The knowledge-capital model: The case of intra-Asian foreign direct investment

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Abstract

Employing a panel dataset of bilateral inward and outward foreign direct investment (FDI) for 31 Asian countries and territories over the period 2001-2012, we estimate the knowledge-capital (KK) model to find the dominant type of FDI within Asia. We consider alternative estimation methods to deal with zero values, which form the majority of the bilateral observations. Based on a series of model selection and diagnostic tests, we conclude that Lognormal Hurdle and Poisson Pseudo-Maximum-Likelihood are the most appropriate. Controlling for host and source country characteristics, our findings suggest that vertical FDI is the dominant type between Asian countries. However, we find little empirical evidence in support of the KK model's predictions for its key variables, such as total GDP and skill difference, when country fixed effects are included. Some factors (distance, trade costs to both source and host country, the GDP difference between source and host country, and a common spoken language) are found to have statistically significant impacts on the volume of FDI between Asian countries, regardless of whether or not fixed effects are included.

Keywords: Intra-Asian FDI, knowledge-capital model, corner solution outcomes, zero values, skill differences

JEL Classification: F21, F23

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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, 2015, 2016), Asia has attracted more than 400 billion dollars of FDI inflows each year since 2012, comprising around a third of global FDI. As Figure 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). There have been numerous empirical studies on FDI in Asia but only a few examine intraregional Asian FDI, e.g., Kim and Oh (2007), Hattari and Rajan (2008), Rajan and Hattari (2009), Petri (2012), Masron (2013) and Garrett (2016). Moreover, these studies focus on only a relatively small number of Asian countries and/or only a specific region, such as East Asia and Southeast Asia. Our research contributes to the literature by studying the drivers of intra-Asian FDI, using a much more comprehensive data set that includes 31 Asian countries and territories, from 2001 to 2012.

Two popular motives for FDI are to serve foreign markets and to take advantage of lower input costs in foreign nations. This leads to the two main types of FDI: horizontal FDI and vertical FDI. Horizontal FDI occurs when multinational enterprises (MNEs) produce the same goods and services in multiple countries in order to expand their markets. In contrast, vertical FDI occurs when MNEs fragment their production process vertically between source and host nations to benefit from lower production costs. Markusen's (2002) knowledge-capital (KK) model integrates both these motives into a general equilibrium model that can explain both horizontal and vertical FDI simultaneously. Empirical evidence based on the KK model, so far, suggests that horizontal FDI is more prevalent than vertical FDI. Ours is the first study that applies the KK model to investigate the determinants of intra-Asian FDI in order to determine whether the dominant type of FDI is horizontal, vertical or mixed. With the KK model as a framework, our regression analysis also takes into account the effect of both source and host countries' characteristics.

The majority of observed values of bilateral FDI are zeros, as is the case for trade data. The KK model not only predicts the volume of FDI but also whether there is no FDI, i.e., if domestic investment is the dominant type. However, empirical applications of the KK model tend to ignore the no-FDI outcome and, instead, focus on the two types of FDI – horizontal or vertical. In our study, we apply the KK model to bilateral FDI between all possible in-sample country pairs to test the model predictions on both FDI and no FDI. This requires estimation methods that can deal with zero outcomes. Several alternative econometric estimation methods have been suggested in the literature, based on different underlying assumptions about the unknown data generating process. Empirical studies of FDI commonly select and apply a specific method without exploring whether it is superior to other available alternative methods. In contrast, we conduct statistical testing to choose the most appropriate estimator for our data.

The remainder of the paper proceeds as follows. Section 2 presents a review of the literature on the KK model as well as determinants of intra-Asian FDI. Section 3 describes the 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 conducts a variety of robustness checks, followed by our conclusions in Section 8.

2. **Literature review**

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 & Salike, 2013). Most studies on FDI in Asia focus on a major source country, such as Japan (Encarnation, 1999; Lakhera, 2008), Taiwan (Chen & Aquino, 1998), or China (Kang & Jiang, 2012).

There are very few studies specifically examining FDI between Asian countries. For example, Kim and Oh (2007) employ aggregate data on Asian FDI flows between 13 East and Southeast Asian countries, from 1995 to 2004, to analyse the effects of regional economic integration on intra-regional FDI. Hattari and Rajan (2008) and Rajan and Hattari (2009) examine the determinants of intra-Asia bilateral FDI, using a gravity framework, 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, 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 low technology achievements and good protection of intellectual property rights.[1]

Based on Dunning's (1977) 'eclectic' or 'OLI' (Ownership, Location, and Internalization) framework, Masron (2013) examines the role of the ASEAN Investment Area (AIA) and the ASEAN free trade agreement (AFTA) in promoting intra-ASEAN FDI during the period from 1998 to 2009. The results reveal that factors encouraging intra-ASEAN FDI in the AIA are the host country's GDP, political stability, labour productivity, and non-ASEAN FDI.

[1] Population is used as a proxy for market size, although it does not capture the purchasing power of an economy as a whole as well as GDP.

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. Comparing results from two different estimation methods (ordinary least squares (OLS) and Heckman selection), he finds (Appendix 7) 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 countries are more likely to attract non-zero FDI, but host country size has a negative impact on FDI flows if FDI takes place.

Our study extends the empirical literature on the determinants of intra-Asia FDI in a number of ways. First, we examine intra-Asia FDI as a whole rather than focusing on only a small sub-group of Asian countries. Second, in addition to considering host-country characteristics, we also include in our analysis the source countries' characteristics, such as factor endowments, as the latter may have a significant effect on FDI location choices.[2] Third, unlike most previous studies on Asian FDI, we base the choice of variables in our empirical model on the KK theory as much as possible. Fourth, we conduct model selection tests in order to find the most appropriate estimator and do not rely solely on one econometric method when alternative suitable methods are available.

