI

also results in a decrease in domestic production and sales; while the decrease in export

caused by increased outward FDI activity leads to an increase in domestic production and

sales. Domestic production and sales may fall or rise depending on the relative scale of the

two effects exerted by outward FDI and export.

3.2. Why the ratio matters

The pendulum gravity model developed in 3.1 has suggested a dynamically optimizing process in international venturing. It has entailed the stages with which the relationship between export and outward FDI evolves between substitution and complementation. There exists a constraint mathematically for the alternation in the relationship. To demonstrate the mechanism, let export be a function of the export to outward FDI ratio:

$$XP_t = \psi \left(\frac{\alpha_{gt}}{1-\alpha_{gt}} \right)^{-\delta} = \psi \left(\frac{XP_t}{\gamma OFDI_t} \right)^{-\delta} \tag{10}$$

where ψ is a positive parameter and γ, as previously defined, is the ratio of world total export to total outward FDI. $\gamma OFDI_t > XP_t$ for an economy means its outward FDI is more intensive than the world average, indicating a mature economy in terms of overseas development. $XP_t > \gamma OFDI_t$, in contrast, indicates an immature, developing economy that relies on primarily on export for generating foreign revenues. The above equation can be re-arranged as follows:

$$XP_t^{(1+\delta)} = \psi (\gamma OFDI_t)^\delta \tag{11}$$

It is required that $\delta < -1$ for $XP_t > \gamma OFDI_t$ and $-1 < \delta < 0$ for $XP_t < \gamma OFDI_t$. Taking logarithm of both sides of equation (11) yields:

$$(1+\delta)xp_t = \tau + \delta(\upsilon + ofdi_t) \tag{12}$$

where $xp_t = Ln(XP_t)$, $ofdi_t = Ln(OFDI_t)$, $\tau = Ln(\psi)$, $\upsilon = Ln(\gamma)$.

$$xp_t = \frac{\tau}{1+\delta} + \frac{\delta \upsilon}{1+\delta} + \frac{\delta}{1+\delta} ofdi_t \tag{13}$$

$\frac{\delta}{1+\delta} > 0$ when $\delta < -1$ or $XP_t > \gamma OFDI_t$, indicating a complementary relationship between outward FDI and export; $\frac{\delta}{1+\delta} < 0$ when $-1 < \delta < 0$ or $XP_t < \gamma OFDI_t$, giving rise to a

substitute relationship between them. Relative to the theoretical model in 3.1, equation (13) is a step closer to being implemented and tested empirically.

So why and how the export to outward FDI ratio is not only reflective of the alternating relationships but also constraining? How our model and the ratio are related to the factors, identified and tested in the literature and prior studies, that influence the relationship between export and outward FDI? There must be a kind of dominance of aggregation in our model and ratio that governs the mechanism in the evolving relationship between export and outward FDI. The ratio falls while the pendulum swings clockwise with its gravity in our model, which is an aggregation of the changing roles played by various factors at varying stages, conforming to laws of nature and rules of economics. It reveals a process in which the economic distances get shortened between the two sides in the international undertakings of trade and FDI. It also aggregates the asymmetric effects exerted by the pertinent factors on the opposite sides in these international engagements.

Amongst the identified factors that influence the relationship between trade and FDI, lower costs of production are one of the most location factors that act as an incentive for firms to invest abroad, maintained by Dunning (1988), Hirsch (1976) and Sharz (2004), thus substituting export. This mainly applies to the advanced economies and their activities in the developing countries. When the economic distance, in terms of relative costs in the host and home economies, shortens, the developing economy starts to pursue direct invest abroad while still relying on export for foreign income. Therefore, export and outward FDI go hand in hand. The developing economy's outward FDI takes off before the cost of production equalizes in the two sides of international engagements, which has been widely observed. It takes place and takes off as and when the falling cost disadvantage is offset by the growing benefit of knowledge acquisition and experience accumulation in an advanced industrialized country. This way, our pendulum gravity model is not only connected to the typical factors in

the prior literature but also assimilates the joint effect of pertinent factors, with dynamic and asymmetric interactions between the two sides of international undertakings.

Factor endowments and relative endowments are important gravity variables for both trade and FDI. With the advancement in technology and management systems, natural resource endowments give way to human resource endowment, management expertise and technology endowment including, among others, innovation capacities. Thus outward FDI, the sole bequest of the developed economies to invest in the developing countries that usually substitutes export, is acquired by the latecomers in the midway of export growth. Consequently, outward FDI complements export for the developing countries in this phase of development. In this context, the substitution relationship between the developed economy's outward FDI and export becomes weak and mingled too. It is an upgrading process for both developing and developed economies, and the economic distance in terms of factor endowments may either shorten or increase between nations while natural resource endowments remain still. Thus the movement of our pendulum catches not only the evolving roles of factors that also have asymmetric effects on the two opposite sides, but also the progressing ingredients imbedded in the emerging factor endowment. Likewise, knowledge and productivity are assembled into the model in such dynamic and asymmetric ways.

