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Explaining the global landscape of foreign direct investment: knowledge capital, gravity, and the role of culture and institutions

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Keywords: FDI, foreign direct investment, institutions, international finance, multinational corporations, model selection, cross validation

JEL classification: F21, F23, O16

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Explaining the global landscape of foreign direct investment: knowledge capital, gravity, and the role of culture and institutions

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1 Introduction

Foreign direct investment (FDI) is a key category of international capital flows that largely reflects investment of multinational enterprises. According to the updated and extended dataset of Lane and Milesi-Ferretti (2007), FDI stocks accounted for 21 percent of global cross-border liabilities in 2010 and in more than a third of countries, FDI is the source of over 50 percent of foreign financing.

In this paper, we use a previously un(der)used bilateral dataset on FDI stocks to evaluate the performance of the key 'big theories' that have emerged over the last decades to explain global FDI patterns. We therefore apply a cross-validation exercise to assess the out-of-sample performance of the gravity model, which Kleinert and Toubal (2010) have shown to accommodate horizontal ('market seeking') and vertical ('efficiency seeking') FDI motives and the knowledge-capital model (Carr, Markusen, & Maskus, 2001; Markusen, Venables, Eby-Konan, & Zhang, 1996), which integrates horizontal and vertical motives into a joint general equilibrium framework. We further add variables that other FDI theories have emphasized, notably aspects related to international finance, institutional and cultural distance. Moreover, we take cross-country interdependencies in the form of export-platform motives into account (Blonigen, Davies, Waddell, & Naughton, 2007; Ekholm, Forslid, & Markusen, 2007; Yeaple, 2003).

For this purpose, we draw on the IMF's 'Coordinated Direct Investment Statistics' (CDIS), which have a much more comprehensive country coverage than bilateral FDI datasets previously used in the literature, especially for developing countries. This comprehensive coverage provides important advantages over previous empirical macro exercises on FDI determinants for at least three reasons.

First, considerable cross-country sample heterogeneity is important for assessing the relevance of vertical vs. horizontal motives for FDI. While earlier studies have emphasized the importance of horizontal FDI motives looking at US outward FDI activities (Brainard, 1997; Helpman, Melitz, & Yeaple, 2004), other contributions have highlighted that vertical motives might be at least as important but more difficult to find in the data (Alfaro & Charlton, 2009; Badinger & Egger, 2010). Notably, Davies (2008) has emphasized that detecting vertical motives in aggregate data requires a sufficiently large difference in endowment structures and development levels between host and source countries.

Second, the global landscape of FDI has considerably changed over the last decades, with more FDI flowing to developing countries, often referred to as the 'South', and particularly more FDI originating from those countries. This trend is depicted in figure 1. Today, 'Southern' economies are the source of over 1/4 of global FDI and account for about 40 % of global FDI inflows. The share of intra-developing-country ('South-South') flows in global FDI has grown from 3 % of global FDI flows at the beginning of the millennial to 14 % in the subsequent decade (OECD, 2014, figure 3.1). While UNCTAD (2006) provided an early picture documenting the rising importance of FDI from developing and transition economies, recent systematic studies on the subject are rare and mostly focused on certain regions, mostly on FDI either from China and/or to Africa (e.g. Abeliansky & Martínez-Zarzoso, 2019; Chen, Dollar, & Tang, 2016; Demir & Hu, 2020; Gold & Seric, 2017; Kolstad & Wiig, 2012).

Figure 1: Global FDI in- and outflows by country groups (in billion US-$)

Note: flows in billion current US-$; source (including country classification): UNCTAD

Third, studies from international business and more recently international economics have emphasized the role of cultural and institutional distance for FDI (e.g. Azemar, Darby, Desbordes, & Wooton, 2012; Bénassy-Quéré, Coupet, & Mayer, 2007; Beugelsdijk, Kostova, & Roth, 2017; Cuervo-Cazurra & Genc, 2008; Demir & Hu, 2016). Empirical studies in that literature were often constrained by focusing on only few or even a single source country. As van Hoorn and Maseland (2016) emphasize, comprehensive bilateral variation is needed to properly identify such factors as cultural or institutional distance.

The comprehensive bilateral FDI data coverage in our paper allows us to add to the literature on FDI determinants in all three aspects. Our results can be summarized as follows: we find the gravity model to achieve the best theory-consistent out-of-sample prediction, particularly when parameter heterogeneity of South and North FDI is allowed for. Such a model improves prediction over a pure fixed effect model by about 25 %. Controlling for surrounding market potential is important to recover the horizontal effect of the gravity model. Including institutional, cultural, or financial factors does not improve the model performance distinctly although results for those variables are mostly in line with theory.

It ought to be clarified that our econometric application is not a standard identification exercise. Given the wide range of explanatory variables suggested by various theoretical FDI models, our focus is not on pinning down structural model variables and resolve endogeneity biases that economists typically have in mind. We are rather interested in an empirical assessment how far we have come in explaining the macroeconomic factors driving global FDI decisions and whether it is possible to discriminate among existing theories. Our results thus help inform the theoretical macro literature on FDI but also provide some revelatory insights for empirical modelling of FDI in future studies. We finally note that by allowing for potential parameter heterogeneity in our econometric candidate models, we address a potential endogeneity problem that ranks prominently in the recent statistical literature (see e.g. Bester & Hansen, 2016) but is often neglected by economists and has been mentioned as a potential problem for empirical FDI studies previously by Blonigen and Wang (2005).