3. Theoretical framework and hypotheses

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 (Faeth, 2009). The KK model developed by Markusen (2002) is used as the basis for our empirical work because it can explain both horizontal and vertical

[2] Petri (2012) and Garrett (2016) are exceptions in the existing literature in considering source countries' characteristics.

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 2×2×2 model with two countries (home and foreign), two inputs (skilled and unskilled labour), and two outputs (homogeneous product and 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 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 (Carr, Markusen, & Maskus, 2003). The most influential empirical study of the KK model is Carr, Markusen, and Maskus (2001), referred to as the CMM specification, as can be seen from Table A1 in the Appendix. Therefore, we base our estimation equation on their specification:

$$FDI = f(SumGDP, GDPdif\_sq, GDPSK, SKdif, Tradecost\_s, Tradecost\_h, TradeSK, Investcost\_h, Dist, GDPdif, BIT, Contig, ComLang, ComCol) \quad (1)$$

where suffix *s* denotes the source/parent country and suffix *h* denotes the host/receiving country. *FDI* is the annual FDI stock accrued due to flows from country *s* to country *h*. Variables with no *s* or *h* suffix are pair-specific.

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 (Carr et al., 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 & 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 (Carr et al., 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 (Carr et al., 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*) hinder vertical FDI because they are a disincentive to produce in host countries and export back to the source countries (Carr et al., 2001). Higher trade costs to the source country are hypothesized to have a negative impact on this process. 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 motive for firms to invest horizontally abroad is 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 magnitude 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 ($TradeSK = Tradecost\_h \times (SK\_s - SK\_h)^2$) (Carr et al., 2001). As noted, 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, 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 (Carr et al., 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. The effects of distance on both forms of FDI are indistinguishable.

Besides basic KK variables from the Carr et al. (2001) model, which have been included in numerous empirical studies, we augment our 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 and the interaction between *GDPdif* and skilled-labour endowments is also included (as *GDPSK*). 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 & Sorensen, 2013; Brambor, Clark, & Golder, 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. However, the Lucas Paradox (Lucas, 1990) highlights that there is little capital flowing from rich countries to poor countries; the vast majority of capital flows are actually between developed or rich countries. If FDI between Asian countries is consistent with the Lucas Paradox, GDP differences may have a negative impact on FDI.

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*).[3] 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. The set of non-official languages in which people between the two countries are proficient can reduce transaction costs in business between them (Kim, Liu, Tuxhorn, Brown, & Leblang, 2015). In the Centre d'Études Prospectives et d'Informations Internationales (CEPII) database, common spoken language takes on 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 to 2012. This is based on an initial list of all countries and territories geographically located in Asia according to the United Nations.[4] From this, we exclude countries that are considered European according to the European Union.[5] We end up with 31 countries and territories with sufficient data for the empirical analysis.

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 maximises the number of bilateral observations and provides consistent reporting for each

[3] Other dummies are used in previous studies such as: ever in a colonial relationship, currently in a colonial relationship, and in a colonial relationship post 1945. 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.
[4] https://unstats.un.org/unsd/methodology/m49/, accessed on 1st May 2016.
[5] https://europa.eu/european-union/about-eu/countries_en, accessed on 1st May 2016.

country pair. Data for GDP are from the World Bank Development Indicators (WDI). The WDI database does not provide data for Taiwan, so we obtain 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 for the reporting country, 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 enrols in tertiary education. We also use the ratio of the workforce that is skilled (skill ratio) in robustness checks. 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. Data sources are described in Table 3.

5. Estimation methods 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 one another. The majority of observations on the dependent variable therefore take the value of zero. A common problem in the international trade and FDI literature is how to deal with these zeros in estimation. The tendency in the literature is to estimate a Heckman sample selection model. However, we do not face missing data here. The zeros are true zeros, i.e., corner solution outcomes. A corner solution response model (Wooldridge, 2010), rather than a sample selection model, is therefore more appropriate.

We assume that the observed values of FDI are the outcomes of a maximization problem that allows the possibility of corner solutions at zero. We can express this as:

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

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

$$FDI^* = \boldsymbol{x\beta} + \varepsilon$$

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

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 $\varepsilon|\boldsymbol{x} \sim N(0, \sigma^2)$, is labelled the ‘Type I Tobit model’ by Wooldridge (2010, Ch. 17), and is the standard Tobit model widely applied in the literature. However, violation of this distributional assumption (due to heteroskedasticity or non-normality) makes the Tobit estimator inconsistent (Wooldridge, 2010).

A more flexible approach is to assume that the mechanisms determining the participation decision and the amount decision 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. The different model types 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 amount decision for each model is:

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

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

In the amount equation for the TNH model in (3), ε given $\boldsymbol{x}$ is assumed to have a truncated normal distribution and the parameters are estimated by a truncated normal regression. In the amount equation for the LH model in (4), ε given $\boldsymbol{x}$ 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 decisions. Relaxing this assumption gives what Wooldridge (2010) calls the 'exponential type II Tobit (ET2T) model'. Assume $FDI = s \cdot FDI^*$, where s is a binary variable determining whether FDI is zero (s = 0) or positive (s = 1). The participation part, s, 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). However, unlike LH, the errors in the probit model, v, and in the LH-type amount equation, ε, are allowed to be correlated. Wooldridge (2010, pp. 698-699) shows that

$$E[\log(FDI^*) \mid \boldsymbol{x}, FDI > 0] = \boldsymbol{x}\beta + \eta\lambda(\boldsymbol{x\gamma})$$

where $\lambda(.)$ is the inverse Mills ratio obtained from the probit estimation of the participation equation (with parameters $\boldsymbol{\gamma}$) and η is the population regression coefficient from the error in the amount equation, ε, on the error in the participation equation, v. 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 (η = 0). An LR test can be applied to choose the appropriate model.