Our pendulum gravity model extends the work of Vernon (1966) along the life cycle of production. With the maturity of the product, it has been advocated that the firm and nation choose to produce the products in different places to achieve various objectives, giving rise to FDI but short of prescribing a relationship between FDI and trade. Given the fact that there are two relationships of substitution and complementation between export and outward FDI and the two relationships alternate, our model and analysis indicate that the complementary relationship precedes the substitute relationship in the maturity phases. Our hypotheses have been developed to reflect the phases in which the relationship evolves dynamically and shifts

gradually from complementation to substitution. They involve two counterparts in our hypotheses, one being immature in international business and the other being mature, which corresponds to the two distinctive phases. The hypotheses gain support from and extend the theory of comparative advantage of Kojima (1977, 1978b) that FDI going from a comparatively disadvantageous industry in the investing country will promote an upgrading of industrial structure on both sides and thus complements trade between the two countries. When investments are made in sectors in which the home country has a comparative advantage, FDI will substitute export. His empirical substitution case was the US and the complementation case was Japan in the decades up to the mid-1970s, the latter country being today's China in these respects of international business development.

We present an illuminating exemplar in the next two sections, to demonstrate the interaction between outward FDI and export in the pendulum gravity modeling framework.

4. Data samples and estimation

4.1. Samples

Our samples consist of two main panel data sets of exports and outward FDI. They are formed in a balanced way while reflecting the stages of outward FDI undertakings embedded in our hypothesis. That is, the opposite sides in each panel are at different stages of outward FDI, one being the beginner and the other mature and advanced. The first panel is between China and OECD countries; the former is the largest developing country, a beginner of outward FDI and the latter more matured. The second panel is between the US and the developing economies; the former is the world's largest economy, the most advanced in outward FDI and the latter immature. There are two sub-panels in the second panel, one is the US versus the individual developing countries and the other is the US versus the groups of developing countries.

<u>Data sources</u>

The data used in this study originates from several sources. The trade volumes between China and OECD countries, GDP, population, labor costs, and technology of OECD countries are collected from OECD databases. FDI flows between China and OECD countries are obtained from China Statistical Yearbook (National Bureau of Statistics of China 1999; 2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008; 2009; 2010) and OECD databases. The data set ranges from 1992 to 2009, and covers 25 OECD countries: Australia, Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, the Netherland, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Given 18 annual data for each of the 25 countries and with 25 countries in the panel, our number of observations is sufficiently large at 450. The trade volumes and FDI flows between the US and the developing economies for the period of 1999-2014 are taken from the US Bureau of Economic Analysis. All available data on trade by country and FDI by country is collected and exhausted. Removing the developed France, Germany, Italy, Japan and Canada from the dataset, Brazil, China, India, Mexico and Saudi Arabia are included as individual developing countries in the first sub-panel. Furthermore, data on South and Central America countries and OPEC is employed in the second sub-panel, which also incorporates China and India for comprehensive geographical coverages without data intersecting. South and Central America countries include Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela, Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama; OPEC covers Algeria, Angola, Ecuador, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

<u>Choice of variables</u>

Gravity models are initially applied to explain trade patterns based on gravity factors or variables, such as economic sizes of trading countries and geographical distances between trading countries. The set of gravity variables has expanded over time to include the distances and relativities in terms of technology and culture, among others. The application areas have also been extended from trade to FDI. Gravity modeling is now a widely used tool in the international business literature to explain country-level trade and FDI flows (Zwinkels & Beugelsdijk, 2010). Our pendulum gravity model investigates the relationship between outward FDI and export, rather than dealing with FDI or trade individually. Nevertheless, we augment our model's specification with the following traditional gravity variables.

Market size is believed to have a strong impact on bilateral trade and FDI (Bhaumik & Co, 2011; Flores & Aguilera, 2007; Root, 1994; Russow & Okoroafo, 1996). A country with a larger market size means that it has a larger demand for products as an importing country and, at the same time, it also owns a great production potential as an exporting country (Chi & Kilduff, 2010). Moreover, a larger market makes itself more attractive to MNCs as an FDI destination (Cuyvers, Soeng, Plasmans, & Van Den Bulcke, 2011; Scaperlanda & Mauer, 1969). In most of the literature, GDP or GNP, which stands for economic market size, is usually adopted as a proxy for market size (Bilgili, Tülüce, & Doğan, 2012; Braunerhjelm & Svensson, 1996; Cuyvers *et al.*, 2011; Filippini & Molini, 2003; Venables, 1999). To a less extent, population, which stands for the absorption ability of international trade, is also used (Ekanayake, Mukherjee, & Veeramacheneni, 2010; Filippini & Molini, 2003; Papazoglou, 2007; Kien, 2009). It should be pointed out that, while population may remain unchanged and change on a piecemeal basis, market size can rise rapidly, especially in developing countries. This suggests a complementary relationship between export and outward FDI for developing countries – while outward FDI is speeding up and export activities are slowing down, they

both rise. Whereas market size remains stable in a developed economy and outward FDI increases at the expense of export, resulting a substitute relationship between them.

Technological distance between importing and exporting countries, or between host and home countries, is often treated as a kind of comparative advantage when referring to trade, and ownership advantage when referring to FDI. Without doubt, no matter what the identification is, technology plays a crucial role in determining trade and FDI (Cassiman & Golovko, 2011; Dunning, 1993). As being reviewed earlier, technological distance remains indeterminate to both export and outward FDI, and is therefore subject to empirical examination under the given circumstances. Technological distance is a static measure in most of the existing literature. Nevertheless, it is more a dynamic measure especially for fast growing developing countries. Therefore, its role is expected to be different for developed countries and developing countries. In most empirical studies, technology has often been indicated by the ratio of R&D expenditure to total sales (Cho & Padmanabhan, 1995; Hennart & Park, 1993; Stern & Maskus, 1981), number of engineers and scientists (Baldwin, 1971) and the annual number of patents registered (Buckley, Clegg, Cross, Liu, & Zheng, 2007), at either the industry, firm, or country level. In this paper, we use annual expenditure on R&D to indicate technology levels.