The remainder of our paper is organized as follows: we start with a description of our used CDIS data set for bilateral FDI stocks in section 2. In section 3 we explain our econometric modelling approach and discuss the related literature and explanatory variables. We thereby move model-by-model. Given the sometimes technical discussions in the related literature, this combination of modelling, literature, and data seems the most logical presentation in our view. Given our comprehensive treatment of potential factors influencing FDI, this part of our paper also provides a comprehensive review of potential FDI determinants to scholars and policymakers. Section 4 provides a short discussion of estimation results for the individual models. Section 5 explains the setup and provides the results of our cross-validation exercise. The final section 6 concludes.

2 The CDIS FDI data

Drawing a comprehensive picture of FDI determinants in a global perspective requires bilateral data. Most empirical studies to date have used UNCTAD's Bilateral FDI Statistics that provide flow and stock data for 206 economies over the period 2001 to 2012.[1]

More recently, the International Monetary Fund (IMF) has put substantial effort into compiling disaggregated bilateral FDI stock data in its 'Coordinated Direct Investment Survey' (CDIS) that uses consistent definitions and best practices in collecting FDI stock data. This dataset, which starts with 2009 data,[2] allows for new dimensions of macroeconomic studies of FDI motives because of its improved quality and coverage compared to the UNCTAD dataset. However, except for two papers of Haberly and Wójcik (2015a); Haberly and Wójcik (2015b) that focus on the very specific question of offshore FDI networks and tax havens, the data so far have not been used in systematic empirical investigations.

We start with data quality. CDIS data reporting templates have built-in validation tools for national compilers before they submit FDI data to the IMF. The IMF Statistics Department then uses 'mirror data' of reported FDI partners to check consistency of the bilateral data and reaches out to national compilers in case of large bilateral asymmetries in data reported by source and host country (see IMF, 2015, ch: 6, for details). Following standard convention, we focus on using the inward position of FDI, which is usually more reliable. After dropping all values that are marked as "confidential", the CDIS allows us to fill missing values with the 'derived' inward position from the 'mirror data'.

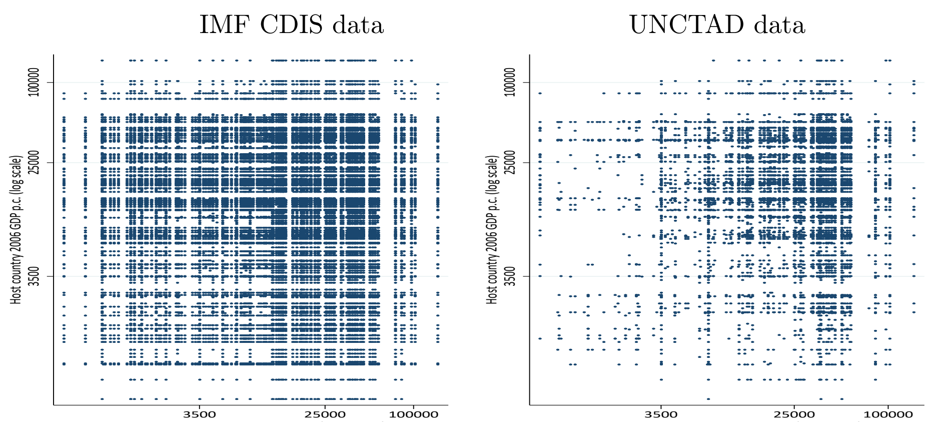
This further contributes to the advantage of comprehensive coverage of the CDIS data. Before merging the FDI stock data with other variables, we observe

[1] OECD also reports bilateral FDI positions but does not cover a relevant sample of developing countries. The data, used among others by Bénassy-Quéré et al. (2007), hence potentially underestimates vertical FDI motives and does not allow to draw a global picture of FDI that investigates determinants most relevant to 'South' FDI.

[2] CDIS includes some 2008 observations for Malaysia.

212,844 bilateral FDI positions, out of which 8,255 are negative and 118,536 are 0. For comparison, the UNCTAD data set only provides 65,729 bilateral observations, out of which 1,926 are negative and 19,479 are 0. This difference is not only of quantitative relevance. Figure 2 depicts the coverage of the IMF's CDIS data set compared to UNCTAD. The vertical and horizontal axes show the 2006 GDP p.c. of the FDI host and source country, respectively (on a log scale). A dot indicates that for each country pair, at least one FDI observation (that might as well be 0) exists. As one can infer, both show a strongly balanced pattern in the sense that if one observes an inward stock in country A from country B, there is also an inward observation in country B originating in country A, although detailed inspection shows that this is not always the case (and need not be). Comparing both panels of figure 2 one can clearly see the higher bilateral coverage of the CDIS data in the left panel. But most importantly, this coverage extends considerably further into the developing world, i.e. countries with a lower GDP p.c. level. Given the above-mentioned necessity of a sample of countries with sufficiently large differences in factor endowments, this is a clear advantage of the CDIS data set over all other previously used data. We finally note that despite discrepancies in FDI values for years and country pairs where both datasets overlap, the correlation coefficient of the 20,581 overlapping observations is 0.73.

