

What drives bilateral foreign direct investment among Asian economies?[☆]

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ARTICLE INFO

JEL classification:

C51
F21
F23

Keywords:

Intra-asian bilateral FDI
Knowledge-capital model
Gravity model
Corner solution outcomes
Zero values
Skill differences
PPML
Lognormal hurdle

ABSTRACT

This study analyses the role of knowledge transfers via bilateral foreign direct investment (FDI) among 31 Asian economies. We make three distinct contributions to the literature on the drivers of FDI by: (1) applying the knowledge-capital model to FDI among Asian economies for the first time, using a comprehensive data set, and comparing it to an empirical gravity-type model of FDI; (2) conducting model selection tests to choose between alternative empirical specifications and estimation methods; and (3) modelling both the FDI participation decision and the decision on the amount of FDI. The main findings are: (1) while vertical FDI, driven by seeking low-cost unskilled labour, appears to be the dominant type of intra-Asian FDI, overall the knowledge-capital model is not supported by the data; and (2) conventional gravity variables (e.g., size, distance, common language) provide a better explanation of intra-Asian FDI and, therefore, a more suitable vehicle for future research.

1. Introduction

Global foreign direct investment (FDI) has grown rapidly since the 1990s. Although the European Union is the largest host and source of the total FDI stock in the world, Asia has gained more attention from foreign investors in recent years. According to the World Investment Reports (UNCTAD, 2019), Asia was the largest recipient of FDI inflows in 2018, at 512 billion US dollars. As Fig. 1 demonstrates, a significant amount of FDI to Asia comes from other Asian countries. Intraregional investments account for nearly 50% of total FDI in Asia from 2001 to 2012. In addition, 53% of announced greenfield projects in Asia (by value in 2015) involved intra-Asian investment (UNCTAD, 2016).

Our aim in this paper is to explore the drivers of intra-Asian FDI. Even though the existing empirical literature explores different aspects of FDI in Asia, very few studies examine the determinants of intra-Asian FDI. A notable exception is the study by Petri (2012), which suggests that FDI patterns within Asia differ systematically from the general FDI patterns observed elsewhere, with intra-Asian FDI dominated by technology upgrading in host countries.¹ This motivates us to explore whether the

so-called knowledge-capital (KK) model (Markusen, 2002) can provide an explanation for intra-Asian FDI based on knowledge-capital transfers.

The KK model is a leading theoretical model in which knowledge is transferred internationally, along with capital, via FDI.² In principle, it is able to explain FDI between countries of similar or different market size, as measured by GDP, when relative skilled- and unskilled-labour endowments are either similar or quite different. For example, a firm may have headquarters in one country and a single production plant in another country, or it may have plants in both countries, even when labour endowments are similar and the goods produced are the same. The KK model involves complex economies of scale at the firm and plant levels in order to provide a theoretical explanation for FDI under these different circumstances. Firms motivated by market-seeking FDI may locate production in the host country to exploit economies of scale at the plant level in a large domestic host-country market, to avoid transport costs, and/or to take advantage of low foreign investment barriers. This leads to horizontal FDI, where every plant produces the same product regardless of its location. On the other hand, the KK model is also able to explain FDI that is instead driven mainly by relative differences in skilled

[☆] The authors thank, without implicating, the Editor, Professor Sushanta Mallick, and two referees for helpful comments. Data are available on request from the authors.

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¹ Petri (2012) study includes 16 Asian economies, among others. He uses bilateral FDI flows for annual observations from 1999 to 2003.

² FDI is one way to transfer knowledge to other countries. Another route for the international diffusion of knowledge is through imports. See Bournakis et al. (2018) on knowledge spillovers through FDI and trade at the industry level for OECD countries.

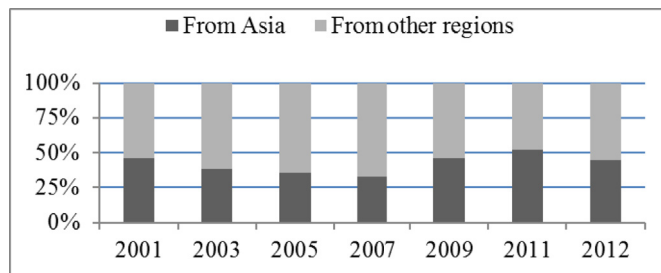


Fig. 1. FDI inflows to Asia, by region, 2001–2012.
Source: UNCTAD database.

and unskilled labour across countries. Firms located in relatively skilled-labour abundant countries use FDI to establish plants abroad in order to outsource parts of the production process that involve unskilled labour to countries where unskilled labour is relatively abundant and low cost. For this type of FDI, referred to as vertical FDI, firms fragment the production process of a specific product into vertical stages.

The KK model is a general-equilibrium model that endogenizes the FDI decisions of multinational enterprises (MNEs) and integrates vertical and horizontal FDI, allowing both to exist simultaneously in equilibrium. It is assumed that knowledge capital is internationally mobile and can be used simultaneously at low cost as a joint input into a firm's multiple production facilities across different countries (Markusen, 1984); in contrast, it is assumed that labour is not mobile across countries. The KK model explains the dominant type of FDI, i.e., vertical, horizontal, or no FDI, based on characteristics of pairs of source and host countries. The KK model makes it necessary to separate inflows and outflows of FDI, instead of using net FDI flows. Skill endowments of the source country relative to the host country play a crucial role, as do the relative and total market size of both countries and the cost of trade and investment among them.

We contribute to the literature on the drivers of FDI in three ways:

- (1) Ours is the first study that applies the KK model to intra-Asian FDI. The theoretical general-equilibrium KK model does not have a closed-form solution that lends itself to empirical estimation and inference. Therefore, various alternative empirical specifications have been employed in the literature, the most popular of which is due to Carr, Markusen and Maskus (henceforth CMM, 2001). We bring together and compare results for different empirical specifications of the KK model, including those of CMM (2001), Braconier et al. (2005), Davies (2008), and Bergstrand and Egger (2013). Although we find some evidence that vertical FDI, driven by unskilled-labour abundance, appears to be the dominant type of FDI between Asian countries, several key variables in the KK model have the wrong signs or are not statistically significant.

We, therefore, also consider an empirical specification, motivated by the general-equilibrium gravity-type model of FDI developed by Anderson et al. (2019), as an alternative approach to the KK model, in order to see whether it provides a more convincing empirical specification. We find that a simple gravity model provides a satisfactory explanation for our intra-Asian FDI data.

- (2) We explore various alternative estimation methods, including ordinary least squares (OLS) (with and without country fixed effects), Tobit, Poisson pseudo-maximum-likelihood (PPML), lognormal hurdle, and exponential-type II Tobit. We conduct model selection tests to choose between alternative empirical specifications and associated estimation methods for our FDI data.
- (3) A novel feature of our analysis is that, as part of the lognormal hurdle model, we separate, for both the KK model and the gravity model, the participation decision (i.e., whether to undertake any FDI or not), from the FDI amount decision, for bilateral FDI

between all possible in-sample country pairs.³ The majority of observed values of bilateral FDI in our sample are zeros, which could bias results if these are deleted. In contrast, empirical applications of the KK model generally ignore the no-FDI outcome choice and, instead, focus only on the two types of non-zero FDI, horizontal and vertical.

The remainder of the paper proceeds as follows. Section 2 presents a review of the literature on the determinants of intra-Asian FDI. Section 3 describes the basic CMM (2001) empirical model. Data definitions and sources are documented in Section 4, followed, in Section 5, by a discussion of the econometric methods used. Section 6 reports and discusses the regression results. Section 7 considers alternative empirical specifications of the KK model, as well as the gravity model, followed by our conclusions in Section 8.

2. Literature review of empirical asian FDI studies

Sizeable outward FDI from Asia commenced when Japanese MNEs shifted their production to other Asian nations in response to the 60% appreciation of the Yen beginning in 1985 (Thorbecke and Salike, 2013). Most studies on FDI in Asia focus on a major source country, such as China (Chou et al., 2011; Kang and Jiang, 2012), Japan (Encarnation, 1999; Lakhera, 2008), Malaysia (Goh et al., 2013), Singapore (Chellaraj et al., 2013), or Taiwan (Chen and Aquino, 1998).⁴

There are relatively few studies examining FDI among Asian countries, i.e., intra-Asian FDI. For example, Hattari and Rajan (2008) and Rajan and Hattari (2009) examine the determinants of intra-Asian bilateral FDI, using a gravity framework, with a dataset including 14 host countries and 10 source countries between 1990 and 2005, and the same empirical method (Tobit regression). Besides standard gravity variables, such as GDP and distance, each of these studies augments the regression analysis with several additional covariates. They find statistically significant influences of exports, common language, exchange rates, stock market capitalisation, financial openness, corporate tax, political risk, and free trade agreements on bilateral FDI between developing economies in Asia. Petri (2012) analyses bilateral FDI flows between 85 countries over the period between 1998 and 2003, with dummy variables for intra-Asian factors for 16 Asian countries. Using a gravity modelling approach and censored Tobit regression, he finds that intraregional FDI in Asia, in contrast to global FDI, is attracted by host countries with less advanced technology and good protection of intellectual property rights.

Based on Dunning (1977) 'eclectic' or 'OLI' (Ownership, Location, and Internalization) framework, Masron (2013) examines the role of the ASEAN Investment Area and the ASEAN free trade agreement in promoting intra-ASEAN FDI in a panel model for the period from 1998 to 2009. Masron (2013) focuses on market-seeking, efficiency-seeking (cost) and resource-seeking motives for FDI. The results reveal that factors encouraging intra-ASEAN FDI are the host country's GDP, political stability, labour productivity, and non-ASEAN FDI.

In an investigation of bilateral FDI flows between 101 countries over the period 1995–2002, Garrett (2016) also analyses determinants of intraregional FDI between a sub-group of 14 Asian countries in a gravity model. Comparing results from two different estimation methods (OLS and Heckman selection), Garrett (2016, Appendix 7, p. 167) finds that, for intra-Asian FDI, belonging to the same regional trade agreement has a negative effect on the probability of entering an FDI relationship but a positive effect on FDI flows if FDI takes place. In addition, larger host

³ The KK model not only predicts the volume of FDI but also whether there is no FDI, in which case there is only domestic investment.

⁴ Chellaraj et al. (2013) apply the CMM (2001) model to Singapore for inward and outward foreign (direct and portfolio) investment from and to countries inside and outside of Asia.

Table 1
Firm types and countries' characteristics in the KK model.

Dominant investment type	Source country	Host country	Similar in size and relative factor endowments	Trade costs	Total income	Notes
Horizontal FDI		Low foreign investment barriers	Yes	High	High	Trade costs are exporting costs from the source country to the host country.
Vertical FDI	Small, skilled-labour abundant	Low foreign investment barriers	No	Not excessive		The vertical firm in the host country may or may not export to its source country. Trade costs are in both directions for country pairs.
Domestic investment	Large, skilled-labour abundant		No			
			Yes	Low		Trade costs are exporting costs from the source country to the host country. Domestic firms may export if exporting costs are not excessive.
		High foreign investment barriers				

Notes: Based on Markusen (2002, Ch. 7). Empty cells denote that there is no condition on the factor in terms of implications for the dominant type.

countries are more likely to attract non-zero FDI, but host country size has a negative impact on FDI flows if FDI takes place.