Labor costs are also one of the most important determinants that influence the relationship between trade and FDI (Kimino *et al.*, 2007). As Egger and Pfaffermayr (2005) point out, it is widely accepted that higher unit labor costs in the parent company in the developed world make exports to its affiliates in developing countries less profitable in intra-firm trade. Higher labor costs therefore reduce the enthusiasm of firms in trading, encouraging them to switch to the mode of FDI instead. However, higher labor costs in developed countries also indicate higher capital intensities. So countries with higher labor costs are more productive in terms of both labor productivity and total factor productivity. As

a result, they have the ability to produce more products and therefore choose to serve foreign markets (Breinlich & Criscuolo, 2011). On the contrary, higher unit labor costs in the developing world make the host countries' location less attractive to MNCs, so the need for FDI is weakened (Bilgili *et al.*, 2012; Culem, 1988). Nevertheless, increasing labor costs in developing countries may also indicate increasing capital intensities, leading to increased labor productivity and total factor productivity. This enables firms in developing countries to engage in, and expand, overseas operations at a time when their exports still enjoy a labor cost advantage. Therefore, rising labor costs, accompanied by rising labor productivity and total factor productivity, suggests a complementary relationship between export and outward FDI. The proxy usually used for labor cost is the average hourly wage of labor or the difference in average annual wage between home and host countries. According to what Culem (1988) has suggested, relatively lower labor costs between developing countries and developed countries are more important than that between developed countries in international activities. Therefore labor costs are included to investigate the different importance of labor costs in influencing the relationship between export and outward FDI in developed and developing countries. In this study, the labor costs variable is the average hourly wage of workers in OECD countries.

4.2. Estimation

Having chosen the above gravity variables, the empirical model is specified as follows:

$$XP_{i,t} = c + \sum_{\tau=0}^{p} \delta_\tau OFDI_{i,t-\tau} + \varphi_1 GDP_{i,t} + \varphi_2 POP_{i,t} + \varphi_3 TECH_{i,t} + \varphi_4 LC_{i,t} + \varepsilon_{i,t} \quad (14)$$

This is a panel data model. The benefit of adopting panel approaches is three-fold with this study. Firstly, it overcomes data shortage problems in economic events, which otherwise can't be investigated properly empirically. By panel data, the number of time series observations is multiplied by the number of cross section entities, 25 in our case, meeting the

required statistical estimation criteria. Secondly, it avoids aggregating values for a group of economic entities under investigation, which mingles the differences between them. Thirdly, individual economic entities' role and effect are fully reflected and incorporated in a systematic way and from an across-the-board perspective. Equation (14) is estimated for China and OECD paring in the first panel, and for the US and developing countries paring in the second panel, respectively. Most of the variables are in relativity measures. In the case of China, $XP_{i,t}$ is the share of export to trading partner i in total exports to OECD countries from China in year t, $OFDI_{i,t}$ is the share of outward FDI to host country i in all outward FDI to OECD countries from China in year t. In the OECD case, $XP_{i,t}$ is the export share of trading partner i in total exports from OECD countries to China in year t, $OFDI_{i,t}$ is the share of outward FDI of home country i in all outward FDI from OECD countries to China in year t. For both cases, $POP_{i,t}$ is the proportion of population of trading partner i in OECD countries in year t. The above variables are measured in percentages adding to 1. $TECH_{i,t}$ is annual R&D expenditure of trading partner i in year t in billion US dollars, $LC_{i,t}$ is labor costs of trading partner i in year t in US dollars. $GDP_{i,t}$ has two measures. One is GDP of trading partner i expressed as its share in total GDP of OECD countries in year t, which is measured in percentages. The other is the relative GDP size of trading partner i and China in year t; there is no binding constraint for the sum of them to be 1 by this design. The former is a gravity measure based on the relative size between OECD countries, and the latter is a direct gravity measure between an OECD country and China. We have also specified $POP_{i,t}$ and $TECH_{i,t}$ this way but there is no differences in results. c is the intercept, δ_τ is the coefficient for growth in outward FDI at lag τ, φ_1, φ_2, φ_3 and φ_4 are coefficients for the GDP, population, technology, and labor costs variables respectively, and $\varepsilon_{i,t}$ is the regression residual.

Estimating equation (14) involves a choice between a fixed effects specification and a random effects specification. Fixed effects models allow individual specific effects to be correlated with explanatory variables while random effects models do not. However, fixed effects models are inferior to random effects models in terms of degrees of freedom; and the estimated coefficients from fixed effects models tend to be less significant due to high correlation between the fixed effects and the explanatory variables. Our models include a country specific effect. Whether this country specific effect is fixed or random determines the choice of model. In our case, we prefer a fixed effects specification to a random effects specification since the random effects estimator relies on the crucial assumption that the country specific effects are uncorrelated with the explanatory variables. Hausman' correlated random effects test and the redundant fixed effects test are conducted to decide whether a fixed effects specification is superior to a random effects specification.

5. Results and analysis

Prior to presenting modeling results, let us gain some intelligence on the export-outward FDI profiles of China and OECD. Table 2 provides the export and outward FDI volumes of China during the period of 1999-2009, and Table 3 presents the export and outward FDI volumes of OECD countries during the same period. It can be observed that China's export to outward FDI ratio is much greater than the world's average while the OECD countries' export to outward FDI ratio is much smaller than the world's average. The ratio of China is 125 in 1999 and is reduced to 24 in 2009. However, the ratio is still more than double the world average. Accordingly, a complementary effect between outward FDI and export is expected for China. The ratio of OECD countries is much lower than the world average, being always below four. Therefore, a substitution relationship between outward FDI and exports is expected for OECD countries.