Figure 2: Coverage of CDIS vs. UNCTAD data



We constrain our analysis to host or source countries with a population above one million in a given year, which also means that small island states that are often centers for offshore FDI are dropped. The overall FDI amount covered by our remaining CDIS data set is depicted in table 1 and compared to other sources (for the year 2010). Overall, CDIS covered 23 trillion US$ inward stocks, which is almost identical with the number provided by the "External Wealth of Nations" database by Lane and Milesi-Ferretti (2007) and about 3 trillion US$ above the aggregate data reported by UNCTAD Stat (which are not identical with the more constrained bilateral UNCTAD data). Out of those 23 trn US$, 16.4 are comprised by our final sample, which includes 6,680 observations in 2010 after dropping small countries and observations with negative FDI stock values (which our PPML estimator cannot facilitate). This means that our most comprehensive sample covers more than 70% of global FDI and includes important economies such as Brazil, China, France, Germany, Japan, Mexico, Russia, UK, and the US among many other source and host countries.

Table 1: Global FDI stocks covered by different data sets

	EWN (Lane and Milesi-Ferretti, 2007)	UNCTAD Stat	CDIS World	**CDIS sample**
(inward) FDI stock	23,8 trn US$	20,3 trn US$	23,0 trn US$	**16,4 trn US$**

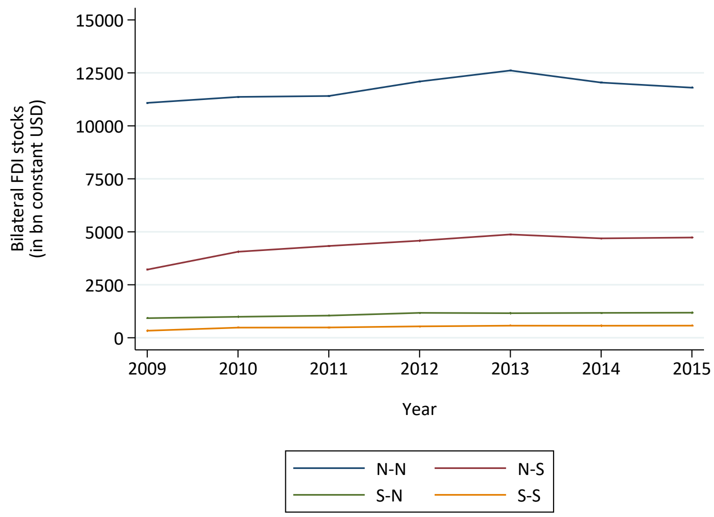
For our econometric analysis, we have deflated CDIS FDI data by the US GDP deflator (using the PWT9.0 series pl_gdpo) and use the data in millions in our regressions.[3]

Figure 3 depicts overall bilateral FDI positions from CDIS over time, broken down by different country-groups.[4] Two key features are worth highlighting. First, there is little variation over the years since 2009. Second, figure 3 reveals that the large majority of FDI positions exist between 'Northern' countries, followed by N-S FDI. Although this is generally well-known, the magnitude is still

[3]One may argue that year fixed effects account for global inflation. This is incorrect if the model includes a combination of 'real' variables (like education, institutions etc.) and nominal variables, like in our case. It is thus necessary to bring both to a common level. We presume that the price level of US output-side GDP is the most appropriate simple deflator for global asset prices.

[4]We code economies as 'South' (S) if they are classified as 'emerging market' or 'low income country' by the IMF and as 'North' (N) otherwise. Country-group doubles are ordered as 'source-to-host', e.g. 'S-N FDI' is FDI from a Southern source country to a Northern host country.

Figure 3: FDI stocks by income groups over time



worth highlighting.

Figures 4 and 5, respectively, show the top-10 source and host countries of FDI in our sample for the year 2015. There are little surprises in those figures which contain large industrialized economies like US, UK, Japan, Germany, and France. The existence of relatively small countries like the Netherlands and Switzerland as FDI hubs is as much known as the round-tipping of FDI via its Hong Kong SAR (and Singapore) or the peculiar situation of Ireland as a host for FDI. Japan is still relatively closed to FDI; it is thus consistent that it only shows up as a top-10 source country but not as a top-10 host.

Those descriptive statistics generally support the notion that our sample is an adequate representation of global FDI patterns, with all their drawbacks.[5] We think that economics still needs to be explain FDI peculiarities like Ireland or round-tipping in Asia but also want to avoid that individual outliers con-

[5]For general discussions about the adequacy of FDI data, refer to Beugelsdijk, Hennart, Slangen, and Smeets (2010) and Wacker (2016). The key finding of those studies is that there are some discrepancies between FDI data and the economic concepts that researchers often presume or intend to measure with these data but that these discrepancies to wide extent have a meaningful economic interpretation. Recent findings by Wacker (2020) suggest that using direct FDI ownership data (as in CDIS and as opposed to ultimate ownership statistics) on average has little effect on economic conclusions on FDI motives.