Blonigen and Piger (2014) point out that empirical studies of bilateral FDI generally rely on very different specifications and that there is little agreement on the set of variables to include as regressors. They apply Bayesian model averaging methods to 56 potential covariates stemming from various theories of FDI and find that a relatively parsimonious set of variables achieve high posterior inclusion probabilities. These include both gravity variables (such as the logs of host and source countries' real GDP, distance, common language and colonial relationships) and KK-type endowment differences between host and source countries (such as squared skill differences). However, their data are limited to primarily OECD country pairs and include only a few OECD-Asia country pairs.

Camarero et al. (2019) also use Bayesian model averaging. They study German FDI decisions for outward bound investment and consider a set of 61 potential covariates from different alternative theories of FDI, including Dunning (1977) OLI framework, gravity models, and knowledge-capital models, among others. They find that outward German FDI to developed and to European core economies is driven by horizontal FDI, whereas to developing and European peripheral countries "vertical motivations seem to prevail" (p. 326).⁵ Furthermore, they find that German FDI decisions are based on variables that originate from a mixture of different FDI theories. Eicher et al. (2012) extend the Bayesian model averaging approach applied to FDI to control for selection bias due to censored data (64% of their FDI values are zero), using OECD outflows of FDI and 55 covariates. They find (p. 649) that it is necessary to correct

(Faeth, 2009). The KK model developed by Markusen (2002) is used as the basis for our empirical work. It can explain both horizontal and vertical FDI simultaneously in a general equilibrium framework, taking into account both source and host countries' characteristics.

The KK model is built around the key idea that there are knowledge-based assets generating firm-level scale economies. These knowledge-based assets, which are referred to as 'knowledge capital', involve research and development activities, patents, human capital, organizational structures, managerial skills, etc. Based on a $2 \times 2 \times 2$ model with two countries (home and foreign), two inputs (skilled and unskilled labour), and two outputs (a homogeneous product and a differentiated product), the model predicts the impacts of country size, distance, trade costs, investment costs, labour endowments, and the interaction between these factors on different types of firms (horizontal MNEs, vertical MNEs, or domestic firms) in equilibrium. Even though most predictions of the KK model, due to its complexity, are derived from numerical simulation results, it does generate a number of empirically testable implications relating FDI to country characteristics. Table 1 summarizes the relationship between host and source countries' characteristics and types of investment.

The complexity of the KK model, incorporating nonlinear and non-monotonic relationships, allows considerable latitude in formulating an empirical estimation equation (CMM, 2003). The most influential empirical study of the KK model is CMM (2001), as can be seen from Table A1 in the Appendix. Therefore, we base our initial estimation equation on their specification:

$$FDI = f(\text{SumGDP}, \text{GDPdif}_{sq}, \text{GDPSK}, \text{Trade cos } t_{-s}, \text{Trade cos } t_{-h}, \text{SKdif}, \text{TradeSK}, \text{Invest cos } t_{-h}, \text{Dist}, \text{GDPdif}, \text{BIT}, \text{Contig}, \text{ComLang}, \text{ComCol}) \quad (1)$$

for selection bias in their data set, that support for horizontal FDI is "only mixed", and that vertical FDI "is not strongly supported".

3. Theoretical framework and hypotheses for the baseline KK model

Numerous explanations of the existence of MNEs and FDI have been developed over time, emphasizing ownership advantages, internalization, diversified FDI, knowledge capital, export-platform FDI, and others

⁵ Three developed and seven developing Asian economies are considered. Most of the total stock of German outward FDI is in developed economies (87% in 2012), and only 19% of total outward FDI stock is located in non-European countries.

where suffix *s* denotes the source/parent country and suffix *h* denotes the host/receiving country. We omit suffixes for pairs and time periods in order to simplify the exposition. Variables with no *s* or *h* suffix are pair-specific. Distance (*Dist*) and the last three variables, which are dummies, are time-invariant. *FDI* is the yearly FDI stock accrued due to flows from country *s* to country *h*. The last five variables in equation (1) are additions to the basic CMM (2001) specification.

The KK model encompasses both horizontal and vertical FDI. For some variables, the effects on these two types of FDI are hypothesized to have the same sign, whereas for other variables the effects can have opposite signs, and some effects are expected to be (approximately) zero. Simulation results from Markusen (2002) show that the combined income of the country pair, measured by the sum of their real GDP levels

($SumGDP = GDP_s + GDP_h$), encourages horizontal FDI. By contrast, horizontal FDI is hypothesized to have an inverted U-shaped relationship with differences in income, with horizontal FDI maximized, other things equal, when the two countries are similar in market size (CMM, 2001). Therefore, the square of the difference in GDP levels, $GDPdif_{sq} = (GDP_s - GDP_h)^2$, is expected to have a negative effect on horizontal FDI. However, when controlling for differences in factor endowments, $SumGDP$ and $GDPdif_{sq}$ are not expected to have any impact on vertical FDI (Markusen and Maskus, 2002).

Whereas horizontal FDI is encouraged when two countries are similar in factor endowments, vertical FDI is expected to be larger when the source country is more skilled-labour abundant than the host country (CMM, 2001). Therefore, the difference in skilled-labour endowments ($SKdif = SK_s - SK_h$, where SK is skilled-labour endowment) is a key variable in determining the dominant type of FDI. The marginal effect of differences in skilled-labour endowments on vertical FDI is maximized when the source country is small (CMM, 2001). Therefore, the interaction between differences in country size and skilled-labour endowments ($GDPSK = (GDP_s - GDP_h) \times (SK_s - SK_h)$) is expected to have a negative influence on vertical FDI, but no effect on horizontal FDI.

Trade costs to the source country ($Tradecost_s$) are hypothesized to hinder vertical FDI because they are a disincentive to produce in host countries and export back to the source countries (CMM, 2001). Markusen and Maskus (2002) suggest that higher inward source-country trade costs will also negatively affect horizontal FDI, although the effect on this type of FDI may be less important.

Markusen and Maskus (2002) predict that trade costs to the host country ($Tradecost_h$) have a positive effect on horizontal FDI. The main motives for firms to invest horizontally abroad are to gain better access to the host country market, to avoid trade barriers, and to lower transportation costs. Consequently, higher trade costs to the host countries motivate horizontal FDI as a substitute for trade. Markusen and Maskus (2002) suggest trade costs to the host country possibly have a positive but smaller effect on vertical FDI. However, vertical FDI firms often have to import materials or other inputs for their production process in host countries; higher trade costs to the host countries would deter this form of investment. Therefore, we expect higher trade costs to the host country to encourage horizontal FDI but, on balance, discourage vertical FDI.

Besides variables that affect only one of the two FDI types or affect both in opposite directions, there are general determinants of FDI that are expected to have a common influence on both types. First, both horizontal and vertical FDI are negatively related to the interaction between trade costs to the host country and the square of skill difference ($TradeSK = Tradecost_h \times (SK_s - SK_h)^2$) (CMM, 2001). Host country trade costs have a positive impact on horizontal FDI but a negative impact on vertical FDI. Meanwhile, horizontal FDI is most significant when two countries have similar endowments, which is the opposite to the case of vertical FDI. Therefore, this interaction term is included to moderate the direct effect of trade costs and it negatively affects both types of FDI. Theoretically, simulation results in Markusen (2002) show that the effect of host-country trade costs is highest when the source country is moderately skilled-labour abundant, not when it has exactly the same endowment as the host country. Empirically, previous papers often find weak or conflicting evidence for this interaction effect (CMM, 2001; Davies, 2008; Markusen, 2002).

In general, investment costs in the host country ($Investcost_h$) deter FDI. However, distance ($Dist$) can be a measure of either trade costs or investment costs. Often when the destination country is further away, investment costs related to monitoring and managing the affiliates are expected to be higher, which deters both types of FDI. However, if distance is regarded as a proxy for trade costs it would have a positive impact on horizontal FDI as firms may use FDI to replace exports to eliminate significant trade costs. Distance's effects on both forms of FDI are indistinguishable.

Besides the basic KK variables from the CMM (2001) model, which have been included in numerous empirical studies, we augment our

Table 2

Variables: Definitions and hypotheses.

Variables	Explanation	Expected signs	
		HOR	VER
<i>Basic KK variables</i>			
<i>SumGDP</i>	Total income: $GDP_s + GDP_h$	+	
<i>GDPdif_sq</i>	Square of difference in income: $(GDP_s - GDP_h)^2$	-	
<i>GDPSK</i>	Interaction between difference in income and in skilled-labour endowments: $(GDP_s - GDP_h) \times (SK_s - SK_h)$		-
<i>Tradecost_s</i>	Trade cost to the source country		-
<i>Tradecost_h</i>	Trade cost to the host country	+	-
<i>SKdif</i>	Difference in skilled-labour endowments: $SK_s - SK_h$	-	+
<i>TradeSK</i>	Interaction between trade costs to the host country and squared difference in skilled-labour endowments: $TC_h \times (SK_s - SK_h)^2$	-	-
<i>Investcost_h</i>	Investment costs in the host country	-	-
<i>Dist</i>	Distance	+/-	-
<i>Additional variables</i>			
<i>GDPdif</i>	Difference in income: $GDP_s - GDP_h$	+/-	+/-
<i>BIT</i>	1 for pairs that have active in-force bilateral investment treaties	+	+
<i>Contig</i>	1 for pairs that have a common border	+	+
<i>ComLang</i>	1 for pairs that have a common spoken language	+	+
<i>ComCol</i>	1 for pairs that were in colonial relationship post 1945	+	+

Notes: Empty cells in columns of expected signs denote no expected impact. 'HOR' and 'VER' denote horizontal and vertical FDI, respectively.

model specification with a number of additional explanatory variables. First, we add the difference in GDP ($GDPdif = (GDP_s - GDP_h)$). The inverted U-shaped relationship between $GDPdif$ and horizontal FDI is captured by the square of GDP difference; in addition, the interaction term, $GDPSK$, involving $GDPdif$ and skilled-labour endowments is included in the model. However, to reduce the possibility of biased estimates, it is advisable to include all constituent terms in interaction variables separately in the model specification (Balli and Sorensen, 2013; Brambor et al., 2006). Consistent with classical economic theory, capital should flow from rich countries to poor countries due to diminishing returns to capital. Hence, the GDP difference may have a positive impact on both types of FDI. In contrast, the Lucas Paradox (Lucas, 1990) highlights that there is little capital flowing from rich (developed) countries to poor countries. However, almost all of the GDP difference terms are positively signed, so there seems to be very little evidence of the Lucas Paradox in our results.

Additionally, we include in the estimation equation four dummies that are found to have a significant impact on FDI in previous studies: existence of a bilateral investment treaty (BIT), contiguity ($Contig$), common spoken language ($ComLang$), and common colonizer post 1945 ($ComCol$).⁶ These variables are expected to reduce investment costs between two countries and thus have a positive impact on FDI in general. We include a dummy variable for having a common spoken language; this encompasses having a common official language, which has been more widely used in the literature (e.g., Bergstrand and Egger, 2013; Blonigen and Piger, 2014). The set of non-official languages in which people in a pair of countries are proficient can reduce transaction costs in business between them (Kim et al., 2015). The Centre d'Études

⁶ See also Blonigen et al. (2014) for details on the relationship of FDI with bilateral tax treaties for US multinational firms. Other dummies are used in previous studies such as: ever, currently, and/or post-1945 in a colonial relationship. However, almost all possible pairs between the 31 Asian countries in our study have never had a colonial relationship, so colonial dummies are not included.