Lastly, the Poisson pseudo-maximum-likelihood (PPML) estimation proposed by Santos Silva and Tenreyro (2006) has been frequently employed to deal with corner solution outcomes for a continuous dependent variable. The equation to be estimated by PPML is:

$$FDI = \exp(\boldsymbol{x\beta}) + \varepsilon$$

For PPML to be consistent the conditional mean must be correctly specified, which can be tested using the Ramsey RESET test. In addition, Santos Silva, Tenreyro, and Windmeijer (2015) propose the HPC test, which can be used to discriminate between one-part models and two-part models for corner-solution data.[6]

6. **Regression results and interpretation**

We estimate the parameters of the model in (1) 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.[7] 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 & 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, estimates from Tobit are inconsistent. We also present results from OLS for comparison with previous studies, although OLS is not an appropriate method as it does not address the issue of excessive zeros in the dependent variable. Further, Table 4 shows that both OLS and Tobit do not pass the RESET functional form test at the 5% significance level. 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).

[6] 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.
[7] Hong Kong was transferred to China on 1 July 1997, after having been ruled for 156 years by the UK.

As noted in section 5, the LH model is nested in the ET2T model, with the former imposing the restriction $\eta = 0$, i.e., 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 HPC test cannot choose between LH and PPML, or between ET2T and PPML. Therefore, we primarily draw conclusions 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. We do not report results from ET2T because they are very similar to LH. For all the tests, we control for source and host country fixed effects (FEs) and year FEs.

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 with low *p*-values (Cameron & 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 FEs (but retaining year FEs) , as several papers applying the KK model exclude country FEs, e.g., Blonigen, Davies, and Head (2003), Davies (2008), and Stack, Ravishankar, and Pentecost (2015). Results are reported in Table 5.

Estimated coefficients from OLS and Tobit are considerably larger than from PPML and LH because the latter two estimation methods assume an exponential function rather than a linear function of the dependent variable. Although not shown in the tables of results, the quantitative marginal effects from alternative estimation methods are considerably different, even between PPML and LH. Therefore, in the discussion we focus mainly on the direction of impact and level of statistical significance.

As can be seen from Table 5, the sum of the host and source countries' 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 host country's investment costs (*Investcost_h*), predicted to be negative for both horizontal and vertical FDI, is also not statistically significant in both PPML and LH (amount) estimations, but has a statistically significant negative effect in the participation equation for LH.

The results for the key variables that have opposite-signed predicted effects on 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_h*), 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 Carr et al. (2001). Other variables with statistically significant effects consistent with their expected impacts are distance, GDP difference, and common language.

Apart from *GDPdif_sq*, these results, without controlling for country FEs, are consistent with the KK model's predictions, i.e. there is empirical evidence for both horizontal and vertical FDI in the results. Also, vertical FDI seems to be the dominant type of FDI.

6.2. Results controlling for country fixed effects

Results controlling for country and year FEs are presented in Table 6. Controlling for country FEs can reduce omitted variables bias related to source or host countries' characteristics that are not captured by the variables in the model, such as economic policies, culture, infrastructure and political stability. Carr et al. (2001) control for host country FEs only, as the source country is always the US in their sample, and find that the signs of the coefficients of interest are robust to the inclusion of FEs. The inclusion of source and host country FEs and year FEs in Table 6 follows the approach adopted by Braconier, Norbäck, and Urban (2005) who apply the KK model to analyse determinants of FDI in different groups of countries. Apart from OLS and Tobit, which are inappropriate estimation methods according to our diagnostic and model selection tests, the results for the other estimation methods reported in Table 6 are not consistent with many of the KK model's predictions.

First, *SumGDP* has a negative impact on FDI with PPML and in the outcome equation of the LH model, although its statistical significance is more marginal. In addition, *GDPdif_sq* has a positive impact on FDI with PPML and in the outcome 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 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 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 affected the conclusions on the CMM 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 (Table 9, column (5)) 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 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 several equations. 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. Its coefficients are also negative in all other equations. 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 for models without fixed effects in Table 5, the point estimates for the *SKdif* coefficient becomes negative but is no longer statistically significant when allowing for country FEs in Table 6. Indeed, Lankhuizen (2014) argues against 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. Using skill difference further implies a strong prediction (coefficients of equal absolute value but opposite sign) for the impact of source and host countries' variables for labour endowment (*SK_s* and *SK_h*). Although the results with fixed effects are less clear-cut, based on the variables that are statistically significant, vertical FDI still appears to be the dominant type between Asian countries.[8] 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 little or no empirical evidence for vertical FDI. The different conclusion may be partly because those studies focus on developed countries only.

Besides the differences in some of the results with and without controlling for country FEs, 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 in all equations, GDP difference and common spoken language have significant positive effects. Hence, intra-Asian FDI is encouraged when source countries are bigger 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, a positive and statistically significant coefficient on the square of GDP difference in columns (7) and (8) in Table 6 suggests that the relationship between GDP difference and FDI is not the inverted U-shape predicted by the KK model. Instead, the pattern is simply that the larger the source country, the more FDI flows to the host country.