Figure 4: Top-10 FDI source countries (in absolute terms)

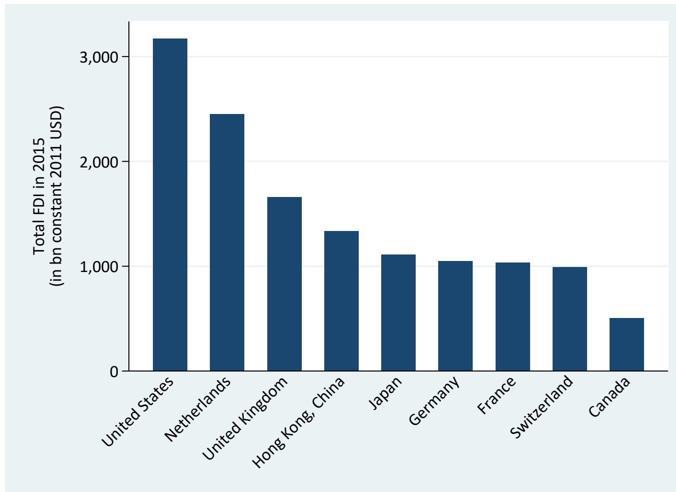
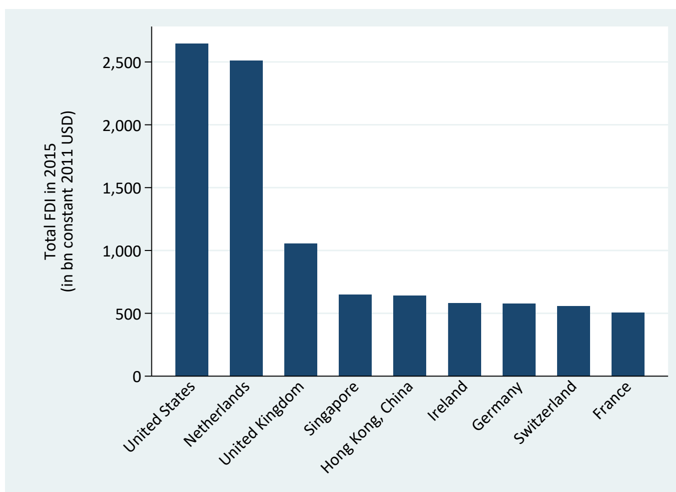


Figure 5: Top-10 FDI host countries (in absolute terms)



siderably distort our analysis of determinants of global FDI. We hence create identifiers in the form of bilateral fixed effects for outliers. To identify those, we first regress FDI stocks on all variables contained in the 'homogeneous gravity' and 'homogeneous KK' model (explained below). The residuals of this regression are plotted against predicted FDI in figure A.1 in the appendix. Outliers are visually identified and must additionally fall into the bottom 1% or top 99% of the residual distribution. Not surprisingly, the resulting outlier identifiers involve UK, Netherlands, US, Ireland, Hong Kong SAR of PRC, and China.[6]

Having introduced our FDI stock variable, we now move to the econometric model used to explain global bilateral FDI positions, including its relevant variables.

3 Modelling FDI: theory and related literature

Our paper aims to asses how certain variables collected in the matrices $X_1,\ X_2,\ Z$ influence FDI positions at year t between source and host countries s and h, respectively. Formally, for observation sht, this can be written:

$$FDIstock_{sht} = X_{1,st}\beta_s + X_{2,ht}\beta_h + Z_{sht}\delta + a_s + a_h + d_t + \epsilon_{sht}, \qquad (1)$$

where $a_s,\ a_h$, and d_t are source-, host-, and time-fixed effects, respectively, and ϵ is an idiosyncratic error term.[7]

The notation of our variables highlights that identification of the parameters collected in the column vectors $\beta_s,\ \beta_h,\ \delta$ results from three different types of variation: identification of β_s (β_h) comes from variation of source (host) country variables in X_1 (X_2) over time, while identification of δ comes from variation of Z between source and host countries over time and over country pairs. The former, for example, includes source country GDP which is the same for all host countries, whereas the latter includes differences in GDP that varies over country pairs.

We estimate equation 1 using PPML, following the standard literature (Bénassy-Quéré et al., 2007; Demir & Hu, 2016; Kleinert & Toubal, 2010). Moreover, we allow for some heterogeneity in the parameters $\beta_s,\ \beta_h,\ \delta$ as we detail below. Note that a homogeneity restriction of parameters, which is often implicitly

[6]More precisely, UK-Netherlands 2015, Netherlands-UK 2009&2010, US-Netherlands 2011-2016, US-Ireland 2015-2016, HK-China 2010-2016.

[7]We are aware of the fact that gravity literature in trade uses more restrictive fixed effect settings but this is not meaningful in our setup because of the short time dimension and particularly the little over-time variation in many variables, notbably FDI stocks as depicted in section 2. As previously stated, our goal is not a structural identification exercise, thus the individual parameters of our estimations should be interpreted with some caution. We are willing to take that cost for the benefit of providing a global assessment how well key theories explain global FDI and for being able to give an informed judgement how non-time-varying factors (such as cultural distance) matter in this context.

assumed in econometric applications, will lead to biased estimates if the true data-generating process is heterogeneous. Conversely, allowing for heterogeneity will inflate the variance of estimates. Our cross-validation exercise allows an assessment of this standard bias-variance tradeoff that receives increasing attention in the heterogeneous panel literature (e.g. Bester & Hansen, 2016).

In the remainder of this section, we explain which variables enter $X_1,\ X_2,\ Z$ according to the different theoretical models of FDI, and how they are measured.