Prospectives et d'Informations Internationales (CEPII) database defines the common spoken language dummy as taking a value of 1 if a language is spoken by at least 9% of the population in both countries. Variable explanations and expected signs for horizontal (HOR) and vertical (VER) FDI are summarized in Table 2. The basic KK variables are separated from the additional variables by a horizontal line in each table of results.

4. Data

The sample includes data for 31 Asian countries and territories, for the years 2001–2012. This is based on an initial list of all countries and territories geographically located in Asia according to the United Nations.⁷ From this, we exclude countries that are considered European according to the European Union.⁸ We end up with 31 countries and territories with sufficient data for the empirical analysis.⁹

There are 930 directional pairs or 465 non-directional pairs, giving a maximum possible number of observations of 11,160. FDI stock data are from the UNCTAD database. Primarily these are inward stock data for the host country, but, for any pair of countries, if the source country provides more observations, outward stock data from the source country are used. This maximizes the number of bilateral observations and provides consistent reporting for each country pair.¹⁰

Data for GDP are from the World Bank Development Indicators (WDI). The WDI database does not provide any data for Taiwan, so we collect data for Taiwan from the IMF's World Economic Outlook Database, 2017 edition. Monetary variables, i.e., GDP and FDI, are real values in constant 2010 US dollars. Nominal FDI is deflated by the ratio between nominal GDP and real GDP, which acts as an implicit deflator for the FDI data.

Due to data availability, the main proxy for skilled-labour endowments is the percentage of the population that enrolls in tertiary education. We also use the ratio of the workforce that is skilled (skill ratio) in alternative specifications of the CMM (2001) model. The skilled jobs group includes managers, professionals, technicians and associate professionals, according to the categorization of the International Labour Organisation (ILO). Investment costs and trade costs are calculated as 100 minus the investment freedom index and 100 minus the trade freedom index, respectively.¹¹ In section 7.4, we use gross fixed capital formation to calculate physical capital-related variables. Data sources are described in Table 3.

5. Methodology and model selection tests

The dependent variable in our model is the stock of bilateral FDI between all possible pairs of countries and territories in Asia. Inspecting the FDI data shows that around 70% of Asian country pairs do not send FDI to each other. The majority of observations on the dependent variable therefore take the value zero. This presents a problem in empirical modelling since the assumption of a conditional mean linear in the

Table 3

Data sources.

Data		Source
FDI stocks	Billions USD	UNCTAD
Nominal GDP	Trillions USD	World Bank and IMF
Real GDP	Trillions 2010 USD	World Bank and IMF
Tertiary enrolment	%, [0, 100]	World Bank
Proportion of the labour force that is skilled	Ratio, [0, 1]	ILO
Investment costs = 100 – Investment Freedom Index	Index, [0, 100]	The Heritage Foundation
Trade costs = 100 – Trade Freedom Index	Index, [0, 100]	The Heritage Foundation
Bilateral investment treaty	0-1 dummy	UNCTAD
Distance	1000 Km	CEPII
Common language, contiguity, common colony	0-1 dummies	CEPII
Gross fixed capital formation	Share of source country in total of source and host country	World Bank

Notes: Data are for the following countries and territories: Bahrain (BHR), Bangladesh (BGD), Cambodia (KHM), China (CHN), Hong Kong (HKG), India (IND), Indonesia (IDN), Iran (IRN), Israel (ISR), Japan (JPN), Jordan (JOR), Kazakhstan (KAZ), South Korea (KOR), Kuwait (KWT), Kyrgyz Republic (KGZ), Laos (LAO), Lebanon (LBN), Macao (MAC), Malaysia (MYS), Mongolia (MNG), Nepal (NPL), Pakistan (PAK), Philippines (PHL), Qatar (QAT), Saudi Arabia (SAU), Singapore (SGP), Sri Lanka (LKA), Taiwan (TWN), Thailand (THA), Vietnam (VNM), Yemen (YEM).

covariates cannot truly be linear (Wooldridge, 2010). This is a common problem in the international trade and FDI literature where it is typical to use a Tobit model or, more recently, a Poisson pseudo-maximum-likelihood (PPML) estimator.

We assume that the observed values of FDI are the outcomes of a maximization problem that allows the possibility of corner solutions at zero. That is, observed zero values do not reflect an observability problem, but rather correspond to corner solution outcomes. We can express this as:

$$FDI = \max(0, x\beta + \varepsilon) \quad (2)$$

where x is the row vector of covariates in our model, β a vector of parameters, and ε a generic error term. This can be written as a latent variable model:

$$FDI^* = x\beta + \varepsilon$$

$$FDI = \max(0, FDI^*)$$

where FDI^* is a latent variable. These equations combine the mechanisms that describe the *participation decision* ($FDI = 0$ versus $FDI > 0$) and the *amount decision* (the magnitude of FDI if $FDI > 0$). Equation (2), with the assumption that $\varepsilon|x \sim N(0, \sigma^2)$, is labelled the 'Type I Tobit model' (Wooldridge, 2010, Ch. 17), and is the standard Tobit model widely applied in the literature. Violation of this distributional assumption (due to heteroskedasticity or non-normality) makes the maximum likelihood estimator for the Tobit model inconsistent.

The Tobit model assumes that the mechanism that determines the participation decision is the same mechanism that determines the amount decision. A more flexible approach is to assume that the two mechanisms are separate; this gives rise to two-part (or hurdle) models (Wooldridge, 2010, Section 17.6). We consider two types of two-part model (proposed by Cragg (1971)): the truncated normal hurdle (TNH) model and the lognormal hurdle (LH) model. These two models correspond to different distributional assumptions for FDI^* , i.e., a truncated normal distribution and a lognormal distribution, respectively. In both models, the participation decision, reflected in the probability of observing positive FDI, is determined by a probit model. By contrast, the

⁷ <https://unstats.un.org/unsd/methodology/m49/>, last accessed on 13 November 2019.

⁸ https://europa.eu/european-union/about-eu/countries_en, last accessed on 13 November 2019.

⁹ A list of these is provided in the Notes to Table 3.

¹⁰ See Nguyen (2019; online appendix) for data issues when using bilateral FDI data. She also explains why it is preferable to use FDI stock instead of FDI flow data. However, using FDI flows instead of stocks does not change any of our conclusions. Results are available from the authors. Further, some studies have used affiliate sales of multinational enterprises and/or mergers and acquisitions across borders instead of FDI. See Blonigen and Piger (2014) for a discussion of the advantages and disadvantages of these three alternative measures. We rely on FDI due to data unavailability of the other measures for Asian countries.

¹¹ See Xu (2019) for a closely related, but more general, economic freedom index and its role for bilateral inward FDI stocks in a gravity model with 155 countries.

amount decision for each model is:

$$FDI^* = x\beta + \varepsilon \quad (\text{TNH model}) \quad (3)$$

$$FDI^* = \exp(x\beta + \varepsilon) \quad \text{or} \quad \log(FDI^*) = x\beta + \varepsilon \quad (\text{LH model}) \quad (4)$$

In the amount equation for the TNH model in equation (3), ε , given x , is assumed to have a truncated normal distribution. In the amount equation for the LH model in equation (4), ε , given x , is assumed to be normally distributed, so FDI^* has a lognormal distribution and the model for $\log(FDI^*)$ is estimated by OLS. Wooldridge (2010, p. 701) suggests using a likelihood ratio (LR) test to choose between the type I Tobit and TNH models, provided the Tobit model is not rejected by violating normality or homoskedasticity assumptions.

The TNH and LH models assume independence between the participation and amount decision mechanisms. Relaxing this assumption gives what Wooldridge (2010) calls the ‘exponential type II Tobit (ET2T) model’. The participation part of ET2T is determined by a probit model, as for TNH and LH, and the amount equation is of the same form as for LH in equation (4).¹² However, unlike LH, the errors in the probit model, v , and in the LH-type amount equation, ε , are allowed to be correlated. The LH model is nested in ET2T, because ET2T reduces to the LH model when the correlation of the errors in the participation and outcome equations equals zero.

We also consider the PPML estimator proposed by Santos Silva and Tenreyro (2006), which has been gaining popularity in dealing with corner solution outcomes for a continuous dependent variable. The equation estimated by PPML is:

$$FDI = \exp(x\beta) + \varepsilon$$

For PPML to be consistent the conditional mean must be correctly specified, which can be tested using the RESET test (Ramsey, 1969). In addition to using general specification tests to check the adequacy of the models, we use the HPC test proposed by, Santos Silva et al. (2015) as a formal statistical test to choose between the competing models we consider.¹³

6. Regression results for the baseline empirical specification

We estimate the parameters of the KK model specification in equation (1), based on CMM (2001), using the different possible methods for dealing with corner solution outcomes discussed in the previous section. We exclude bilateral FDI between China and Hong Kong in the empirical analysis because FDI between this pair is considerably larger (nearly ten times larger) than FDI between any other pair in the sample.¹⁴ Even without the China – Hong Kong pair, one of the estimation methods, TNH, does not converge; consequently, we report results for Tobit, LH, ET2T, and PPML.

The conditional moment (CM) test of normality of the errors for Tobit (Skeels and Vella, 1999) shows that this assumption is not met in the data (CM = 213.51; p -value = 0.000, which rejects the null hypothesis of normality). Therefore, the Tobit estimator is inconsistent in this context. We also present results from OLS for comparison with previous studies, although OLS is not an appropriate method as explained in the previous section. Further, following the RESET test procedure outlined in Santos

Table 4

Model comparison and specification test results: p -values.

	OLS	Tobit	PPML	LH	ET2T	Conclusion
RESET test	0.000	0.000	0.819	0.412	0.045	Neither PPML nor LH is rejected
HPC test:						
Tobit versus ET2T		0.000			0.651	ET2T not rejected; Tobit rejected
Tobit versus LH		0.000		0.625		LH not rejected; Tobit rejected
PPML versus ET2T			0.787		0.192	Neither PPML nor ET2T is rejected
PPML versus LH			0.762	0.189		Neither PPML nor LH is rejected
LH versus ET2T				0.537	0.420	Neither LH nor ET2T is rejected
LR test:						
LH versus ET2T				0.333		LH is preferred to ET2T: independence of two parts is not rejected

Note: PPML refers to Poisson pseudo-maximum-likelihood, LH to log hurdle, and ET2T to exponential type II Tobit.

Silva and Tenreyro (2006), Table 4 shows that both OLS and Tobit do not pass the RESET functional form test at the 5% significance level.¹⁵ Based on the diagnostic and model selection tests, OLS and Tobit are therefore given less weight in evaluating our results. However, we report the results for these two estimation methods as they are the most popular in previous studies applying the KK model (See Table A1 in the Appendix).