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 language can affect investors' decisions, common spoken language does not have a statistically significant impact on the participation decision in our LH results (in Table 6, column (10)). It has a positive and significant effect in

[8] 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.

the amount equation (column (9)) only. Similar to common language, contiguity has a positive effect on the amount of FDI but does not have a statistically significant impact on participation decisions. Empirical evidence for contiguity is weak since its coefficient is statistically significant only in column (9) and only at the 10% significance level.

Interestingly, existence of a bilateral investment treaty (*BIT*) 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. Many recent empirical papers on trade and FDI, such as Bruno, Campos, Estrin, and Tian (2017) and Berger, Busse, Nunnenkamp, and Roy (2013), apply PPML and derive conclusions from this estimation method without any model selection tests. 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% significance 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. Finally, having a common colonizer post 1945 is often found to have a positive impact on FDI (Eichengreen & Tong, 2006; Liebscher, Christl, Mooslechner, & Ritzberger-Grünwald, 2007); however, in our results, the effect of this variable on intra-Asian FDI is not statistically significant.

7. **Robustness checks**

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 still evidence for vertical FDI as discussed above. In this section, we conduct sensitivity tests to see if the conclusions remain unchanged with a different sample, different model specifications, and a different proxy for labour endowments.

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 result from a sample overly dominated by zero values. To explore this possibility, Table 7 reports results with the same sampling method used in previous studies, i.e., 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 are still the preferred estimators.

The results in Table 7 are almost identical to 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. Accordingly, our results do not appear to be due to different sampling criteria. With or without the zero pairs, vertical FDI is still the dominant type in intra-Asian FDI and the KK model predictions for key variables do not hold. Therefore, in the following sensitivity tests we include all possible pairs, which maximizes the number of observations.

7.2. Davies's (2008) specification

Whereas results in Table 6 suggest that vertical FDI is the dominant type between Asian countries, the key variables in the CMM specification are either not statistically significant or have signs opposite to what is expected. In addition, many previous studies find evidence only for horizontal FDI (see Table A1 in the Appendix). Davies (2008) claims this is because the CMM 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 8 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.[9] Therefore, in Table 8, we omit the expected sign column entry for vertical FDI when *SKdif* < 0. In contrast to the CMM 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).[10]

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 the positive *SKdif* specification, the coefficients on these variables are not statistically significant. 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 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's (2008) results on the

[9] Markusen and Maskus (2002) also test this prediction but in a different specification and without *SKdif_sq*.
[10] 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 also not appropriate estimation methods.

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 specification and the KK model predictions in general.

7.3. Braconier et al.'s (2005) specification

The diversity in empirical results testing the CMM 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's (2002) simulation results.[11] However, the roles and expected signs of these variables are the same as the original variables in Carr et al. (2001), so, for ease of comparison with the previous tables, we use both sets of variable names in tabulating the results.

In order to apply 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 9. OLS results in Table 9 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

[11] *SIZE_h* is defined as $(s\_h^2 + u\_h^2)^{0.5}$, and *SKILL*_h as *s_h*/*u_h*, where *s_h* and *u_h* 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).

all the basic KK variables (*SumGDP*, *SIZESQ* (for *GDPdif_sq)*, *GDPSK*, and *SKILL* (for *SKdif*)) 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 equations. 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.

8. **Conclusion**

The KK model has been widely used in the FDI literature in the last two decades in order to identify horizontal and vertical FDI empirically. 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. This is the first study to apply the KK model to intra-Asian data to examine the determinants of FDI and to find the dominant type of intra-Asian FDI. The KK model includes specific difference, interaction and squared variables that distinguish it from previous theories on FDI. This is also the first study to attempt to estimate the KK model using a comprehensive set of alternative estimation methods for dealing with corner solution outcomes and to perform model selection tests to find the most appropriate estimation method.

Our empirical results, based on appropriate estimation methods that deal with zero values (especially PPML and LH), show that the coefficients of the KK-specific variables (*SumGDP*, *GDPdif_sq*, *TradeSK*, and *SKdif*) either have signs opposite to what is predicted by the theory or are statistically insignificant when country and time fixed effects are included in the fitted models. To some extent, our empirical findings signal that vertical FDI is the dominant type of FDI between Asian countries, although the key variable to distinguish horizontal and vertical FDI (*SKdif*) has an unexpected sign but is also not statistically significant when country fixed effects are included.

As our study is the first study including all possible pairs among a group of countries to explain the zero FDI part of the KK model, we also estimate models based on the same sample selection methods as in previous studies, but our conclusions remain unchanged. Through a variety of sensitivity tests with different choices of samples, model specifications, and proxies for skilled-labour endowments, we do not find empirical evidence in support of the main predictions of the KK model for both forms of FDI. The non-monotonic and nonlinear relationships that the KK model predicts based on its numerical simulation results appear not to be supported empirically in the case of intra-Asian FDI. On the other hand, a number of factors are found to have a significant impact on the volume of FDI between Asian countries. These are distance, trade costs to both source and host countries, the GDP difference between source and host country, and a common spoken language. Existence of a bilateral investment treaty also has a positive impact on FDI decisions but any subsequent effect on the amount of investment is imprecisely estimated.

Overall, our results suggest that future research should consider alternative models of FDI (e.g., gravity-based and other models). 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.