3.1 Gravity model

Kleinert and Toubal (2010) have shown that structural models for horizontal and vertical FDI motives can be assessed in reduced form by substituting

$$b_{s1}\ln(GDP_{st})+b_{h1}\ln(GDP_{ht})+\delta_1\ln(D_{sh})+\delta_2 RSkE_{sht}+\delta_3\ln(GDP_{st}+GDP_{ht})$$

into equation (1). We measure GDP by the rgdpna series from PWT9.0, which is most appropriate to track GDP developments in countries over time (Feenstra, Inklaar, & Timmer, 2015), D by population-weighted distance from the CEPII gravity dataset, and relative skill endowment $RSkE$ as:

$$RSkE_{sht} := \ln\Big(\frac{skilled_{st}}{skilled_{st}+skilled_{ht}}\Big) - \ln\Big(\frac{unskilled_{st}}{unskilled_{st}+unskilled_{ht}}\Big),$$

where 'skilled' is the sum of 'secondary completed' and 'tertiary total' in the Barro and Lee (2010) dataset, and 'unskilled' is defined as 100-'skilled'.[8] $RSkE_{sht} > 0$ hence indicates that the source country is more skilled in year t.

The first three terms in equation (2) are well-known gravity components, whereas the latter two represent vertical motives. More precisely, Kleinert and Toubal (2010) show that parameter restrictions as depicted in table 2 apply for the horizontal and vertical model, respectively.[9]

[8] Barro-Lee data were interpolated since they only come in 5-year intervals. Our measure essentially follows the idea of Kleinert and Toubal (2010) but we have to take educational attainment instead of occupational task data to gauge skill levels because the latter (provided by the ILO) are available for a much less countries.

[9] Note that Kleinert and Toubal (2010) derive their predictions for affiliate sales. Since the respective parameters are elasticities, the same predictions can be applied to FDI data if the latter are a homogeneous function of the former, as Wacker (2016) suggests.

Table 2: Predictions for parameters in the horizontal and vertical model

	horizontal model	vertical model
b_{s1}	$= 1$	< 0
b_{h1}	$= 1$	> 0
δ_1	< 0	< 0
δ_2	0	> 0
δ_3	0	$= 1$

Source: Kleinert and Toubal (2010).

One concern in estimating the gravity component is the likely possibility that horizontal motives may be more present in one part of the sample (notably in 'North-North' FDI), whereas vertical motives may be more important in other parts of the sample where factor price differences are larger (such as 'North-South' FDI). Putting a homogeneity restriction on the parameters $b_{s1}, b_{h1}, \delta_2, \delta_3$ may thus be restrictive and mask the true FDI motives. We hence allow for heterogeneity in those 4 parameters among the N-N, N-S, S-N, and S-S pairs and label the respective model the 'heterogeneous gravity' model.

3.2 KK model

Given the analytical complexity of the knowledge-capital (KK) model, which already involves 30 non-linear (in)equalities for a bare-bone partial equilibrium representation, deriving a testable reduced-form equation is not straightforward and has been subject to some debate in the literature (Blonigen, Davies, & Head, 2003; Carr et al., 2001). The core of the argument concerns the non-symmetry in the parameter for skill differences, which should be allowed to vary between skill-intensive source vs. host countries in bilateral FDI relationships. Davies (2008) thus suggests substituting the following terms into equation (1):

$$\begin{aligned}
&\delta_4(GDP_{st} + GDP_{ht}) + \delta_5(GDP_{st} - GDP_{ht})^2 + \delta_6(skilled_{st} - skilled_{ht}) + \\
&\delta_7(skilled_{st} - skilled_{ht})^2 + \delta_8(skilled_{st} - skilled_{ht})(GDP_{st} - GDP_{ht}) + \\
&\delta_9 D_{sh} + \delta_{10}(skilled_{st} - skilled_{ht})^2 tradecost_{ht} + \beta_3 tradecost_{st} + \\
&+\beta_4 tradecost_{ht} + \beta_5 investmentbarriers_{ht}. \qquad (2)
\end{aligned}$$

We measure *GDP*, *D*, and *skilled* as defined above, *tradecost* by 100× [1 - X/GDP + M/GDP] using the export and import shares csh_x and csh_m×(-1) from PWT9.0, and *investmentbarrier* by investment freedom from the Heritage Foundation, where 100 indicates the highest freedom.

As the KK component (2) indicates, the knowledge-capital model is 'global' in the sense that differences in GDP and skill/factor endowments rank prominently within the model, such that a split along the 'North' and 'South' dimension (as for the gravity model) does not appear meaningful. However, to account for the above-mentioned non-symmetry in the skill-difference parameters, we allow for a 'heterogeneous KK' model variant, where parameters for variables involving skill differences are allowed to differ between skill-intensive host vs. source country pairs.

The KK model combines motives for horizontal and vertical FDI. Horizontal FDI arises to reduce trade costs by serving the foreign market through local production and to reduce head quarter costs by jointly using headquarter activities in all subsidiaries. Since production of a multinational firm is skill-intensive relative to non-FDI sectors, increasing skill differences reduce the presence of horizontal FDI. Vertical FDI emerges to exploit factor price differences, which arise when skill differences increase.