{Table 2 here}

{Table 3 here}

The results from estimating equation (14) are reported in Table 4 for China and Table 5 for OECD countries respectively. Lag lengths are determined by the Akaike information criterion, Schwarz criterion and Hannan-Quinn criterion. Seven lags are chosen for China and four lags for OECD respectively. The reported results are based on fixed effects specifications. Both Hausman' correlated random effects test and the redundant fixed effects test confirm firmly that the fixed effects model is superior to a random effects model for our cases, as shown in Table 8. The upper panel reports the results of Hausman test and the lower panel the results of the redundant fixed effects test. For China, the null of random effects is summarily rejected by a large Chi-square statistic of 87.3074 with a p-value of 0.0000. The hypothesis that fixed effects are redundant is also rejected, the Chi-square statistic being large at 364.0522 with a p-value of 0.0000. Likewise for OECD countries, both tests reject the random effects model resolutely in favor of a fixed effects model.

{Table 4 here}

{Table 5 here}

A pattern of complementation between export and outward FDI has emerged in Table 4 for the case of China. The coefficients for contemporaneous outward FDI and that for outward FDI at lag three, δ_0 and δ_3, are all significantly positive at the 1% and 5% level. Nevertheless, the coefficient for outward FDI at lag six, δ_6, is significantly negative, though at a modest 10% level. This indicates that outward FDI and export generally go hand in hand in the case of China, and an increase in outward FDI would contribute to an upsurge in export three years later. Yet, there is a tendency in export being substituted by outward FDI in the longer term, which is well counterweighed by the complementary effect. These results lend further support to a complementary effect of outward FDI on export, for the case of China at

an early stage of outward FDI developments. On the contrary, export and outward FDI substitute each other for OECD countries representing mature outward FDI undertakings, as revealed by the figures in Table 5. δ_3, the coefficient for outward FDI at lag three, is significantly negative, suggesting that an increase in outward FDI would result in a drop in export three years later exhibiting substitute effects.

In addition to the above findings with regard to pendulum gravity swings in trade-FDI relationships, conventional gravity variables play a role. Moreover, they play a different role for economies at different development stages too. Confirming the common-sense results in most previous empirical studies, China's export shares to individual OECD countries are positively related to individual OECD countries' relative sizes. The coefficient for population shares, φ_2, is significantly positive. That is, China's export to individual OECD countries is found to be proportional to the size of the population relative to OECD total. The effect of the relative economic size on export, though with the expected sign, is not significant, which may be overtaken by the population effect. However, export from OECD to China is explained by the relative economic size of individual OECD countries and China, not the relative size between OECD economies. φ_1 in that model, the coefficient for the relative size of an OECD economy and China's GDP, is significantly positive. This difference in the use of two different GDP measures would not have materialized effects, if and when OECD and China's economies grow at the same or comparable pace. As China's GDP has been growing much faster, and it has been growing with a two digit growth rate for most of this period, our second GDP measure entitles a time effect. Given that China's GDP grows faster than OECD's overall, the relative size shrinks over time. Hence, the part of export shares explained by the GDP variable decreases over time when China's economy grows. This time effect, if exists as it does, won't be picked up by the first GDP measure, which may distort the results. Further, export shares by the economies that shrink faster in their relative size to

China's GDP would have their export shares reduced faster. The other size variable of population does not have any effect on export, due partly to its close association with, and inferior to, the economic size variable.

China tends to export more goods to countries with lower R&D expenditures, i.e., to destinations with shorter technological distances. However, OECD countries with higher R&D expenditures have an edge in export to China. The coefficient for technology, φ_3, is significantly negative in the case of China; but it is significantly positive in the case of OECD economies. Either way, technology is confirmed to contribute to the improvement in terms of trade. It promotes export while bringing down import, thereby reducing trade deficits or boosting trade surpluses. Labor costs are a factor of consideration for China's export, given a significant coefficient φ_4 in Table 4. But China is likely to import more from countries associated with higher labor costs, indicated by a significantly positive φ_4 in Table 5. This finding seems to contradict the doctrine that firms would set up subsidiaries instead of exporting when labor costs are higher in home countries. However as reviewed earlier, higher labor costs in developed countries can be associated with higher capital intensities, labor productivity and total factor productivity. All of these proffer advantages in trade. So the finding is a challenging call to advanced economies – labor costs themselves are not a deterrent to export.

{Table 6a, 6b here}

{Table 7a, 7b here}

{Table 8 here}

The results are more convincing for the case of the US versus the developing countries even without conventional gravity variables. The quality of data is higher for US trade and FDI flows by country in a sense. Similar to the first panel, lag lengths are determined by the Akaike information criterion, Schwarz criterion and Hannan-Quinn criterion for the case of

the US versus developing economies in the second panel. The reported results for the second panel are also based on fixed effects specifications. As Table 8 advises, both Hausman' correlated random effects test and the redundant fixed effects test confirm firmly that the fixed effects model is superior to a random effects model from both the US and developing countries' perspectives. The hypothesis that fixed effects are redundant is rejected for trade and FDI flows from the individual developing economies and groups of developing countries to the US, and the for flows from the US to the individual developing economies and groups of developing countries. The Chi-square statistic is 225.8367, 174.2143, 203.7563 and 168.9550 respectively with a *p*-value of 0.0000. The Hausman test also rejects the null of random effects resolutely in favor of a fixed effects specification.