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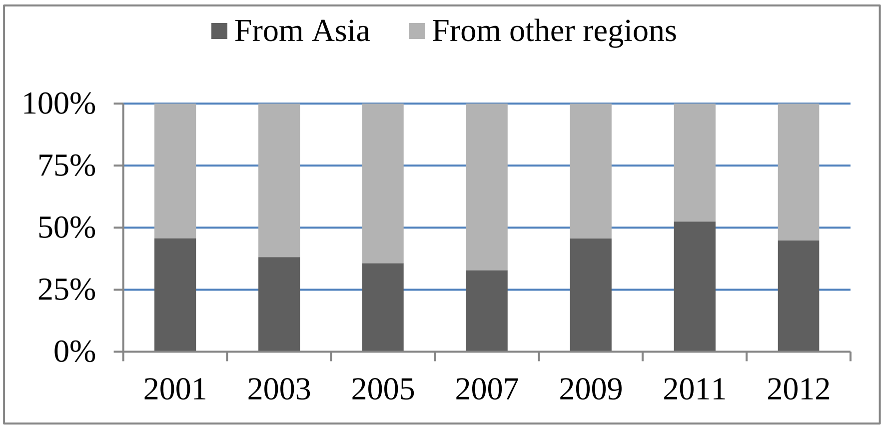

Figure 1: FDI inflows to Asia, by region, 2001-2012 (%)

Data source: UNCTAD.

Table 1

Firm types and countries' characteristics in the KK model

<table>
<tr><th>Dominant investment type</th><th>Source country</th><th>Host country</th><th>Similar in size and relative factor endowments</th><th>Trade costs</th><th>Total income</th><th>Notes</th></tr>
<tr><td>Horizontal FDI</td><td></td><td>Low foreign investment barriers</td><td>Yes</td><td>High</td><td>High</td><td>Trade costs are exporting costs from the source country to the host country.</td></tr>
<tr><td>Vertical FDI</td><td>Small, skilled-labour abundant</td><td>Low foreign investment barriers</td><td>No</td><td>Not excessive</td><td></td><td>The vertical firm in the host country may or may not export to its source country.
Trade costs are in both directions between two countries.</td></tr>
<tr><td rowspan="3">Domestic investment</td><td>Large, skilled-labour abundant</td><td></td><td>No</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Yes</td><td>Low</td><td></td><td>Trade costs are exporting costs from the source country to the host country.</td></tr>
<tr><td></td><td>High foreign investment barriers</td><td></td><td></td><td></td><td>Domestic firms may export if exporting costs are not excessive.</td></tr>
</table>

Note. Based on Markusen (2002, Ch. 7). Empty cells denote that there are no specific implications for the dominant type.

Table 2

Variables: Definitions and hypotheses

No	Variables	Explanation	Expected signs HOR	VER
Basic KK variables				
1	*SumGDP*	Total income: *GDP_s* + *GDP_h*	+	
2	*GDPdif_sq*	Square of difference in income: $(GDP\_s - GDP\_h)^2$	–	
3	*GDPSK*	Interaction between difference in income and in skilled-labour endowments: $(GDP\_s - GDP\_h) \times (SK\_s - SK\_h)$		–
4	*Tradecost_s*	Trade cost to the source country		–
5	*Tradecost_h*	Trade cost to the host country	+	–
6	*SKdif*	Difference in skilled-labour endowments: SK_s – SK_h	–	+
7	*TradeSK*	Interaction between trade costs to the host country and squared difference in skilled-labour endowments: $Tradecost\_h \times (SK\_s - SK\_h)^2$	–	–
8	*Investcost_h*	Investment costs in the host country	–	–
9	*Dist*	Distance	+/–	–
Additional variables				
10	*GDPdif*	Difference in income: *GDP_s* – *GDP_h*	+/–	+/–
11	*BIT*	1 for pairs that have active in-force bilateral investment treaties	+	+
12	*ComLang*	1 for pairs that have a common spoken language	+	+
13	*Contig*	1 for pairs that have a common border	+	+
14	*ComCol*	1 for pairs that were in colonial relationship post 1945	+	+

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

Table 3
Data sources

Data		Source
FDI stocks	Million 2010 USD	UNCTAD
Nominal GDP	Million USD	World Bank & IMF
Real GDP	Million 2010 USD	World Bank & 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

Country list: Bahrain, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Iran, Israel, Japan, Jordan, Kazakhstan, South Korea, Kuwait, Kyrgyz Republic, Laos, Lebanon, Macao, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam, Yemen.

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	0.047	PPML, LH are not rejected at the 5% significance level
HPC test						
Tobit versus ET2T		0.004			0.261	ET2T is preferred to Tobit
Tobit versus LH		0.003		0.285		LH is preferred to Tobit
PPML versus ET2T			0.787		0.192	Neither PPML nor ET2T preferred
PPML versus LH			0.762	0.189		Neither PPML nor LH preferred
LR test						
LH versus ET2T				0.333		LH is preferred to ET2T, independence of two parts not rejected