Accounting for both motives the KK model implies a nonmonotonic relationship between skill differences and FDI. In the presence of reasonably large trade costs, moving from a negative skill difference of source relative to host (skill-abundant host), to larger values of skill differences, total FDI, which is now horizontal, increases as skill differences become less negative, that is skill endowments of the countries become more similar. After a peak of FDI, increasing positive skill differences of source relative to host (skill-abundant source) leads to a decrease in (horizontal) FDI, while vertical FDI starts to become profitable due to emerging factor prize differences. Vertical and horizontal FDI coexist, until vertical FDI dominates as skill differences go to infinity. Consequently, for a negative skill difference (skill-intensive host), we expect a positive relationship of skill difference, while for a positive skill difference (skill-intensive source), we expect a nonmonotonic effect, meaning a negative coefficient for δ_6 and a positive effect for δ_7.

For the *sum of real GDPs* and the *squared difference in real GDPs* we expect a positive and negative effect, respectively. The coefficient of the interaction term of skill difference and real GDP difference (δ_8) should be negative. Distance (D) is included to account for transport costs and thus should show a negative relationship. The coefficient of the interaction term of squared skill difference and trade costs in the host country (δ_{10}) captures the effect of host trade costs promoting horizontal FDI but not vertical FDI, while horizontal FDI is most important when skill differences are small. Thus, we expect a negative relationship. Correspondingly, the coefficient of trade costs in the host, β_4, should be positive. For the effect of trade costs in the source, β_3, we anticipate a negative relationship, as an increase in trade costs of the source reduces the incentive to ship back, goods produced by a subsidiary located abroad. Finally, we capture investment barriers by investment freedom which should positively affect FDI (β_5).

3.3 Export platform FDI

The literature has highlighted possible spatial interdependencies in FDI motives (see Blonigen et al., 2007, and Antras & Yeaple, 2014, for summaries). Probably the most common among them is 'export platform FDI' (Ekholm et al., 2007; Yeaple, 2003), which is essentially an extension of horizontal motives to countries surrounding the host country and can hence quite easily be included in our reduced form exercise. Formally, we include the term $\beta_{h2} \ln(SMP_{sht})$ into our model, where 'surrounding market potential' SMP is calculated as:

$$SMP_{sht} := \sum_{s_i \neq s}^{S} \frac{GDP_{s_i t}}{D_{s_i h}},$$

and where GDP and D are defined as above.

3.4 Institutional and cultural aspects

While FDI generally requires some form of market imperfection that gives rise to an internalization argument, an interesting literature for our purpose has focused on the similarity of market imperfections across source and host countries (e.g. Azemar et al., 2012; Cuervo-Cazurra & Genc, 2008; Darby, Desbordes, & Wooton, 2010; Desbordes, Darby, & Wooton, 2011). Their rationale can be summarized as follows: while FDI is generally distracted by weak institutions, firms' previous experience with institutional risk at home lets them develop the skills that render similar problems overseas less problematic. This creates an advantage for those firms to invest in other host countries with potentially weak institutional environments and is hence one potential explanation for South-South FDI.[10] Recent work by Demir and Hu (2016) is, in our view, the most elaborate empirical assessment of this idea. They investigate the effects of institutional development and institutional distance on FDI and on the direction of FDI flows from and to developing and developed countries. Their results show that the effects of institutional distance depend on the direction of FDI flows and development level of host and source. Although institutional differences appear as an entry barrier for investment flows in both North-South and South-North directions, this effect is smaller if the source country is from the South. On the other hand, South-South flows appear to be positively driven by institutional differences, which can be an explanation for the prevalence of South-South FDI.

To some of the econometric models, we hence add

$$\delta_{11} InstDist_{sht} + \delta_{12} \mathbf{1}(InstDist)_{h>s,t} \times InstDist_{sht}, \tag{3}$$

where $\mathbf{1}(InstDist)_{h>s,t}$ is a dummy variable that equals 1 if institutional quality is higher in the host country than in the source country (in year t). We expect $\delta_{12} > 0 > \delta_{11}$ because institutional distance should generally have a negative effect on FDI but this effect should be mitigated with increasing institutional development of the host economy (conditional on all other factors).

Our measure for institutional distance aggregates the 12 dimensions d of the ICRG political risk index $Inst$, following Demir and Hu (2016):

$$InstDist_{sht} = \frac{1}{12} \sum_{d=1}^{12} \frac{(Inst_{dst} - Inst_{dht})^2}{V_d},$$

where V_d is the variance of each dimension d.

Similarly, especially the international business literature has emphasized that cultural distance makes firm integration more difficult and thus detracts FDI (e.g. Beugelsdijk, Kostova, Kunst, Spadafora, & van Essen, 2018). We thus

[10] Relatedly, Dippenaar (2009) argues that Southern firms may face less risk of expropriation since they may not be tackled as colonizing companies by populist leaders.

control for a number of cultural factors, including the dummy variables common colonizer, common official language, colonial relationship after 1945 from the CEPII gravity dataset, and two dimensions of cultural distance from the traditional measure of Hofstede, Hofstede, and Minkov (2010). We chose the measures for 'long-term orientation vs. short-term orientation' and 'indulgence vs. restraint' because the other 3 cultural dimensions of Hofstede et al. (2010) are available for a much smaller country sample. Note that those measures do not vary over time and that their limited availability is the key sample constraint in our dataset. Similar to the model component (3) we additionally interacted both Hofstede measures with a dummy variable equal 1 if the value in the host country exceeded the value in the source to allow for asymmetry.