The test results are reported in Table 6 for the developing economies and Table 7 for the US respectively. Each table is split into two sub-panels. Table 6a presents the results for the individual developing countries, while Table 6b reports the results for the developing country groupings. Lag lengths are chosen to be six for the former and five for the latter. A complementary relationship between outward FDI and export is evident in both sub-panels. The coefficients for contemporaneous outward FDI and that for outward FDI at lags one and two, δ_0, δ_1, and δ_2, are all significantly positive in Table 6a for the individual developing economies, with δ_1 being significant at the 5% level. In Table 6b, the coefficients for outward FDI at lags one and two, δ_1 and δ_2, are significantly positive for the developing country groupings, with δ_1 being significant at the 5% level. These results indicate that the developing economies' outward FDI to the US complements their export to the US, and growth in outward FDI would accompany an increase in export and contribute to further export growth in the next two years. The above results reinforce the case of China versus OECD. For economies at early stages of outward FDI developments, their outward FDI and

export are complementary when engaging with the economies that are relatively more mature and advanced in their development stages.

Next, the results for trade and FDI flows from the US to the individual developing countries are reported in Table 7a, and the results for the flows from the US to the developing country groupings are reported in Table 7b. Five lags are chosen for the former and four lags for the latter. The results reveal a clear pattern of substitution between outward FDI and export in both sub-panels. The coefficients for contemporaneous outward FDI and that for outward FDI at lags three, four and five, δ_0, δ_3, δ_4 and δ_5, are all significantly negative in Table 7a, with δ_3 being significant at the 1% level and δ_4 being significant at the 5% level. Similarly, a substitute relationship is confirmed by the results in Table 7b. The coefficients for contemporaneous outward FDI and that at lags one and three, δ_0, δ_1 and δ_3, are significantly negative, with δ_0 being significant at the 5% level. These results reinforce the case of OECD versus China. For advanced economies at mature stages of outward FDI developments, their outward FDI substitutes their export to the developing economies that are relatively immature and at early stages of outward FDI.

6. Summary and conclusion

A pendulum gravity model of outward FDI and export has been proposed and empirically tested in this paper, to examine how trade and FDI interact with each other. The study has made three-fold contributions to advancing research in this field. It has been widely documented in the literature that export and outward FDI are complementary in many studies; they are found to be substitute in many other studies. Our research is a response to these mixed results for outward FDI and export relationships. However, we respond to these mixed results in a constructive way. The mixed findings do not constitute inconsistent answers themselves, taking various circumstances, under which a variety of studies are conducted,

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into consideration. Amongst various circumstances, the development stage of outward FDI is conjectured to be crucial in determining a complementary or substitute effect between export and outward FDI. This conjecture, featured by pendulum gravity swings, integrates the two seemingly opposing sets of literature. Hence our model, developed along this line of inquiry, makes a theoretical contribution to the literature in a unique way. It is a unified model across sections and over time. It is theorized that, under the given economic setting, firms optimize a production function that involves three activities of export, direct investment overseas and domestic production and sales. The optimization of production functions and the attainment of firms' objectives require firms to complement export with outward FDI, or substitute export with outward FDI, according to the development stage of outward FDI undertakings.

The second major contribution is empirical. Implementing this pendulum gravity model empirically, it has been found that outward FDI complements export in the case of China as a beginner in outward FDI undertakings. The pendulum is positioned on the left side in the case of China, gradually moving towards the 6 o'clock locus. Accompanied is the complementation of outward FDI with export. The same pattern has been found for more developing economies and developing economy groupings. When the pendulum has swung to the other side, outward FDI is indicated to have entered a mature phase, which is the case of OECD and the US. Outward FDI is then found to substitute export for OECD countries' engagement with China. Similarly, it is revealed that US outward FDI substitutes its export to the developing countries.

Finally, our empirical results additionally synthesize a number of traditional gravity factors in playing their varied roles at different stages of development. This contributes to the on-going debate by opening up new channels for further investigations that shed new light on this on-going issue. Our pendulum gravity model aggregates the traditional gravity factors in terms of relativity and dynamics. The dominance of aggregation in our model and the export

to outward FDI ratio governs the mechanism in the evolving relationship between export and outward FDI. The ratio falls while the pendulum swings clockwise with its gravity in our model, which is an aggregation of the changing roles played by various factors at varying stages. It reveals a process in which the economic distances get shortened between the two sides in the international undertakings of trade and FDI.