As noted in section 5, the LH model is nested in the ET2T model, with the former imposing the restriction that the mechanisms generating the zeros and positive FDI values are uncorrelated. The LR test reported in Table 4 does not reject this restriction, favouring LH over ET2T. PPML assumes the mechanisms generating the zeros and positive FDI values are the same. However, the results reported in Table 4 for the HPC test do not allow us to choose between LH, ET2T and PPML. The LR test from the ET2T model implies that the LH model is appropriate. Therefore, the various tests in Table 4 lead us to draw conclusions primarily based on both LH and PPML. For comparison, we present empirical results from the other estimation methods to show the degree of agreement or conflict between the different methods. However, we do not report results from ET2T because they are very similar to those of LH.

In all regressions, the standard errors are clustered by non-directed pairs, i.e., by distance, to account for within-pair correlation or heteroskedasticity. Failure to control for this can lead to understated standard errors, and overstated levels of statistical significance (Cameron and Miller, 2015).

6.1. Results without controlling for country fixed effects

Before discussing the main regression results, we first report results without controlling for source and host country fixed effects (FEs) (but retaining year FEs), as several papers applying the KK model exclude country FEs. For example, Blonigen et al. (2003) report that including country FEs leaves their results unchanged, whereas Davies (2008), Bergstrand and Egger (2013), and Stack et al. (2015) do not consider country FEs in their regressions. Our results without country FEs are presented in Table 5. We report the OLS and Tobit results for comparison only because the original applications of the KK model in Carr et al. (2001) and Blonigen et al. (2003), inter alia, used these estimation methods.

As can be seen from Table 5, the sum of the host and source countries’

¹² The standard Type II Tobit model, where the amount equation is linear as in equation (3), cannot be used with corner solution outcomes (Wooldridge, 2010, Section 17.6.3).

¹³ The HPC test is so named because it builds on the approach of the P and C tests of non-nested hypotheses, proposed by Davidson and MacKinnon (1981), and allows for heteroskedasticity.

¹⁴ Hong Kong was transferred to China on 1 July 1997, after having been ruled for 156 years by the UK.

¹⁵ For all the different tests in Table 4, we control for source and host country fixed effects (FEs) and year FEs.

Table 5

Results without country fixed effects.

	HOR	VER	(1)	(2)	(3)	(4)	(5)
			OLS	Tobit	PPML	LH	
						Amount	Part
<i>SumGDP</i>	+		2.695*** (0.586)	4.703*** (0.352)	0.480*** (0.038)	0.736*** (0.212)	1.153*** (0.101)
<i>GDPdif_sq</i>	–		–0.340*** (0.103)	–0.548*** (0.045)	–0.011 (0.008)	–0.051 (0.038)	–0.161*** (0.017)
<i>GDPSK</i>		–	–1.650*** (0.621)	–1.692*** (0.593)	–0.356*** (0.094)	–0.320*** (0.121)	–0.063 (0.120)
<i>Tradecost_s</i>		–	–0.039*** (0.009)	–0.146*** (0.028)	–0.107*** (0.017)	–0.075*** (0.009)	–0.020*** (0.004)
<i>Tradecost_h</i>	+	–	–0.029*** (0.008)	–0.059*** (0.022)	–0.027* (0.014)	–0.040*** (0.009)	–0.006 (0.004)
<i>SKdif</i>	–	+	1.314** (0.662)	3.786*** (1.340)	1.937*** (0.369)	1.432*** (0.308)	0.506*** (0.140)
<i>TradeSK</i>	–	–	0.038 (0.037)	0.168*** (0.052)	0.028 (0.024)	0.034** (0.016)	0.033*** (0.009)
<i>Investcost_h</i>	–	–	0.002 (0.007)	–0.027* (0.015)	–0.007 (0.007)	–0.002 (0.006)	–0.008*** (0.002)
<i>Dist</i>	+/–	–	–0.333*** (0.059)	–1.137*** (0.174)	–0.269*** (0.068)	–0.456*** (0.057)	–0.190*** (0.026)
<i>GDPdif</i>	+/–	+/–	0.074 (0.170)	0.453** (0.195)	0.150*** (0.033)	0.111** (0.045)	0.144*** (0.027)
<i>BIT</i>	+	+	–1.016*** (0.338)	1.312** (0.641)	0.198 (0.286)	0.125 (0.235)	0.469*** (0.104)
<i>Contiguity</i>	+	+	–1.389* (0.751)	–0.966 (1.326)	–0.019 (0.543)	–0.048 (0.395)	0.005 (0.231)
<i>ComLang</i>	+	+	0.906* (0.493)	3.078*** (0.993)	1.193*** (0.289)	1.101*** (0.286)	0.266* (0.141)
<i>ComCol</i>	+	+	–0.018 (0.252)	0.604 (0.785)	–0.224 (0.420)	0.404 (0.339)	0.197 (0.150)
Constant			2.563*** (0.668)	1.574 (1.455)	2.968*** (0.567)	0.561 (0.515)	0.523** (0.223)
<i>N</i>			9531	9531	9531	9531	
Log pseudo likelihood			–26,906	–11,771	–9591	–1626	

Notes: ‘HOR’ and ‘VER’ denote horizontal and vertical FDI, respectively. PPML refers to Poisson pseudo-maximum-likelihood and LH to log hurdle. ‘Amount’ and ‘Part’ refer to the amount decision and participation decision, respectively. Clustered standard errors are in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Year fixed effects are included in all regressions; however, their coefficient estimates are not presented for brevity.

GDPs (*SumGDP*) positively affects FDI in all equations, which supports the KK model’s predictions for horizontal FDI. The effect of the square of GDP differences (*GDPdif_sq*) on horizontal FDI is negative, as predicted, but is not statistically significant when estimated by PPML and LH (for the amount equation), in contrast to the significant effects for OLS and Tobit. However, *GDPdif_sq* does have a significant negative effect in the participation equation for LH.

The results for the key variables that have opposite-signed predicted effects for vertical compared to horizontal FDI support the view that vertical FDI is more strongly represented in intra-Asian FDI. Specifically, trade costs to the host country (*Tradecost_h*) have a negative impact and differences in skilled-labour endowments (*SKdif*) have a positive impact, consistent with the KK model’s predictions for vertical FDI. Other factors predicted to specifically affect vertical FDI are the interaction between income and skill difference (*GDPSK*) and trade costs to source countries (*Tradecost_s*), and these both have statistically significant negative effects.

The interaction between trade cost to the host country and skill difference (*TradeSK*) has the opposite sign to the theory in all equations, but this effect is less precisely estimated, in line with the weak empirical evidence reported by CMM (2001). The host country’s investment costs (*Investcost_h*), predicted to be negative for both horizontal and vertical FDI, is not statistically significant in both PPML and LH (amount) estimations, but has a statistically significant negative effect in the participation equation for LH. Other variables with statistically significant

effects consistent with their expected impacts are distance, GDP difference, and common language.

Overall, apart from the lack of statistical significance of *GDPdif_sq* for the preferred estimators, these results, without controlling for country FEs, agree with the KK model predictions. Empirical support for both horizontal and vertical FDI is evident in the results, but vertical FDI seems to be the more dominant type.

6.2. Results controlling for country fixed effects

Results for the specification in equation (1), controlling for both country FEs and year FEs, are presented in Table 6. CMM (2001) demonstrate that including host country FEs can affect the magnitude of estimates, reducing some to half or less in absolute terms, even though their inclusion leaves qualitative results unchanged in their analysis.¹⁶ Controlling for country FEs can reduce omitted variables bias related to home or host countries’ characteristics that are not captured by the variables in the model, such as economic policies, culture, infrastructure and political stability. In addition, Wooldridge (2010, Ch. 10) and Baier and Bergstrand (2007) discuss how FEs can account for potential endogeneity due to unobservable time-invariant heterogeneity. The inclusion

¹⁶ CMM (2001) control for host country FEs only, as the source country is always the US in their sample.

Table 6

Results with country fixed effects.

	HOR	VER	(6)	(7)	(8)	(9)	(10)
			OLS	Tobit	PPML	LH	
						Amount	Part
<i>SumGDP</i>	+		3.827*** (0.488)	2.758*** (0.587)	−0.175** (0.069)	−0.205* (0.108)	0.917*** (0.351)
<i>GDPdif_sq</i>	−		−0.475*** (0.058)	−0.405*** (0.057)	0.017*** (0.005)	0.022* (0.012)	−0.089** (0.038)
<i>GDPSK</i>		−	−2.482*** (0.691)	−2.162*** (0.795)	−0.118* (0.071)	−0.151 (0.136)	−0.188 (0.200)
<i>Tradecost_s</i>		−	0.009*** (0.003)	−0.007 (0.016)	−0.013 (0.012)	−0.020*** (0.007)	−0.003 (0.004)
<i>Tradecost_h</i>	+	−	−0.006 (0.006)	−0.026* (0.016)	−0.025*** (0.006)	−0.006 (0.005)	−0.000 (0.004)
<i>SKdif</i>	−	+	−0.365 (0.293)	−1.102 (1.539)	−0.311 (0.649)	−0.209 (0.579)	−0.051 (0.405)
<i>TradeSK</i>	−	−	0.064* (0.034)	0.070 (0.056)	0.039*** (0.015)	0.014 (0.014)	−0.011 (0.017)
<i>Investcost_h</i>	−	−	0.002 (0.003)	0.026** (0.011)	0.003 (0.005)	−0.008* (0.004)	0.006** (0.003)
<i>Dist</i>	+/−	−	−0.223*** (0.052)	−1.026*** (0.163)	−0.290*** (0.043)	−0.493*** (0.056)	−0.286*** (0.036)
<i>GDPdif</i>	+/−	+/−	0.196** (0.097)	0.467*** (0.158)	0.228*** (0.055)	0.211*** (0.071)	0.207*** (0.077)
<i>BIT</i>	+	+	−0.702** (0.314)	0.134 (0.565)	−0.282*** (0.106)	0.011 (0.175)	0.517*** (0.129)
<i>Contiguity</i>	+	+	−0.600 (0.637)	−0.099 (0.943)	0.375 (0.268)	0.548* (0.285)	0.117 (0.265)
<i>ComLang</i>	+	+	1.514** (0.637)	2.813*** (1.031)	0.678*** (0.156)	0.614*** (0.229)	0.141 (0.202)
<i>ComCol</i>	+	+	−0.527* (0.307)	0.202 (0.874)	−0.155 (0.321)	0.478 (0.337)	0.286 (0.207)
Constant			−0.239 (0.498)	−11.624*** (2.984)	5.555*** (0.999)	−1.535 (0.939)	−2.129*** (0.492)
<i>N</i>			9531	9531	9531	9531	
Log pseudo likelihood			−25,620	−10,731	−3589	704	

Notes: See Table 5. Coefficient estimates for host and source country fixed effects and for year fixed effects are not reported for brevity.

of both country FEs and time FEs in Table 6 follows the approach adopted by Braconier et al. (2005), who apply the KK model to analyse determinants of FDI in different groups of countries.