3.5 International finance aspects

An interesting aspect of FDI research is that it allows to combine trade aspects, which are generally 'real' (as opposed to monetary) and often studied from a general equilibrium perspective, with international finance aspects that by definition include a monetary and thus frictional aspect. A close integration of the two is still at its infancy (see Foley & Manova, 2014; Manova, Wei, & Zhang, 2015, for important contributions) but the international finance perspective generally suggests inclusion of the following variables.

Exchange rates are important as they influence international asset prices (e.g. Blonigen, 1997; Froot & Stein, 1991). We thus include the series xr for source and host from PWT9.0.

Moreover, exchange rate volatility and thus the *exchange rate regime* may matter, as discussed extensively in Harms and Knaze (2018). We hence include their bilateral de jure regime measure in our regressions.

It is also well-known and extensively studied that tax considerations play an important role in FDI allocation (see Davies, Martin, Parenti, & Toubal, 2018, for a recent contribution and references). To gauge this effect, we include the difference in *corporate tax rates*, extracted from KPMG documents, into the 'international finance' specification of our model.[11] Again, we additionally interact

[11] We interpolate some missing values of corporate tax rates.

this difference with a dummy variable equal 1 if the host tax rate is higher than the source tax rate.

Donaubauer, Neumayer, and Nunnenkamp (2020) discuss why and how *financial development* matters for bilateral FDI. To gauge this effect, we take differences between source and host country's aggregate "broad-based index of financial development" developed and provided by the IMF, which again is additionally included with a dummy variable interaction indicating higher financial development in the host country.

4 Results for individual models

To preserve space and focus, we have relegated an extensive discussion of several baseline models to appendix B.2. In the rest of this section, we thus only discuss the key results of those model estimations.

Two main takeaways for the gravity model include the importance of surrounding market potential (SMP) and the need to allow for parameter heterogeneity across combinations of North and South FDI. The parameter estimate for SMP is positive and significant and lowers the estimated elasticity for host GDP close to unity, which would be the prediction of a horizontal model (see table A.3 in appendix B.2, column 2 and compare to column 1). Parameter heterogeneity (columns 3 and 4) allows to detect a prevalence of clearly horizontal motives in North-North FDI, as one would expect because this is mostly 'market seeking' FDI and not likely to be driven by factor price differences. For other bidirectional relationships, the evidence is rather mixed. We find some evidence for vertical FDI in South-North FDI but surprisingly little evidence for vertical motives in North-South FDI. For South-South FDI, no clear prevalence of vertical vs. horizontal can be inferred from the results. Overall, we conclude that results for the gravity model are not at odds with theory and for most bidirectional relationships reflect a mixture of vertical and horizontal motives.

By contrast, some of the results for the KK model are conflicting with theory (table A.4 in appendix B.2). Particularly, the essential parameter estimates for skill differences and its square are at odds with theoretical predictions, irrespective of the specification. Many other estimates for essential model parameters are insignificant and the negative coefficient on surrounding market potential is difficult to reconcile with theory as well. While there are some significant parameter estimates in line with theory (squared GDP difference, interaction of GDP difference and skill difference, host trade costs, and the interaction of squared skill difference and trade costs), we conclude that the results of the KK model are not very appealing to describe the global landscape of FDI: while the model is much more complex and difficult to interpret than a gravity model, several estimated model parameters are at odds with theory.

We also look at baseline models augmented with all other factors previously discussed (tables A.5 and A.6 in appendix B.2). Overall, we find that financial and cultural factors play a role for FDI, while institutional differences between host and source do not seem to matter much. Especially the bilateral de-jure exchange rate regime significantly affects FDI. Tax rates also play a role: in higher-tax host countries, FDI declines with differences in tax rates. From a cultural perspective, common language and a post-1945 colonial relationship positively correlate with FDI but the Hofstede measure does not lead to clear theory-consistent results that are consistent for both the gravity and KK model. Results for financial development do not conflict with theory but are only significant for the KK model. The effect of institutional differences is only estimated to be significantly different from 0 in the augmented KK model, where higher FDI levels are associated with higher institutional differences for country pairs with better institutions in the host country.

5 Cross validation

The main goal of our paper is to assess the performance of key theories explaining global FDI. Put differently, how well do the models presented so far explain bilateral FDI positions? This requires analyzing their predictive power out of sample, because an in-sample analysis would either lead to overfitting or rely on the restrictive assumptions for asymptotic model selection criteria (see e.g. Zucchini, 2000, for an overview on the issue). The natural tool to use for such a purpose is cross validation, which splits the dataset into one part, where estimation is performed ('estimation sample'), and another part, used to assess the predictive power of the estimated model ('calibration sample').

More precisely, the following procedure is applied for all our candidate models:

1. From the original sample, we randomly draw an 'estimation sample' (without replacement) that consists of 90 percent of the original observations.[12]

2. Use this 'estimation sample' to estimate the parameters for each candidate model.

3. Apply the estimated parameters to predict $F\widehat{DIstock}_{sht}$ for each candidate model in the remaining 10 percent of observations that are not part of the estimation sample (the 'calibration sample').