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Figures
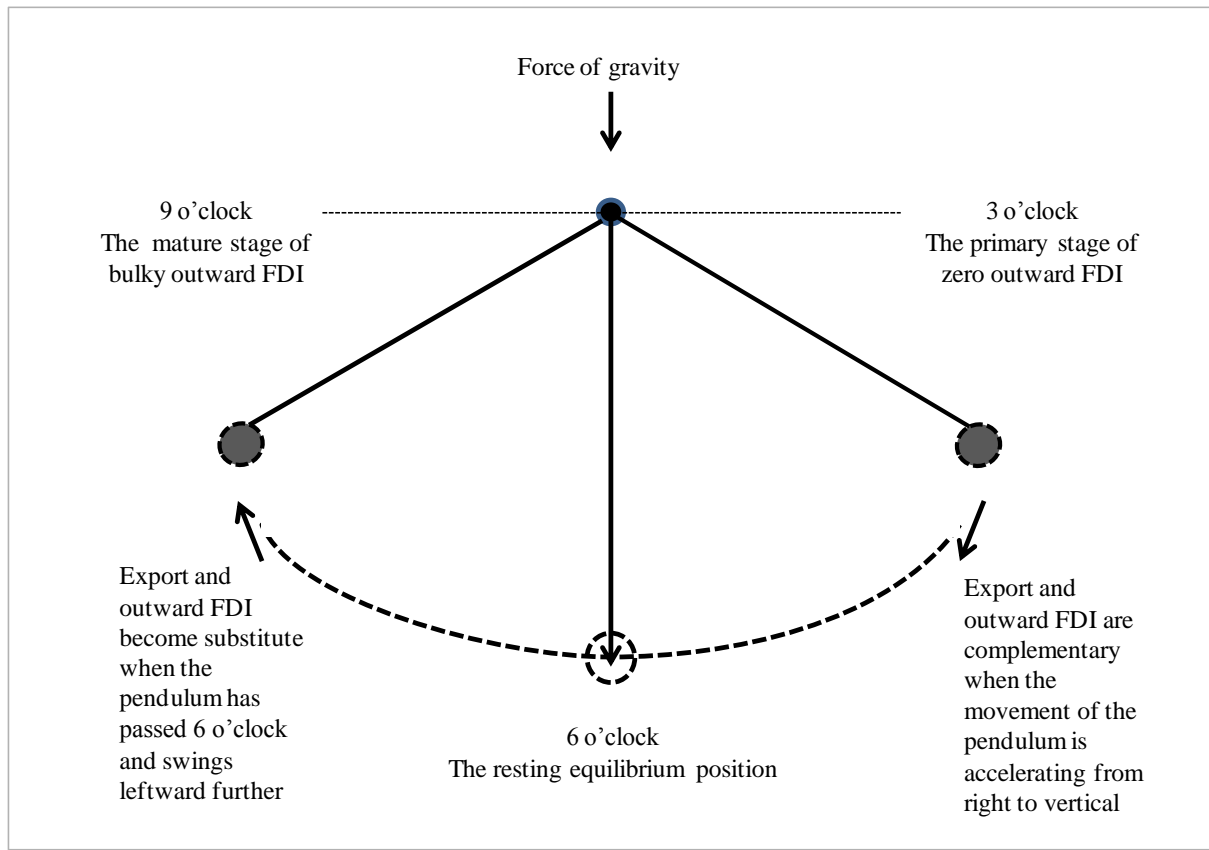
Figure 1. Export-outward FDI relations portrayed by a pendulum gravity model
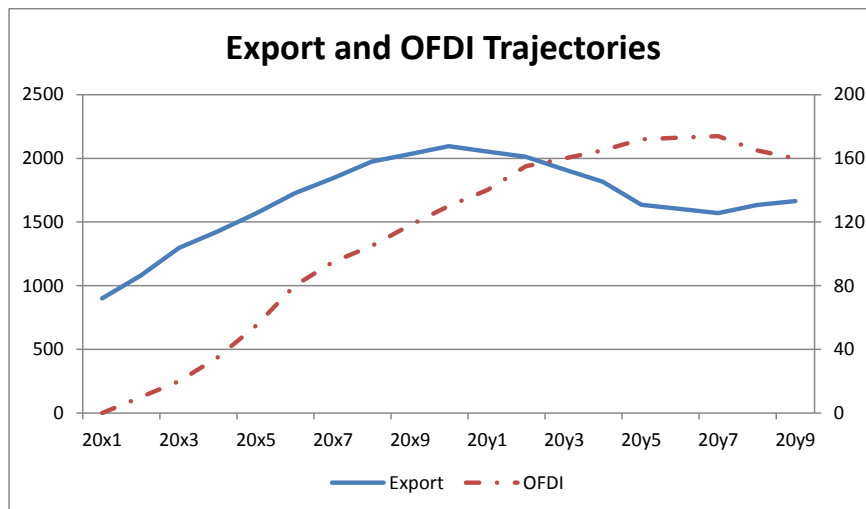
Figure 2. From complementation to substitution – the trajectories
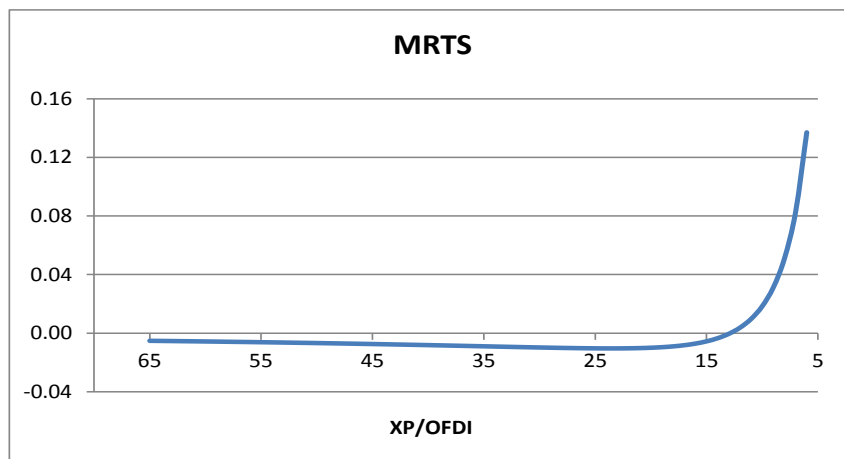
Figure 3. Exhibition of substitution and complementation effects