We observe that including country FEs makes the support we find for the KK model disappear when we focus on our preferred PPML and LH models. The results are no longer consistent with many of the KK model's predictions.¹⁷

First, *SumGDP* has a negative impact on FDI with PPML and in the outcome equation of the LH model, although statistical significance is more marginal for LH. In addition, *GDPdif_sq* has a positive impact on FDI with PPML and in the amount equation of the LH model, contradicting the inverted U-shaped relationship between the amount of FDI and difference in country size predicted by the KK model. Interestingly, the signs of these two variables in the participation equation of the LH model are consistent with the predictions for horizontal FDI. However, the participation equation models whether positive FDI is observed between the pair; it does not tell us anything about the relationship between the amount of FDI and country size, as predicted by the KK model. It is also worth noting that most previous studies applying the KK model find empirical evidence for horizontal FDI based on these variables. Our results are the opposite, but are similar to what Kristjánsdóttir (2010) finds in the case of inward FDI stock in Iceland. However, Kristjánsdóttir

(2010) does not control for country FEs or time FEs in her regression. This feature and the relatively small sample size (78 observations from a panel from 1989 to 1999) may have had an effect on the conclusions for the CMM (2001) specification and the KK model. Additionally, in one of the robustness checks in Waldkirch (2011) study applying the KK model to inward FDI in Mexico, the regression controlling for country FEs (Waldkirch, 2011, Table 9, column (5), pp. 501–502) also shows statistically significant effects for *SumGDP* and *GDPdif_sq* that are opposite in sign to the KK predictions, although the discussion does not draw attention to these results.

Although opposite to the theory predictions, the signs of *sumGDP* and *GDPdif_sq* may, to some extent, signal vertical FDI. The KK model predicts vertical FDI to be highest when the source country is small and skilled-labour abundant. In this case, total income of the two countries (*sumGDP*) may not be very large while the squared differences in country size (*GDPdif_sq*) is large. Therefore, the results that *sumGDP* negatively affects FDI and *GDPdif_sq* encourages FDI are consistent, to some extent, with the predictions for vertical FDI.

In contrast to the above two predictors for horizontal FDI, the coefficients of variables affecting vertical FDI follow the theory. In particular, *GDPSK*, the interaction between country size differences and skilled-labour abundance differences, has a negative impact, although this is statistically significant only at the 10% level for PPML. Similarly, trade costs to the source country (*Tradecost_s*), with LH, and trade costs to the host country (*Tradecost_h*), with PPML, have statistically significant negative effects (at the 1% level) on intra-Asian FDI.

Whereas skill differences (*SKdif*) have significant positive effects on FDI in Table 5, the point estimates for the *SKdif* coefficient become negative but are no longer statistically significant when allowing for country FEs in Table 6. Indeed, Lankhuizen (2014) argues against

¹⁷ The results from the Tobit model, the most commonly used method to estimate and find empirical support for the KK model (see Table A1 in the Appendix), are not affected much. Furthermore, excluding the additional variables *GDPdif*, *BIT*, *Contiguity*, *ComLang* and *ComCol* from the regressions does not change the results with respect to the performance of the KK model. Detailed results are available from the authors.

distinguishing between horizontal and vertical FDI on the basis of the coefficient on *SKdif* because the host country's skill level can have a positive impact on both types of FDI due to the need for absorptive capacity to attract FDI and for technology transfer.

Although the results with FEs are less clear-cut, based on the variables that are statistically significant, vertical FDI still appears to be the dominant type of FDI between Asian countries.¹⁸ This is different from the finding in many previous papers, such as *Blonigen et al. (2003)* and *Stack et al. (2015)*, that horizontal FDI is the dominant type and there is overall little or no empirical evidence for vertical FDI.¹⁹ The different conclusion may be partly because those studies focus on developed countries only, as do most of the empirical studies on the KK model (see Appendix Table A1). Among the studies listed in Table A1, there is none that finds that only vertical FDI is the dominant type of FDI.

Advanced economies have relatively large market sizes as measured by total GDP. They also have relatively similar skilled-labour endowments, which would not be associated with vertical FDI; instead, vertical FDI is attracted by relatively abundant low-skilled labour. In the case of intra-Asian FDI, the majority of the countries in our sample are developing economies: among 31 economies in our sample, only four are classified as high-income (Hong Kong, Japan, Singapore and South Korea) over our entire sample period.²⁰ Hence, it is not surprising to find results that differ from the previous literature that focuses on developed economies. Furthermore, Fig. 2 shows, for each country, the total inward and outward intra-Asian FDI stock for our sample in 2012. Net receivers of intra-Asian FDI, which are economies above the 45-degree line, are generally relatively unskilled-labour abundant and provide low-cost labour in comparison to the net senders of intra-Asian FDI, which are the countries below the 45-degree line. The top four net senders of intra-Asian FDI in 2012 are Japan, Singapore, South Korea and Taiwan, whereas the top four net receivers of intra-Asian FDI are China, Hong Kong, India and Thailand.

Focusing on the gravity variables, we observe that a number of determinants of intra-Asian FDI are consistent in terms of the coefficients' signs and significance levels across Tables 5 and 6. To be specific, whereas distance is found to have a significant negative impact on FDI at the 1% significance level in all equations, GDP difference and common spoken language have significant positive effects. Hence, intra-Asian FDI is encouraged when source countries have higher levels of GDP than host countries and when the two countries share a common spoken language. This result suggests there is no evidence for the Lucas Paradox in intra-Asian FDI. Furthermore, positive and statistically significant coefficients on the GDP difference and on its squared value in columns (8) and (9) in Table 6 suggest that the relationship between GDP difference and FDI is not inverted U-shaped; rather, the larger the source country, the more FDI flows to the host country.

Interestingly, existence of a bilateral investment treaty has a positive impact on the decision to undertake FDI, but any impact on the amount of FDI is imprecisely estimated in the LH model. Note that the results on *BIT* for PPML and LH contradict each other. If we solely relied on PPML, our

conclusion on *BIT* would be that a bilateral investment treaty deters intra-Asian FDI, with significance at the 1% level. However, the opposite result for this variable for LH emphasizes the importance of using alternative estimation methods to draw robust conclusions. We give more weight to the LH results in this case as this method allows the mechanisms generating zero and positive FDI to be different.

Empirical evidence on the effect of contiguity is weak. Contiguity has a positive effect on the amount of FDI for the PPML and LH results, but its coefficient is statistically significant only at the 10% level for the amount of FDI in Table 6, column (9); it does not have a statistically significant impact on participation decisions.

A positive impact of common spoken language is in line with the finding of *Kim et al. (2015)*. However, whereas *Kim et al. (2015)* find that a common language can affect investors' decisions, it does not have a statistically significant impact on the participation decision in our LH results. It has a positive and significant effect for PPML and in the LH amount equation only. Finally, having a common colonizer post 1945 is often found to have a positive impact on FDI (*Eichengreen and Tong, 2006; Liebscher et al., 2007*); however, in our results, the effect of this variable is not statistically significant for PPML or LH.

7. Alternative specifications

The main regression results in our analysis (Table 6) do not support the KK model's predictions for key variables such as total GDP and skill difference, although there is evidence for vertical FDI as discussed above. In this section, we explore alternative specifications. First, we consider a sample that is restricted to pairs of countries with positive FDI in at least one time period. Next, we estimate three alternative specifications of the KK model in *Braconier et al. (2005)*, *Davies (2008)*, and *Bergstrand and Egger (2013)*. Last, we specify a basic gravity-type model of FDI, based on *Anderson et al. (2019)*, as an alternative to the KK model.

7.1. A smaller sample

One of the most significant differences in our study compared to previous studies applying the KK model is that we include data for all possible country pairs within a group of countries. As a consequence, around 70% of FDI stocks are zero as these country pairs do not invest in each other. Other studies that apply the KK model consider only pairs of countries that have positive FDI in at least one year over their study periods. The differences in our results may stem from a sample overly dominated by zero values. To explore this possibility, Table A2 reports results including only pairs of countries that have at least one year of positive FDI stock over the period of analysis. The number of observations is reduced from 9531 to 3703. We repeat the same model selection and diagnostic testing process with this sample, and PPML and LH remain the preferred estimators.

The results in Table A2 are almost identical to those in Table 6 in terms of variables' signs and significance levels, except for the participation equation of the LH model in which fewer variables are statistically significant. With or without the zero pairs, vertical FDI is still the dominant type in intra-Asian FDI and the KK model predictions for other key variables do not hold: PPML and LH reveal opposite signs for *SumGDP* and *GDPdif_sq*. Accordingly, our results do not appear to be due to different sampling criteria. Therefore, in the following sensitivity tests we include all possible pairs, which maximizes the number of observations.

7.2. Braconier et al. (2005) Specification

The diversity in empirical results testing the CMM (2001) specification of the KK model motivated *Braconier et al. (2005)* to construct a different specification (labelled BNU), with new variables *SIZESQ*, *SKILL*, and *SIZE* (to replace *GDPdif_sq*, *SKdif*, and *GDPdif*, respectively), based on geometric features of the Edgeworth box diagram from *Markusen (2002)*

¹⁸ Investment costs in the host country surprisingly have a marginally significant positive impact on the probability to invest but a negative impact on the amount of investment. A possible theoretical explanation is provided by *Mukherjee and Suetrong (2012)*, showing how exporting back from the host country of FDI to the source country of FDI can lead to a negative relationship between trade cost and amounts of FDI.

¹⁹ See Table A1 in the Appendix. *Stack et al. (2015)* apply a stochastic frontier analysis to the KK model. They study the determinants of positive FDI stocks, originating from 10 western European countries, in 10 eastern European countries from 1996 to 2007. They find empirical support not only for horizontal FDI but also for vertical FDI. They argue that there is a skills gap between the western and eastern (transition) European economies that is relatively narrow, although wide enough to allow room for both types of FDI.

²⁰ <http://databank.worldbank.org/data/download/site-content/OGHIST.xls>, last accessed on 16 April 2020.

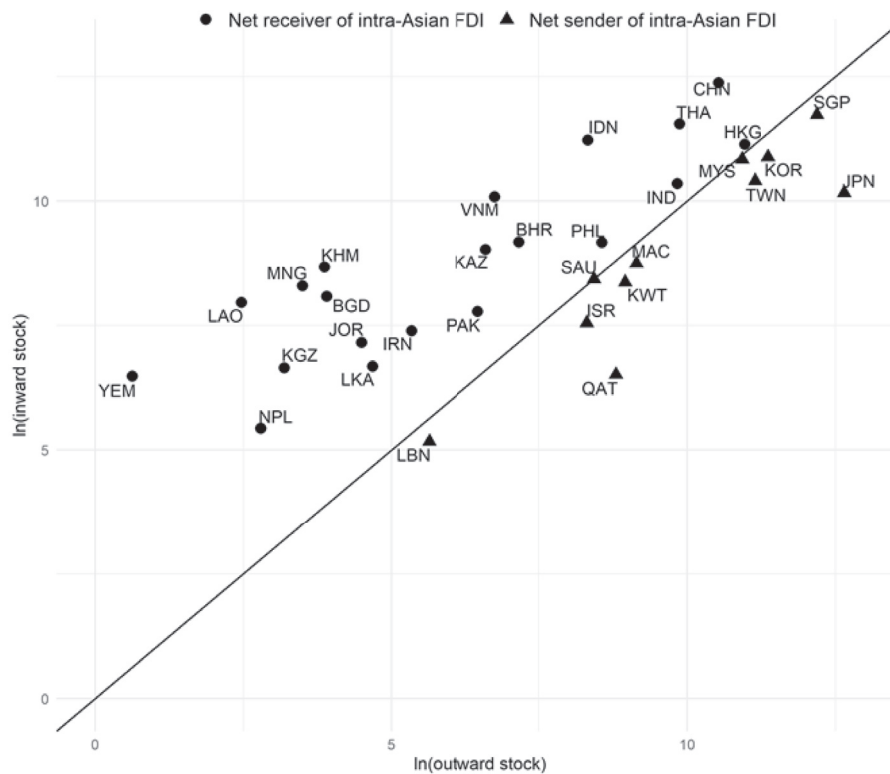


Fig. 2. Inward and outward intra-Asian FDI stocks in 31 countries in 2012. Note: The abbreviations for each country are explained in the Notes to Table 3.

simulation results.²¹ However, the roles and expected signs of these variables are the same as the original variables in CMM (2001), so, for ease of comparison with the previous tables, we use both sets of variable names in tabulating the results.