Table 5
Results without country fixed effects

	HOR	VER	(1) OLS	(2) Tobit	(3) PPML	(4) LH Amount	(5) LH Part
SumGDP	+		2694.690***	4703.331***	0.480***	0.736***	1.153***
			(586.246)	(352.294)	(0.038)	(0.212)	(0.101)
GDPdif_sq	–		–339.874***	–547.567***	–0.011	–0.051	–0.161***
			(103.486)	(44.869)	(0.008)	(0.038)	(0.017)
GDPSK		–	–1650.162***	–1692.071***	–0.356***	–0.320***	–0.063
			(620.759)	(592.940)	(0.094)	(0.121)	(0.120)
Tradecost_s		–	–38.813***	–146.157***	–0.107***	–0.075***	–0.020***
			(9.481)	(28.166)	(0.017)	(0.009)	(0.004)
Tradecost_h	+	–	–28.680***	–59.262***	–0.027*	–0.040***	–0.006
			(8.063)	(22.325)	(0.014)	(0.009)	(0.004)
SKdif	–	+	1314.471**	3786.349***	1.937***	1.432***	0.506***
			(662.005)	(1340.229)	(0.369)	(0.308)	(0.140)
TradeSK	–	–	37.508	167.924***	0.028	0.034**	0.033***
			(36.993)	(51.980)	(0.024)	(0.016)	(0.009)
Investcost_h	–	–	1.974	–27.017*	–0.007	–0.002	–0.008***
			(6.788)	(15.192)	(0.007)	(0.006)	(0.002)
Dist	+/–	–	–333.035***	–1137.307***	–0.269***	–0.456***	–0.190***
			(58.704)	(173.991)	(0.068)	(0.057)	(0.026)
GDPdif	+/–	+/–	74.296	453.305**	0.150***	0.111**	0.144***
			(170.136)	(195.331)	(0.033)	(0.045)	(0.027)
BIT	+	+	–1016.473***	1312.449**	0.198	0.125	0.469***
			(338.473)	(640.525)	(0.286)	(0.235)	(0.104)
Contiguity	+	+	–1389.474*	–966.116	–0.019	–0.048	0.005
			(750.972)	(1326.418)	(0.543)	(0.395)	(0.231)
ComLang	+	+	906.024*	3078.175***	1.193***	1.101***	0.266*
			(492.745)	(992.542)	(0.289)	(0.286)	(0.141)
ComCol	+	+	–17.734	604.015	–0.224	0.404	0.197
			(252.487)	(785.175)	(0.420)	(0.339)	(0.150)
Constant			2562.836***	1573.558	9.876***	7.469***	0.523**
			(668.323)	(1454.723)	(0.567)	(0.515)	(0.223)
N			9531	9531	9531	9531	
Log pseudo likelihood			–92743.48	–32266.24	–7681712.07	–22121.33	

Clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. 'Amount' and 'Part' refer to the amount decision and participation decision, respectively. 'HOR' and 'VER' denote horizontal and vertical FDI, respectively. Year fixed effects are included.

Table 6
Results with country fixed effects

	HOR	VER	(6) OLS	(7) Tobit	(8) PPML	(9) LH Amount	(10) LH Part
SumGDP	+		3827.364***	2758.204***	–0.175**	–0.205*	0.917***
			(488.001)	(586.730)	(0.069)	(0.108)	(0.351)
GDPdif_sq	–		–474.756***	–405.117***	0.017***	0.022*	–0.089**
			(57.772)	(56.753)	(0.005)	(0.012)	(0.038)
GDPSK		–	–2481.519***	–2161.680***	–0.118*	–0.151	–0.188
			(690.567)	(795.221)	(0.071)	(0.136)	(0.200)
Tradecost_s		–	9.017***	–6.715	–0.013	–0.020***	–0.003
			(3.419)	(15.823)	(0.012)	(0.007)	(0.004)
Tradecost_h	+	–	–5.527	–26.332*	–0.025***	–0.006	–0.000
			(5.731)	(15.966)	(0.006)	(0.005)	(0.004)
SKdif	–	+	–364.806	–1101.726	–0.311	–0.209	–0.051
			(293.084)	(1538.507)	(0.649)	(0.579)	(0.405)
TradeSK	–	–	64.201*	69.654	0.039***	0.014	–0.011
			(34.254)	(56.256)	(0.015)	(0.014)	(0.017)
Investcost_h	–	–	2.134	25.784**	0.003	–0.008*	0.006**
			(3.350)	(10.763)	(0.005)	(0.004)	(0.003)
Dist	+/–	–	–222.896***	–1026.150***	–0.290***	–0.493***	–0.286***
			(52.121)	(163.191)	(0.043)	(0.056)	(0.036)
GDPdif	+/–	+/–	195.666**	467.230***	0.228***	0.211***	0.207***
			(97.149)	(157.738)	(0.055)	(0.071)	(0.077)
BIT	+	+	–702.147**	133.894	–0.282***	0.011	0.517***
			(314.293)	(564.791)	(0.106)	(0.175)	(0.129)
Contiguity	+	+	–599.690	–98.582	0.375	0.548*	0.117
			(636.698)	(943.457)	(0.268)	(0.285)	(0.265)
ComLang	+	+	1514.446**	2813.118***	0.678***	0.614***	0.141
			(637.492)	(1031.232)	(0.156)	(0.229)	(0.202)
ComCol	+	+	–527.423*	201.686	–0.155	0.478	0.286
			(306.629)	(873.800)	(0.216)	(0.337)	(0.207)
Constant			–238.812	–11624.107***	1.618	5.373***	–2.129***
			(497.625)	(2984.433)	(1.112)	(0.939)	(0.492)
N			9531	9531	9531	9531	
Log pseudo likelihood			-91458.04	-31226.73	–1679811.78	–19790.86	

Clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. 'Amount' and 'Part' refer to the amount decision and participation decision, respectively. 'HOR' and 'VER' denote horizontal and vertical FDI, respectively. Source and host country fixed effects and year fixed effects are included.