Tables

Table 1. Summary of Literature Review

Outward FDI substitutes exports	Country Samples
Adler & Stevens (1974)	United States to Japan, Germany, and Canada
Buckley & Casson (1981)	Theoretical only. N.A.
Arribas & Pérez (2011)	United States and 58 countries
Buckley & Pearce (1979)	Firm level. N.A.
Chang & Gayle (2009)	United States to 56 countries
Daniels & Ruhr (2014)	United States to world
Dunning (1980)	United States to seven countries
Helpman, Melitz, & Yeaple (2004)	United States to world
Hirsh (1976)	Theoretical only. N.A.
Horst (1972)	United States to Canada
Kimino, Saal, & Driffield (2007)	World to Japan
Kimura & Kiyota (2006)	Japan to world
Schmitz & Helmberger (1970)	United States to world
Vernon (1966)	United States to world
Outward FDI complements exports	**Country Samples**
Alguacil & Orts (1999)	Spain to world
Camarero & Tamarit (2004)	11 EU member countries plus US and Japan
Cardamone & Scoppola (2012)	EU to 173 countries
Görg & Labonte (2012)	107 countries
Head & Ries (2001)	Japan to world
Lin (1995)	Taiwan to ASEAN
Yamawaki (1991)	Japan to United States

Pantulu & Poon (2003)	US and Japanese outward FDI to 29 and 32 countries
Mixed results for outward FDI and export relationships	**Country Samples**
Amiti & Wakelin (2003)	36 counties including both OECD and developing countries
Braunerhjelm, Oxelheim, & Thulin (2005)	EU and the rest of the world
Chang & Gayle (2009)	United State to 56 countries
Kojima (1977, 1978a, 1978b)	Japan and United States (US FDI substitutes its exports, Japan FDI complements its exports)
Oberhofer & Pfaffermayr (2012)	EU

Table 2. Export and Outward FDI Volumes - China

Year	China Export (Million US$)	China OFDI (Million US$)	China Export/ OFDI	World Export/ OFDI
1999	220964	1774	125	5
2000	279561	916	305	5
2001	299409	6885	43	8
2002	365396	2518	145	12
2003	485004	2855	170	13
2004	655827	5498	119	10
2005	836888	12261	68	12
2006	1061681	21160	50	9
2007	1342206	22469	60	6
2008	1581712	52150	30	8
2009	1333349	56530	24	11

Table 3. Export and Outward FDI volumes – OECD Countries

Year	OECD Export (Billion US $)	OECD OFDI (Billion US$)	OECD Export/ OFDI	World Exports/ OFDI
1999	1560	1052	1.48	5
2000	1752	1253	1.40	5
2001	1765	696	2.54	8
2002	1805	509	3.55	12
2003	1854	548	3.38	13
2004	2014	831	2.42	10
2005	2137	781	2.74	12
2006	2330	1187	1.96	9
2007	2482	1929	1.29	6
2008	2531	1644	1.54	8
2009	2246	893	2.52	11

Table 4. Effects of Outward FDI on Export – China

Variable	Coefficient	Std. error	t-statistic	Prob.
C	-0.2188^{***}	0.0539	-4.0641	0.0000
δ_0	$0.1924e^{-2**}$	$0.0660e^{-2}$	2.9170	0.0042
δ_1	$0.0957e^{-2}$	$0.0635e^{-2}$	1.5067	0.1344
δ_2	$0.0469e^{-2}$	$0.0720e^{-2}$	0.6521	0.5155
δ_3	$0.1543e^{-2**}$	$0.0760e^{-2}$	2.0294	0.0445
δ_4	$-0.0480e^{-2}$	$0.0951e^{-2}$	-0.5038	0.6153
δ_5	$-0.1420e^{-2}$	$0.0875e^{-2}$	-1.6239	0.1069
δ_6	$-0.1850e^{-2*}$	$0.1008e^{-2}$	-1.8325	0.0683
δ_7	$-0.1680e^{-2}$	$0.1189e^{-2}$	-1.4141	0.1597
φ_1	0.8564	0.7247	1.1817	0.2395
φ_2	3.8904^{***}	1.4216	2.7366	0.0071
φ_3	$-0.6490e^{-1***}$	$0.1140e^{-1}$	-5.6858	0.0000
φ_4	2.9632^{***}	0.8733	3.3933	0.0009
R-squared	0.9881	Mean dependent var	$6.0703e^{-2}$	
Adjusted R-squared	0.9852	S.D. dependent var	$9.0730e^{-2}$	
F-statistic	342.7218^{***}	Prob. (F-statistic)	0.0000	

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Table 5. Effects of Outward FDI on Export – OECD

Variables	Coefficient	Std. error	t-statistic	Prob.
C	$-0.3251e^{-1}$	$0.3448e^{-1}$	-0.9430	0.3473
δ_0	$0.2200e^{-1}$	0.0140	1.5678	0.1191
δ_1	$-0.8904e^{-2}$	0.0142	-0.6272	0.5315
δ_2	$-0.1776e^{-1}$	0.0137	-1.2958	0.1971
δ_3	$-0.2482e^{-1**}$	0.0119	-2.0898	0.0384
δ_4	$-0.1729e^{-1}$	0.0123	-1.4072	0.1651
φ_1	6.3217^{***}	1.3891	4.5508	0.0000
φ_2	0.3508	0.6804	0.5157	0.6069
φ_3	$0.3530e^{-1***}$	$0.1540e^{-1}$	2.2891	0.0235
φ_4	3.8163^{***}	0.6384	5.9782	0.0000
R-squared	0.9941	Mean dependent var	$5.6709e^{-2}$	
Adjusted R-squared	0.9928	S.D. dependent var	$8.9659e^{-2}$	
F-statistic	764.2910^{***}	Prob. (F-statistic)	0.0000	