In order to estimate the BNU specification, we use data from the ILO on the number of skilled and unskilled workers. This is also the most common data source for labour endowments for empirical studies of the KK model, although, for our 31 Asian countries, it leads to a lower number of observations than available data on tertiary education. Results based on the BNU specification in the case of our Asian sample are shown in Table A3. OLS results in Table A3 support the KK model predictions for a number of variables, including *SumGDP*, *SKILL* (the replacement for *SKdif*) and *TradeSK*. This matches BNU's conclusion in their study, based on OLS and weighted least squares (WLS) estimates for a sample containing 56 source countries and 85 host countries from 1986 to 1998. Moreover, Braconier et al. (2005) also control for both time and country FEs. However, our results for all the other estimation methods for corner solution outcomes (Tobit, PPML, and LH) do not support their predictions. In particular, almost all the basic KK variables (in particular *SumGDP*, *SIZESQ*, *GDPSK*, and *SKILL*) are not statistically significant. Furthermore, the replacement of *GDPdif* by the *SIZE* variable leads to no statistically significant impact of this variable on FDI in all regressions. Meanwhile, the results for other variables, which are not affected by the new measures of Braconier et al. (2005), continue to show similar impacts as in Table 6.

The KK model predicts a relationship between the relative income of the source country compared to the host country and FDI. In BNU, the

relative country size relies purely on geometrical features of the Edgeworth box in Markusen (2002) and is calculated by ratios of labour endowments. It does not capture the total income or purchasing power of the country in monetary terms. This may help explain why all the empirical results from models for corner solution outcomes fail to provide support for the BNU specification and the KK model predictions.

7.3. Davies (2008) Specification

Whereas results in Table 6 suggest that vertical FDI is the dominant type between Asian countries, the key variables associated with horizontal FDI are either not statistically significant or have signs opposite to what is expected. In contrast, many previous studies find evidence only for horizontal FDI instead (see Appendix Table A1). Davies (2008) claims this is because the CMM (2001) specification is too restrictive to identify vertical FDI.

When $SKdif < 0$, i.e., the host country is more skilled-labour abundant than the source country, FDI is horizontal and a decreasing function of the absolute size of $SKdif$. However, if $SKdif > 0$, horizontal FDI can arise when source countries are more or less skill-abundant than the host country, and FDI can be a combination of horizontal and vertical types. Because of this lack of symmetry, Davies estimates the model separately for subsets of the data with positive skill difference and negative skill difference. Table A4 shows regression results for positive and negative $SKdif$ separately, with $SKdif_{sq}$ as an additional explanatory variable. When $SKdif < 0$, vertical FDI does not happen, so the regression for $SKdif < 0$ is mainly to see if there is support for horizontal FDI.²² Therefore, in Table A4, we omit the expected sign column entry for vertical FDI when

²¹ $SIZE_s$ is defined as $(s_s^2 + u_s^2)^{0.5}$, and $SKILL_s$ as s_s/u_s , where s_s and u_s are the source country's shares in total (source + host) endowments of high-skilled and low-skilled labour, respectively (Braconier et al., 2005, Table 1).

²² Markusen and Maskus (2002) also test this prediction but in a different specification and without $SKdif_{sq}$.

$SKdif < 0$. In contrast to the CMM (2001) specification, the expected signs for $SKdif$ and $SKdif_{sq}$ when $SKdif < 0$ follow the Blonigen et al. (2003) and Davies (2008) argument that when $SKdif$ decreases in the negative range, it diverges from zero and reduces horizontal FDI. This leads the coefficients of $SKdif$ and $SKdif_{sq}$ to be positive and negative respectively if $SKdif < 0$. The separation of the sample into two groups based on the value of skill difference is also adopted by Blonigen et al. (2003) and Kristjánsdóttir (2010).²³

Again, for both the positive and negative $SKdif$ specifications, the results do not support the KK model's predictions for key variables. For the negative $SKdif$ specification, $SumGDP$ and $GDPdif_{sq}$ still have unexpected signs and are highly significant for PPML and the LH amount regression in three out of four cases. For the positive $SKdif$ specification, the coefficients on these variables are not statistically significant for PPML and the LH amount regression, and only show significant and expected signs for the LH participation regression. Predictions by Davies (2008) on $SKdif$ and $SKdif_{sq}$ are not met either. For the negative $SKdif$ specification, $SKdif_{sq}$ has the expected sign and is significant in the LH amount estimation, but the coefficient for $SKdif$ is not statistically significant. The coefficients on these variables are also not significant for the positive $SKdif$ specification in the LH estimation. Davies (2008) results on the relationship between $SKdif$ and FDI are based on regressions that do not control for either time FEs or country FEs. This is similar to our results that do not control for country FEs (Table 5), which support the CMM (2001) specification and the KK model predictions in general.

7.4. Bergstrand and Egger (2013) Specification

Bergstrand and Egger (2013) develop a three-country, three-factor, two-good version of the KK model; this is closely related to the KK model in Bergstrand and Egger (2007). Both of these papers include physical capital, which is imperfectly mobile, as a third factor of production in addition to skilled and unskilled labour, and they also introduce a third country into the model in order to represent the rest-of-the-world. Bergstrand and Egger (2007) assume identical relative (and absolute) factor endowments to focus only on the roles of GDP size and country similarity in explaining the co-existence of horizontal bilateral foreign affiliate sales (FAS) and horizontal FDI. The vertical FAS and FDI motives of MNEs play no role in Bergstrand and Egger (2007) KK model. In contrast, Bergstrand and Egger (2013) bring back vertical FAS and FDI into the three-country, three-factor, two-good KK model so that both vertical and horizontal FAS/FDI can co-exist in equilibrium. Bergstrand and Egger (2013) study the determinants of FAS instead of FDI.

The additional variables required for the empirical specification of the KK model for FDI that follows Bergstrand and Egger (2013) model are the relative factor endowments of the source and host countries. Table A5 lists all the variables included. Variables specified in natural logarithms have the prefix 'ln'. Instead of $GDPdif$ and/or $GDPdif_{sq}$, Bergstrand and Egger (2013) use 'similarity'. This is defined as the share of the source country's GDP in the sum of source and host country GDP multiplied by the share of the host country's GDP in the sum of source and host country GDP. Hence, the largest value it can take is 0.25 when both countries have exactly the same GDP. As dissimilarity increases, the value of *similarity* moves closer to zero. Its expected sign is positive and, together with a positive sign for $SumGDP$, suggests horizontal FDI.

Bergstrand and Egger (2013) specification requires factor input ratios.²⁴ Ks , Ss and Us are defined as the source country's shares of total

source and host countries' capital, skilled labour, and unskilled labour, respectively. The expected signs are positive for Ks and Ss , and negative for Us (Bergstrand and Egger, 2013). The numerical suffixes 2, 3 and 4 in these variables' names in Table A5 are the powers, stemming from approximations to theoretical Edgeworth-box KK model relationships; $SsKs$, $SsUs$ and $KsUs$ are interaction terms.

Bergstrand and Egger (2013) report results without country FEs but include time FEs.²⁵ All estimations in Table A5 are based on PPML regressions, the method used in Bergstrand and Egger (2013). First, we report results without country FEs, initially adding only Ss , Ks and Us to a basic version of the KK model.²⁶ The reported coefficients have the theoretically expected signs and are significant at conventional levels for key variables, supporting Bergstrand and Egger (2013) model. In particular, Ks and Us are significant at the 1% level; however, Ss is not significant at conventional levels. Next, we add powers and interaction terms of the Ss , Ks and Us variables. Results are broadly similar to those in the simpler model, but only $KsUs$ is statistically significant among the terms added.

The last two columns in Table A5 repeat the above PPML regressions with country FEs added. The simpler model no longer shows statistical significance at conventional levels for key KK model variables: $\ln(SumGDP)$, $\ln(Similarity)$, $\ln(Tradecost_h)$, $\ln(Tradecost_s)$, and Ks . The extended model with country FEs in the last column reports results even less supportive of the KK model: all variables involving Ss , Ks and Us are not statistically significant.²⁷ Overall, the extensions of the KK model proposed by Bergstrand and Egger (2007, 2013) also do not lend support to a KK model-based specification for FDI for the Asian countries in our sample.

7.5. A basic FDI gravity model

Anderson et al. (2019) develop a formal structural gravity model of FDI that resembles the traditional gravity system from the trade literature. The FDI stock is proportional to the size (measured by GDP) of the source and host countries. The FDI stock is also inversely related to FDI barriers, and bilateral FDI stock values are linked to trade via so-called inward and outward multilateral resistance that reflect direct and opportunity costs of investing in non-rival technology capital. In addition, FDI stocks are inversely related to the amount of technology capital in the source country due to diminishing returns.

We estimate a basic version of the gravity model in Table 7.²⁸ The functional form of the relationship between FDI stocks and source and host country characteristics in the model becomes linear in the

²⁵ The rest-of-the-world changes (third-country effects) are accounted for by the time FEs. See Bergstrand and Egger (2013, p. 956).

²⁶ Omitting BIT and $\ln(Similarity)$ in the regressions does not affect the signs or significance levels in Table A5.

²⁷ In addition, instead of gross fixed capital formation, we employed an alternative physical capital series in the regressions, using the "capital stock at current PPPs (in millions of 2011 US \$s)" from the Penn World Tables 9.1, last accessed on 20 April 2020 at <https://www.rug.nl/ggdc/productivity/pwt/>. Results with country FEs do not support theoretical predictions of the model and our conclusions remain robust. Detailed results are available from the authors.

²⁸ The PPML and LH specifications for our gravity model pass the RESET test, with p -values of 0.26 and 0.59 respectively. The HPC test does not reject the LH nor the PPML specification (the p -value is 0.998 for PPML and 0.20 for LH). A more sophisticated global empirical version of Anderson et al. (2019) FDI model can be found in Nguyen (2019). Nguyen approximates a country's global technology share by its share of patent applications. Instead, we assume here that country-specific levels of GDP capture the effects of technology capital on FDI. Further, Hsu and Tiao (2015) explore the role of a patent rights index for global FDI inflows into 11 Asian countries in a panel setup for the year 2010, using a standard trade gravity model. Their empirical results show that strengthening patent rights protection in Asian host countries can increase FDI inflows.