Table 7
Results for pairs with at least one year of positive FDI

	HOR	VER	OLS	Tobit	PPML	LH	
						Amount	Part
SumGDP	+		2740.532***	2209.512***	–0.172***	–0.205*	–0.052
			(756.469)	(759.703)	(0.065)	(0.108)	(0.242)
GDPdif_sq	–		–425.244***	–388.864***	0.013***	0.022*	0.020
			(60.093)	(59.483)	(0.004)	(0.012)	(0.023)
GDPSK		–	–2303.586***	–2053.656***	–0.177**	–0.151	0.200
			(678.736)	(665.024)	(0.070)	(0.136)	(0.203)
Tradecost_s		–	36.362***	18.179	–0.011	–0.020***	–0.009
			(12.138)	(18.378)	(0.012)	(0.007)	(0.006)
Tradecost_h	+	–	–22.932*	–38.095**	–0.023***	–0.006	–0.007
			(11.741)	(15.636)	(0.006)	(0.005)	(0.005)
SKdif	–	+	–1214.219	–3010.184*	–0.265	–0.209	–0.846
			(1032.874)	(1708.232)	(0.658)	(0.579)	(0.920)
TradeSK	–	–	53.987	58.687	0.036***	0.014	–0.010
			(37.712)	(41.418)	(0.014)	(0.014)	(0.015)
Investcost_h	–	–	15.764	32.765***	0.004	–0.008*	0.013***
			(9.645)	(11.735)	(0.005)	(0.004)	(0.005)
Dist	+/–	–	–401.975***	–680.946***	–0.246***	–0.493***	–0.237***
			(114.355)	(121.854)	(0.035)	(0.057)	(0.037)
GDPdif	+/–	+/–	940.061**	980.674**	0.231***	0.211***	0.161
			(383.447)	(385.285)	(0.053)	(0.071)	(0.125)
BIT	+	+	–677.563	–570.482	–0.284***	0.011	0.292**
			(582.630)	(582.327)	(0.099)	(0.175)	(0.133)
Contiguity	+	+	352.603	386.926	0.343	0.548*	–0.063
			(1082.463)	(1045.135)	(0.255)	(0.286)	(0.226)
ComLang	+	+	1659.874*	1930.708*	0.554***	0.614***	0.176
			(976.610)	(1002.183)	(0.156)	(0.229)	(0.213)
ComCol	+	+	–667.153	–518.927	–0.063	0.478	–0.017
			(700.639)	(764.916)	(0.200)	(0.338)	(0.203)
Constant			2635.206	1159.616	8.818***	5.373***	1.729***
			(3390.636)	(1736.349)	(0.749)	(0.940)	(0.511)
N			3703	3703	3703	3703	
Log pseudo likelihood			–36741.62	–30075.00	–1342424.72	–18359.88	

Clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. 'Amount' and 'Part' refer to the amount decision and participation decision, respectively. 'HOR' and 'VER' denote horizontal and vertical FDI, respectively. Source and host country fixed effects and year fixed effects are included.

Table 8
Results based on Davies' (2008) specification

	Negative SKdif				Positive SKdif				
	HOR	PPML	LH		HOR	VER	PPML	LH	
			Amount	Part				Amount	Part
SumGDP	+	–0.821***	–0.650***	1.022**	+		–0.072	0.093	1.063**
		(0.272)	(0.202)	(0.448)			(0.076)	(0.161)	(0.537)
GDPdif_sq	–	0.049*	0.030***	–0.101**	–		0.010**	0.006	–0.132**
		(0.025)	(0.010)	(0.050)			(0.004)	(0.017)	(0.055)
GDPSK		–0.058	–0.051	0.197		–	–0.110	0.156	–0.963***
		(0.192)	(0.238)	(0.318)			(0.090)	(0.239)	(0.325)
Tradecost_s		–0.024***	–0.008	0.004		–	–0.002	–0.030**	–0.013**
		(0.008)	(0.009)	(0.005)			(0.012)	(0.012)	(0.006)
Tradecost_h	+	0.001	0.005	–0.018**	+	–	–0.020***	–0.010	0.004
		(0.020)	(0.011)	(0.009)			(0.006)	(0.006)	(0.005)
SKdif	+	–1.240	–2.252	–1.574	–	+	–2.996**	–1.490	1.396
		(1.601)	(1.724)	(1.126)			(1.204)	(1.471)	(1.452)
SKdif_sq	–	2.694	–7.326**	–0.435	–	+	5.105***	2.236	–2.448
		(5.041)	(3.318)	(1.992)			(1.827)	(1.882)	(2.685)
TradeSK	–	–0.069	0.279***	–0.020	–	–	0.012	0.017	0.012
		(0.150)	(0.083)	(0.054)			(0.017)	(0.019)	(0.027)
Investcost_h	–	0.014**	–0.002	0.019***	–	–	0.003	–0.010*	–0.006*
		(0.007)	(0.006)	(0.005)			(0.004)	(0.005)	(0.004)
Dist	+/–	–0.357***	–0.520***	–0.307***	+/–	–	–0.262***	–0.460***	–0.391***
		(0.072)	(0.092)	(0.040)			(0.036)	(0.055)	(0.046)
GDPdif	+/–	0.388**	0.393**	0.375***	+/–	+/–	0.283***	0.272***	0.121
		(0.163)	(0.183)	(0.136)			(0.068)	(0.089)	(0.403)
BIT	+	0.104	0.176	0.324**	+	+	–0.331***	–0.154	0.738***
		(0.160)	(0.235)	(0.151)			(0.119)	(0.196)	(0.182)
Contiguity	+	0.214	1.151***	0.087	+	+	0.481**	0.293	0.433
		(0.583)	(0.445)	(0.311)			(0.235)	(0.397)	(0.326)
ComLang	+	0.113	0.076	0.042	+	+	0.842***	0.890***	0.086
		(0.308)	(0.342)	(0.235)			(0.130)	(0.239)	(0.252)
ComCol	+	–0.051	0.905*	0.431*	+	+	–0.134	0.602*	0.360
		(0.376)	(0.491)	(0.258)			(0.240)	(0.351)	(0.253)
Constant		2.517	3.348***	–1.199*			11.984***	8.734***	–2.326***
		(1.838)	(1.034)	(0.676)			(1.065)	(0.872)	(0.649)
N		4806	4806				4725	4725	
Log pseudo likelihood		–572454.89	–7587.60				–744809.18	–11485.80	

Clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. 'Amount' and 'Part' refer to the amount decision and participation decision, respectively. 'HOR' and 'VER' denote horizontal and vertical FDI, respectively. Source and host country fixed effects and year fixed effects are included.