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Table 6a. Effects of Outward FDI on Export – Developing countries panel a

Variable	Coefficient	Std. error	t-statistic	Prob.
C	0.1899^{***}	$0.1500e^{-2}$	126.5970	0.0000
δ_0	$0.8045e^{-2*}$	$0.3939e^{-2}$	2.0422	0.0503
δ_1	$0.8933e^{-2***}$	$0.3723e^{-2}$	2.3997	0.0231
δ_2	$0.7066e^{-2*}$	$0.4157e^{-2}$	1.7000	0.0998
δ_3	$0.0204e^{-2}$	$0.5464e^{-2}$	0.0373	0.9705
δ_4	$-0.4593e^{-2}$	$0.6173e^{-2}$	-0.7442	0.4628
δ_5	$-0.2885e^{-2}$	$0.5566e^{-2}$	-0.5183	0.6082
δ_6	$-0.3678e^{-2}$	$0.5800e^{-2}$	-0.6342	0.5309
R-squared	0.9980	Mean dependent var	0.1918	
Adjusted R-squared	0.9973	S.D. dependent var	0.1591	
F-statistic	1442.5310^{***}	Prob. (F-statistic)	0.0000	

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Table 6b. Effects of Outward FDI on Export – Developing countries panel b

Variable	Coefficient	Std. error	t-statistic	Prob.
C	0.2128^{***}	$0.5216e^{-2}$	40.8065	0.0000
δ_0	$0.5722e^{-2}$	$0.5485e^{-2}$	1.0433	0.3072
δ_1	$0.1346e^{-1**}$	$0.5405e^{-2}$	2.4908	0.0201
δ_2	$0.1078e^{-1*}$	$0.5388e^{-2}$	2.0017	0.0567
δ_3	$0.3158e^{-2}$	$0.6817e^{-2}$	0.4634	0.6473
δ_4	$0.9641e^{-2}$	$0.6758e^{-2}$	1.4266	0.1666
δ_5	$0.6903e^{-2}$	$0.7431e^{-2}$	0.9289	0.3622
R-squared	0.9952	Mean dependent var	0.2279	
Adjusted R-squared	0.9936	S.D. dependent var	0.1486	
F-statistic	624.2160^{***}	Prob. (F-statistic)	0.0000	

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Table 7a. Effects of Outward FDI on Export – US panel a

Variables	Coefficient	Std. error	t-statistic	Prob.
C	0.1222^{***}	$0.3171e^{-2}$	38.5283	0.0000
δ_0	$-0.16913e^{-1*}$	$0.9388e^{-2}$	-1.8015	0.0785
δ_1	$-0.1932e^{-2}$	$0.8304e^{-2}$	-0.2327	0.8171
δ_2	$-0.8153e^{-2}$	$0.9169e^{-2}$	-0.8893	0.3787
δ_3	$-0.31934e^{-1***}$	$0.7312e^{-2}$	-4.3672	0.0001
δ_4	$-0.18292e^{-1**}$	$0.7094e^{-2}$	-2.5786	0.0133
δ_5	$-0.15625e^{-1*}$	$0.7867e^{-2}$	-1.9862	0.0533
R-squared	0.9778	Mean dependent var	0.1152	
Adjusted R-squared	0.9727	S.D. dependent var	0.1023	
F-statistic	193.3821^{***}	Prob. (F-statistic)	0.0000	

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Table 7b. Effects of Outward FDI on Export – US panel b

Variables	Coefficient	Std. error	t-statistic	Prob.
C	0.1585^{***}	$0.2987e^{-2}$	53.0703	0.0000
δ_0	$-0.1293e^{-1**}$	$0.5717e^{-2}$	-2.2615	0.0294
δ_1	$-0.9758e^{-2*}$	$0.5480e^{-2}$	-1.7808	0.0827
δ_2	$-0.2365e^{-2}$	$0.4318e^{-2}$	-0.5477	0.5870
δ_3	$-0.8429e^{-2*}$	$0.4346e^{-2}$	-1.9396	0.0597
δ_4	$-0.5609e^{-2}$	$0.4474e^{-2}$	-1.2537	0.2174
R-squared	0.9864	Mean dependent var	0.1511	
Adjusted R-squared	0.9836	S.D. dependent var	0.0971	
F-statistic	352.3213^{***}	Prob. (F-statistic)	0.0000	

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Table 8. Fixed v. Random Effects Tests

a. Correlated Random Effects - Hausman Test

	Chi-Square Statistic	Prob.
China to OECD	87.3074	0.0000
OECD to China	169.3408	0.0000
Individual developing economies to US	1184.4809	0.0000
Groups of developing economies to US	1204.8831	0.0000
US to individual developing economies	1180.4992	0.0000
US to groups of developing economies	963.4086	0.0000

b. Redundant Fixed Effects Tests

	Chi-Square Statistic	Prob.
China to OECD	364.0522	0.0000
OECD to China	667.0289	0.0000
Individual developing economies to US	225.8367	0.0000
Groups of developing economies to US	174.2143	0.0000
US to individual developing economies	203.7563	0.0000
US to groups of developing economies	168.9550	0.0000