²³ We do not present results from OLS and Tobit estimation to save space and because, based on the model specification and diagnostic tests, these are not appropriate estimation methods.

²⁴ We use gross fixed capital formation as a proxy for changes in each country's capital stock over time, although see also fn. 26. For the ratios with skilled and unskilled labour we use the same definitions of skilled and unskilled labour as previously, in order to make results comparable.

Table 7
Results based on a gravity specification.

	Sign	PPML No country FE	PPML With country FE	LH amount No country FE	LH part No country FE	LH amount With country FE	LH part With country FE
$\ln(GDP_s)$	+	0.812*** (0.098)	0.479* (0.288)	0.817*** (0.075)	0.468*** (0.032)	1.247** (0.503)	0.873*** (0.320)
$\ln(GDP_h)$	+	0.756*** (0.089)	−1.529*** (0.270)	0.541*** (0.062)	0.151*** (0.029)	−0.260 (0.441)	0.496** (0.248)
$\ln(Dist)$	−	−0.848*** (0.137)	−0.579*** (0.098)	−1.381*** (0.195)	−0.524*** (0.083)	−1.109*** (0.162)	−0.821*** (0.109)
<i>BIT</i>	+	−0.416 (0.287)	−0.398*** (0.145)	−0.269 (0.243)	0.507*** (0.106)	0.040 (0.191)	0.488*** (0.134)
<i>Contiguity</i>	+	−0.590 (0.432)	0.496 (0.393)	−0.603 (0.457)	−0.207 (0.248)	0.452 (0.360)	−0.265 (0.322)
<i>ComLang</i>	+	1.424*** (0.317)	0.806*** (0.209)	1.101*** (0.331)	0.273* (0.141)	0.644** (0.255)	0.197 (0.203)
<i>ComCol</i>	+	−0.132 (0.437)	−0.373 (0.294)	0.069 (0.364)	0.126 (0.147)	0.515 (0.347)	0.362* (0.210)
<i>Constant</i>		−8.581*** (0.562)	11.282*** (3.698)	−8.604*** (0.597)	−3.090*** (0.279)	−7.217*** (2.415)	−6.980*** (1.507)
<i>N</i>		10,059	10,059	10,059	10,059	10,059	10,059
Log pseudo likelihood		−11,243	−4020	−1943		558	

Note: See Table 5.

parameters after taking logs. Multilateral resistance in our specification in Table 7 is captured by variables that we have used previously: bilateral investment treaty, contiguity, common language, and a post-1945 colonial relationship. Any omitted variables are captured by country fixed effects.

Table 7 presents results for PPML estimation with and without country FEs. Without FEs, we find statistically significant coefficients, with signs as expected, for source and host country GDP, distance, and common language. With country FEs, results are similar, except that the host country's GDP has a negative impact on FDI. Also, *BIT* has a coefficient with a negative sign, which is counterintuitive. As explained earlier, we give more weight to LH results because this method allows the mechanisms generating zero and positive FDI to be different. The LH results in Table 7 with country FEs lead us to conclude that all statistically significant coefficients have signs as expected.²⁹ For the FDI participation decision, source and host country GDP, distance, *BIT*, and a common language are the relevant determinants. A common colonial relationship also has a positive influence, but is statistically significant only at the 10% level. On the other hand, the decision on the amount of FDI depends statistically significantly on source country GDP, distance, and sharing a common language. Overall, the LH regressions produce empirical results that are consistent with a basic gravity model of FDI.³⁰

8. Conclusion

The knowledge-capital (KK) model has been widely used in the empirical FDI literature in the last two decades in order to identify the motives behind FDI. The majority of studies focus on a group of developed countries, such as the OECD, or on inward and outward FDI for a single economy. An unanswered question in the existing literature is whether the KK model is a suitable vehicle to explain FDI among Asian economies or whether a gravity-type model is preferable. The KK model postulates that investment related to transfers of knowledge and know-

how may play an important role for FDI. The KK model includes specific difference, interaction and squared variables that distinguish it from other theories of FDI. We compare various empirical KK model specifications to a gravity model in line with Anderson et al. (2019) and use model specification tests to choose the best fitting model and estimation methods. A novel feature of our study is that, due to the prevalence of zero values in our FDI data, we model the decision to participate in FDI as being separate from the decision on the amount of FDI.

KK model-specific variables are the bilateral sum of GDP and its squared difference, the difference in skilled-labour endowments, and its squared interaction with trade cost to the host country. To some extent, our KK model-specific empirical findings signal that low-cost-labour seeking (vertical) FDI is the dominant type of FDI between Asian economies. However, the empirical results reveal that key coefficients either have signs opposite to what is predicted by the KK theory or are not statistically significant when country and time fixed effects are included in the fitted models.

We explore the robustness of our results, but our conclusions remain unchanged. A variety of alternative empirical significant impact on the volume of FDI between Asian countries. However, these are typical variables used in the FDI literature based on gravity model specifications. Therefore, we also fitted a gravity model.

A basic gravity model seems to provide a satisfactory empirical explanation of FDI among Asian countries. The variables relevant for FDI are GDP in the source country, GDP in the host country for the participation decision, distance between source and host country, a common spoken language for the FDI amount decision, and a common colonial relationship for the participation decision. Existence of a bilateral investment treaty also has a positive impact on FDI decisions.

Overall, our results suggest that future research on intra-Asian FDI should consider alternative models to the KK model, such as the gravity model of Anderson et al. (2019). Our results also highlight the importance of checking the robustness of results to the inclusion of fixed effects and alternative estimation methods that deal specifically with corner solution outcomes reflected in large numbers of zeros in the FDI data, which may bias results if removed.

Our results have several implications for economic policies related to trade and investment among Asian countries. While we do not find much empirical support for the KK model, which focuses on the transfer of knowledge and capital, it nevertheless reveals that relative unskilled-labour-cost advantages are an important channel that drives FDI within Asia. This is in line with recent movements of foreign investors from China to other low-wage Asian countries due to rising labour costs in

²⁹ We also report the LH results with no country FEs for completeness, even though these regressions may be subject to omitted variables and endogeneity biases.

³⁰ The logs of the trade and investments cost variables do not enter the gravity regression statistically significantly, except for the host country's investment cost in the participation decision and the source country's trade cost in the amount decision at the 10% level, but not at the 5% level. However, all other qualitative results are not affected. Detailed results are available from the authors on request.

China (Donaubauer and Dreger, 2018). Furthermore, the empirically preferred model for FDI, the gravity model of Anderson et al. (2019), points to additional crucial drivers of intra-Asian FDI that are relevant for policy: bilateral investment treaties and distance. Distance has a negative effect on FDI. It serves in our model as a proxy for trade costs. Therefore, policies that reduce trade costs, such as China's belt and road initiative, are likely to enhance FDI significantly.

interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of competing interest

The authors declare that they have no known competing financial

Appendix B. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.econmod.2020.08.003>.

Appendix A

Table A1

Summary of empirical applications of the KK model.

Study/US	Country and period	Estimation method	Empirical specification	Evidence for KK model
Carr et al. (2001)	US, 1986–1994	OLS, WLS, Tobit	CMM	KK
Markusen and Maskus (2001)	US, 1986–1994	OLS, WLS, Tobit	CMM	Mixed
Markusen and Maskus (2002)	US, 1986–1994	WLS, Tobit	CMM	Mixed
Blonigen et al. (2003)	US, 1986–1994	OLS, Tobit	Modified CMM	HOR
	OECD, 1982–1992			
Gao (2003)	China, 1992	N/A	CMM	KK
Yeaple (2003)	US, 1994	OLS	Own	KK
Blonigen and Davies (2004)	US, 1980–1999	OLS, FE	Modified CMM	HOR
Egger and Pfaffermayr (2004)	OECD, 1982–1997	FE	CMM	KK
Braconier et al. (2005)	56 source and 85 host countries, 1986–1998	OLS, WLS	Own	KK
Baltagi et al. (2007)	US, 1989–1999	Spatial GMM	Own	Mixed
Davies (2008)	US, 1986–1994	OLS	Modified CMM	KK
	OECD, 1982–1992			
Mariel et al. (2009)	OECD, 1982–2003	Time-varying coefficient model	CMM	KK
Kristjánisdóttir (2010)	Iceland, 1989–1999	OLS, Tobit	Modified CMM	Mixed
Waldkirch (2011)	Mexico, 1994–2000	Tobit	Own	KK
Awokuse et al. (2012)	US, 1985–1999	GMM, WLS, Tobit	CMM	Mixed
Kristjánisdóttir (2012)	Iceland, 1989–1999	OLS, Tobit	CMM	Mixed
Bergstrand and Egger (2013)	35 source and host countries, 1986–2000	PPML	Own	Extended KK
Chellaraj et al. (2013)	Singapore, 1984–2007	Tobit	CMM	Mixed
Lankhuizen (2014)	OECD, 1985–1992	WLS,	Modified CMM	No support
Stack et al. (2015)	Europe, 1996–2007	Stochastic frontier analysis	Modified CMM	KK
Dixon and Haslam (2016)	Latin America, 1990–2008	GMM, LSDV	CMM	Mixed

Notes: WLS is weighted least squares, FE is fixed effect, GMM is generalized method of moments, PPML is Poisson pseudo-maximum-likelihood, LSDV is least squares dummy variables, and CMM is Carr et al. (2001). Empirical evidence for the KK model: KK means support for both vertical and horizontal FDI; HOR indicates support for horizontal FDI only; 'Mixed' signifies support for the KK model in some cases but not in others.

Table A2

Results for pairs with at least one year of positive FDI.

	HOR	VER	OLS	Tobit	PPML	LH	
						Amount	Part
SumGDP	+		2.741*** (0.756)	2.210*** (0.760)	−0.172*** (0.065)	−0.205* (0.108)	−0.052 (0.242)
GDPdif_sq	−		−0.425*** (0.060)	−0.389*** (0.059)	0.013*** (0.004)	0.022* (0.012)	0.020 (0.023)
GDPSK		−	−2.304*** (0.679)	−2.054*** (0.665)	−0.177** (0.070)	−0.151 (0.136)	0.200 (0.203)
Tradecost_s		−	0.036*** (0.012)	0.018 (0.018)	−0.011 (0.012)	−0.020*** (0.007)	−0.009 (0.006)
Tradecost_h	+	−	−0.023* (0.012)	−0.038** (0.016)	−0.023*** (0.006)	−0.006 (0.005)	−0.007 (0.005)
SKdif	−	+	−1.214 (1.033)	−3.010* (1.708)	−0.265 (0.658)	−0.209 (0.579)	−0.846 (0.920)
TradeSK	−	−					

(continued on next column)

Table A2 (continued)

	HOR	VER	OLS	Tobit	PPML	LH	
						Amount	Part
			0.054 (0.038)	0.059 (0.041)	0.036*** (0.014)	0.014 (0.014)	−0.010 (0.015)
<i>Investcost_h</i>	−	−	0.016 (0.010)	0.033*** (0.012)	0.004 (0.005)	−0.008* (0.004)	0.013*** (0.005)
<i>Dist</i>	+/−	−	−0.402*** (0.114)	−0.681*** (0.122)	−0.246*** (0.035)	−0.493*** (0.057)	−0.237*** (0.037)
<i>GDPdif</i>	+/−	+/−	0.940** (0.383)	0.981** (0.385)	0.231*** (0.053)	0.211*** (0.071)	0.161 (0.125)
<i>BIT</i>	+	+	−0.678 (0.583)	−0.570 (0.582)	−0.284*** (0.099)	0.011 (0.175)	0.292** (0.133)
<i>Contiguity</i>	+	+	0.353 (1.082)	0.387 (1.045)	0.343 (0.255)	0.548* (0.286)	−0.063 (0.226)
<i>ComLang</i>	+	+	1.660* (0.977)	1.931* (1.002)	0.554*** (0.156)	0.614*** (0.229)	0.176 (0.213)
<i>ComCol</i>	+	+	−0.667 (0.701)	−0.519 (0.765)	−0.063 (0.200)	0.478 (0.338)	−0.017 (0.203)
Constant			2.635 (3.391)	1.160 (1.736)	−0.137 (0.975)	−1.535 (0.940)	1.729*** (0.511)
<i>N</i>			3703	3703	3703	3703	
Log pseudo likelihood			−11,162	−9580	−3252	2135	

Notes: See Table 6. Source country and host country fixed effects and year fixed effects are included in all regressions.