Table 9
Results based on Braconier et al.'s (2005) specification

	HOR	VER	OLS	Tobit	PPML	LH	
						Amount	Part
SumGDP	+		1950.188***	324.430	0.210	0.223	–0.356
			(625.979)	(1011.698)	(0.255)	(0.359)	(0.374)
GDPdif_sq	–		–571.898	–469.379	–0.254	–0.984	0.490
(*SIZESQ*)			(814.494)	(1968.515)	(0.488)	(0.771)	(0.496)
GDPSK		–	–611.632	–1052.158	0.097	0.018	–0.070
			(413.996)	(670.385)	(0.092)	(0.188)	(0.143)
Tradecost_s		–	4.960	–13.708	–0.030***	–0.020***	–0.009**
			(4.078)	(13.633)	(0.011)	(0.007)	(0.004)
Tradecost_h	+	–	0.311	–6.399	–0.014**	0.002	–0.003
			(4.241)	(11.259)	(0.006)	(0.004)	(0.004)
SKdif	–	+	703.615***	847.457**	0.006	0.093	0.036
(*SKILL*)			(253.055)	(351.668)	(0.066)	(0.099)	(0.071)
TradeSK	–	–	–0.491**	–0.679**	–0.000	–0.000**	–0.000
			(0.217)	(0.286)	(0.000)	(0.000)	(0.000)
Investcost_h	–	–	8.332**	35.303***	0.004	–0.008**	0.010***
			(3.906)	(10.111)	(0.004)	(0.004)	(0.003)
Dist	+/–	–	–273.063***	–847.036***	–0.245***	–0.444***	–0.281***
			(50.553)	(125.725)	(0.047)	(0.060)	(0.041)
GDPdif	+/–	+/–	553.064	623.456	–0.049	1.118	–0.427
(*SIZE*)			(1729.101)	(3885.939)	(0.865)	(1.247)	(0.838)
BIT	+	+	–789.806***	144.641	–0.187	–0.033	0.525***
			(296.608)	(494.194)	(0.160)	(0.193)	(0.146)
Contiguity	+	+	317.954	1528.466	0.165	0.718*	0.396
			(687.605)	(933.780)	(0.288)	(0.402)	(0.340)
ComLang	+	+	521.837	785.493	0.652***	0.552**	0.091
			(353.726)	(710.911)	(0.247)	(0.265)	(0.207)
ComCol	+	+	–291.617	675.341	–0.207	0.348	0.499**
			(308.047)	(857.066)	(0.296)	(0.392)	(0.238)
Constant			–827.403	–11670.030***	–3.275*	5.691***	–2.691***
			(3551.807)	(3332.490)	(1.979)	(1.007)	(0.682)
N			7259	7259	7259	7259	
Log pseudo likelihood			–67735.48	–23572.93	–1228429.28	–15196.30	

Clustered standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. 'Amount' and 'Part' refer to the amount decision and participation decision, respectively. 'HOR' and 'VER' denote horizontal and vertical FDI, respectively. Source and host country fixed effects and year fixed effects are included.

Appendix – Table A1

Summary of empirical applications of the KK model

Study	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 OECD, 1982-1992	OLS, Tobit	Modified CMM	HOR
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
Blonigen and Wang (2004)	US, 1970-1999	N/A	CMM	Mixed
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, Egger, and Pfaffermayr (2007)	US, 1989-1999	Spatial GMM	Own	KK
Davies (2008)	US, 1986-1994 OECD, 1982-1992	OLS	Modified CMM	KK
Mariel et al. (2009)	OECD, 1982-2003	Time-varying coefficient model	CMM	KK
Kiyoyasu (2009)	Japan and US, 1989-2002	GMM	CMM	Mixed
Kristjánsdóttir (2010)	Iceland, 1989-1999	OLS, Tobit	Modified CMM	HOR
Waldkirch (2011)	Mexico, 1994-2000	Tobit	Own	KK
Awokuse et al. (2012)	US, 1985-1999	GMM, WLS, Tobit	CMM	Mixed
Kristjánsdóttir (2012)	Iceland, 1989-1999	OLS, Tobit	CMM	Mixed
Chellaraj et al. (2013)	Singapore, 1984-2007	Tobit,	CMM	Mixed
Lankhuizen (2014)	OECD, 1985-1992	WLS	Modified CMM	No support for KK
Stack et al. (2015)	Europe, 1996-2007	Stochastic frontier analysis	Modified CMM	HOR
Dixon and Haslam (2016)	Latin America, 1990-2008	GMM, LSDV	CMM	Mixed

Notes: CMM = Carr et al. (2001) specification, FE = fixed effects, GMM = generalized method of moments, LSDV = least squares dummy variables

Empirical evidence for the KK model: KK = Support for both vertical and horizontal FDI, and thus the KK model; HOR = Support for horizontal FDI only; Mixed = Support for the KK model in some cases but not in others, e.g., the KK model's predictions are true only for some industries or some specific groups of countries. In other cases, results support horizontal FDI only.