Table A3

Results based on Braconier et al. (2005) specification.

	HOR	VER	OLS	Tobit	PPML	LH	
						Amount	Part
<i>SumGDP</i>	+		1.950*** (0.626)	0.324 (1.012)	0.210 (0.255)	0.223 (0.359)	−0.356 (0.374)
<i>GDPdif_sq</i> (<i>SIZESQ</i>)	−		−0.572 (0.814)	−0.469 (1.969)	−0.254 (0.488)	−0.984 (0.771)	0.490 (0.496)
<i>GDPSPK</i>		−	−0.612 (0.414)	−1.052 (0.670)	0.097 (0.092)	0.018 (0.188)	−0.070 (0.143)
<i>Tradecost_s</i>		−	0.005 (0.004)	−0.014 (0.014)	−0.030*** (0.011)	−0.020*** (0.007)	−0.009** (0.004)
<i>Tradecost_h</i>	+	−	0.000 (0.004)	−0.006 (0.011)	−0.014** (0.006)	0.002 (0.004)	−0.003 (0.004)
<i>SKdif</i> (<i>SKILL</i>)	−	+	0.704*** (0.253)	0.847** (0.352)	0.006 (0.066)	0.093 (0.099)	0.036 (0.071)
<i>TradeSK</i>	−	−	−0.000** (0.000)	−0.001** (0.000)	−0.000 (0.000)	−0.000** (0.000)	−0.000 (0.000)
<i>Investcost_h</i>	−	−	0.008** (0.004)	0.035*** (0.010)	0.004 (0.004)	−0.008** (0.004)	0.010*** (0.003)
<i>Dist</i>	+/−	−	−0.273*** (0.051)	−0.847*** (0.126)	−0.245*** (0.047)	−0.444*** (0.060)	−0.281*** (0.041)
<i>GDPdif</i> (<i>SIZE</i>)	+/−	+/−	0.553 (1.729)	0.623 (3.886)	−0.049 (0.865)	1.118 (1.247)	−0.427 (0.838)
<i>BIT</i>	+	+	−0.790*** (0.297)	0.145 (0.494)	−0.187 (0.160)	−0.033 (0.193)	0.525*** (0.146)
<i>Contiguity</i>	+	+	0.318 (0.688)	1.528 (0.934)	0.165 (0.288)	0.718* (0.402)	0.396 (0.340)
<i>ComLang</i>	+	+	0.522 (0.354)	0.785 (0.711)	0.652*** (0.247)	0.552** (0.265)	0.091 (0.207)
<i>ComCol</i>	+	+	−0.292 (0.308)	0.675 (0.857)	−0.207 (0.296)	0.348 (0.392)	0.499** (0.238)
Constant			−0.090 (6.785)	−11.670*** (3.332)	−10.183*** (1.979)	−1.217 (1.007)	−2.691*** (0.682)
<i>N</i>			7259	7259	7259	7259	
Log pseudo likelihood			−17,592	−7602	−2700	774	

Note: See Table A2.

Table A4Results based on [Davies \(2008\)](#) specification.

Negative SKdif					Positive SKdif				
	HOR	PPML	LH		HOR	VER	PPML	LH	
			Amount	Part				Amount	Part
<i>SumGDP</i>	+	−0.821*** (0.272)	−0.650*** (0.202)	1.022** (0.448)	+		−0.072 (0.076)	0.093 (0.161)	1.063** (0.537)
<i>GDPdif_sq</i>	−	0.049* (0.025)	0.030*** (0.010)	−0.101** (0.050)	−		0.010** (0.004)	0.006 (0.017)	−0.132** (0.055)
<i>GDPSK</i>		−0.058 (0.192)	−0.051 (0.238)	0.197 (0.318)	−	−	−0.110 (0.090)	0.156 (0.239)	−0.963*** (0.325)
<i>Tradecost_s</i>		−0.024*** (0.008)	−0.008 (0.009)	0.004 (0.005)	−	−	−0.002 (0.012)	−0.030** (0.012)	−0.013** (0.006)
<i>Tradecost_h</i>	+	0.001 (0.020)	0.005 (0.011)	−0.018** (0.009)	+	−	−0.020*** (0.006)	−0.010 (0.006)	0.004 (0.005)
<i>SKdif</i>	+	−1.240 (1.601)	−2.252 (1.724)	−1.574 (1.126)	−	+	−2.996** (1.204)	−1.490 (1.471)	1.396 (1.452)
<i>SKdif_sq</i>	−	2.694 (5.041)	−7.326** (3.318)	−0.435 (1.992)	−	+	5.105*** (1.827)	2.236 (1.882)	−2.448 (2.685)
<i>TradeSK</i>	−	−0.069 (0.150)	0.279*** (0.083)	−0.020 (0.054)	−	−	0.012 (0.017)	0.017 (0.019)	0.012 (0.027)
<i>Investcost_h</i>	−	0.014** (0.007)	−0.002 (0.006)	0.019*** (0.005)	−	−	0.003 (0.004)	−0.010* (0.005)	−0.006* (0.004)
<i>Dist</i>	+/−	−0.357*** (0.072)	−0.520*** (0.092)	−0.307*** (0.040)	+/−	−	−0.262*** (0.036)	−0.460*** (0.055)	−0.391*** (0.046)
<i>GDPdif</i>	+/−	0.388** (0.163)	0.393** (0.183)	0.375*** (0.136)	+/−	+/−	0.283*** (0.068)	0.272*** (0.089)	0.121 (0.403)
<i>BIT</i>	+	0.104 (0.160)	0.176 (0.235)	0.324** (0.151)	+	+	−0.331*** (0.119)	−0.154 (0.196)	0.738*** (0.182)
<i>Contiguity</i>	+	0.214 (0.583)	1.151*** (0.445)	0.087 (0.311)	+	+	0.481** (0.235)	0.293 (0.397)	0.433 (0.326)
<i>ComLang</i>	+	0.113 (0.308)	0.076 (0.342)	0.042 (0.235)	+	+	0.842*** (0.130)	0.890*** (0.239)	0.086 (0.252)
<i>ComCol</i>	+	−0.051 (0.376)	0.905* (0.491)	0.431* (0.258)	+	+	−0.134 (0.240)	0.602* (0.351)	0.360 (0.253)
Constant		1.897 (1.809)	−3.560*** (1.034)	−1.199* (0.676)			−0.274 (1.253)	8.734*** (0.872)	−2.326*** (0.649)
<i>N</i>		4806	4806				4725	4725	
Log pseudo likelihood		−1205	874				−2021	709	

Note: See [Table A2](#).**Table A5**Results based on [Bergstrand and Egger \(2013\)](#) specification with PPML.

	Sign	No country FE	No country FE	With country FE	With country FE
$\ln(\text{SumGDP})$	+	1.647*** (0.147)	1.721*** (0.136)	0.893 (0.803)	0.763 (1.008)
$\ln(\text{Similarity})$	+	0.778*** (0.135)	0.989*** (0.258)	−0.061 (0.439)	0.403 (0.524)
$\ln(\text{Dist})$	−	−0.625*** (0.161)	−0.687*** (0.144)	−0.739*** (0.155)	−0.833*** (0.168)
<i>BIT</i>	+	−0.134 (0.341)	−0.325 (0.338)	0.038 (0.184)	0.011 (0.174)
<i>Contiguity</i>	+/−	0.901* (0.543)	0.703 (0.497)	−0.674* (0.407)	−0.689 (0.440)
<i>ComLang</i>	+	0.616 (0.460)	0.466 (0.378)	0.343 (0.232)	0.395* (0.228)
<i>ComCol</i>	+	0.262 (0.405)	0.253 (0.377)	0.443 (0.283)	0.181 (0.281)
$\ln(\text{Investcost}_h)$	−	−0.242 (0.294)	−0.387* (0.214)	0.153 (0.275)	0.169 (0.279)
$\ln(\text{Tradecost}_h)$	−	−1.127*** (0.200)	−0.942*** (0.207)	−0.090 (0.162)	−0.064 (0.160)
$\ln(\text{Tradecost}_s)$	+/−	−1.481*** (0.242)	−1.316*** (0.224)	−0.178 (0.225)	−0.089 (0.199)
<i>Ss</i>	+	0.155 (0.348)	−9.549 (6.468)	−0.003 (0.235)	−5.587 (5.524)
<i>Ks</i>	+	2.787*** (0.427)	18.372 (11.650)	1.646** (0.825)	−3.781 (9.886)
<i>Us</i>	−	−1.980*** (0.460)	−6.285** (2.456)	−1.700*** (0.577)	−1.035 (1.190)
Ss^2	−		30.258 (30.467)		28.837 (21.658)

(continued on next column)

Table A5 (continued)

	Sign	No country FE	No country FE	With country FE	With country FE
Ss^3	+		–34.145 (50.875)		–45.210 (33.247)
Ss^4	–		10.680 (26.630)		23.381 (16.831)
Ks^2	–		–30.197 (41.895)		17.241 (31.913)
Ks^3	+		6.172 (59.201)		–28.520 (43.234)
Ks^4	–		9.264 (28.166)		16.660 (20.279)
$SsKs$	+/–		0.666 (1.652)		–0.057 (1.031)
$SsUs$	+/–		2.525 (3.311)		–2.331 (1.642)
$KsUs$	+/–		3.988** (1.994)		1.220 (1.732)
Constant		–1.283 (2.005)	–2.084 (2.046)	–17.224*** (3.267)	–14.902*** (4.329)
N		5596	5596	5596	5596
Log pseudo likelihood		–4482	–4027	–2082	–2044

Notes: See Table 5. FE refers to fixed effects. See Section 7.4 for explanations of Ss , Ks , and Us ; S is skilled labour, K capital, U unskilled labour, and s the source country. $SsKs$, $SsUs$ and $KsUs$ are interaction terms.

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