4. For each model and calibration observation calculate the residual

$$\hat{\varepsilon}_{sht} \equiv FDIstock_{sht} - F\widehat{DIstock}_{sht} \tag{4}$$

and their 'mean absolute deviation' (MAD) per model over all calibration observations:

$$MAD \equiv \frac{1}{N_c} \sum_{i}^{N_c} |\hat{\varepsilon}_i|, \tag{5}$$

where $i = 1, ..., N_c$ are all s, h, t combinations that are part of the calibration sample.

5. Repeat 1 to 4 100 times and calculate the average MAD over all 100 iterations.

In a first step, we consider each of the following candidate models with and without surrounding market potential: a homogeneous gravity model, a heterogeneous gravity model (N-N, N-S, S-N, S-S), a homogeneous KK model, and a heterogeneous KK model (host skilled, source skilled). Out of these 8 models evaluated, the 'best performing' gravity and KK model (with the lowest average MAD) proceed to a second stage.

[12]We do not put any restrictions on the drawing procedure. This is motivated by the fact that 'wild' procedures generally perform well for iterative inference methods such as bootstrapping. The 'original sample' includes all observations for which all the variables from all respective candidate models are non-missing.

In the second stage, the two 'best performing' models from the first step are augmented with the following variables, respectively:[13]

A. institutions

B. financial development, exchange rate, & FX regime, corporate tax rate

C. A & B

D. A, B, ComColonizer, ComLanguage, & Col45

E. D & Hofstede cultural distance (smallest sample)

At both stages, we compare the model performance relative to a 'fixed effect only' model, which only includes the respective fixed effects and outlier identifiers. Moreover, we compare the models in the second stage to a 'pure institutions' model, which includes $InstDist$, $\mathbf{1}(InstDist)_{h>s,t} \times InstDist$, $ComLang$, $ComCol$, $Col45$, and the 'FE only' parameters.

Table 3 and figure 6 summarize the results from the first stage. Looking at figure 6 one can see three clusters of model performance. Clearly, the FE model performs worst. Even in the best cases (i.e. 'most favorable' sample draws), the FE model performs barely better than the next class of models on average, which are the homogeneous gravity models (with and without market potential). In the 'best performing' cluster on the left in figure 6, we see that the heterogeneous gravity model (with and without SMP) and all variants of the KK model perform equally well but that the MADs of the heterogeneous gravity models are much more narrowly distributed, suggesting that their estimation risk with respect to the sample is lower. Close inspection of figure 3 reveals that overall the heterogeneous gravity model with surrounding market potential performs best by a tight margin. Within the KK models considered, the heterogeneous KK model without SMP performs best. Both of those models thus move as 'benchmark' to the second stage.

What can we say about the overall performance of those models in describing global bilateral FDI positions? Generally, the best-performing models decrease the mean absolute prediction error compared to a pure fixed effect model with

[13]Note that due to the increase in variables in the second stage, the 'original sample' considerably shrinks (and is limited by all observations in the sample for model E).

additional outlier control by about 25 %. While non-negligible, one may argue that this is a rather disappointing magnitude. Without rejecting this negative interpretation, we remind that the fixed effects per se already explain quite a good part of variation in bilateral FDI positions. To interpret the results of our assessment how well prevailing models of FDI explain global bilateral data, consider the heterogeneous gravity model with SMP. Its average MAD of 1,137 suggests that on average one would expect this model's out-of-sample prediction for a randomly chosen bilateral observation to make an error equal to 52.8 % of mean FDI. In other words, the sample's mean bilateral FDI position is about twice as large as the MAD of the best-performing model.

Figure 6: Distribution of MAD across models (1st stage)

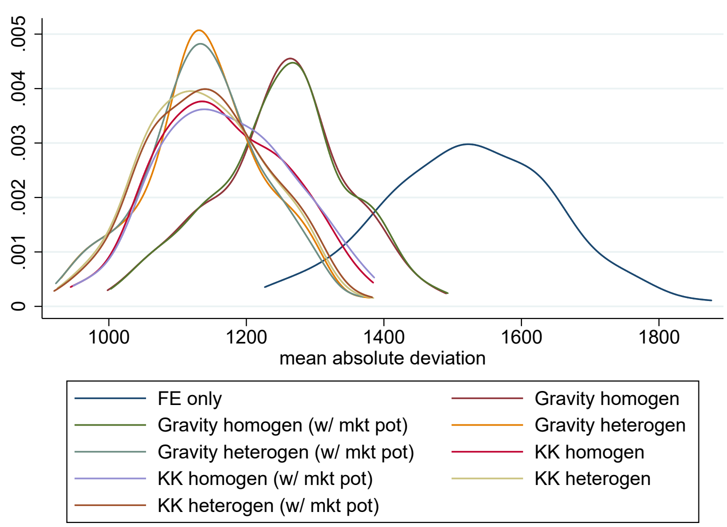


Table 4 and figure 7 summarize the results from the second stage. As one can see, all models except for the 'institutions only' model perform much better than the fixed effect only model. This is not really surprising given that we consider augmented versions of the models performing best in the first stage. It is nevertheless assuring given that the sample size non-randomly shrinks by more than 60 %. Again, the best-performing models have a mean absolute prediction error by about 25 % smaller than a pure fixed effect model with additional outlier

Table 3: Cross validation results (1st stage)

	MAD	SD(MAD)	RMAD
FE only	1,523	127	100.0%
KK homo (w/o SMP)	1,167	96	76.7%
KK homo (w/ SMP)	1,171	97	76.9%
KK hetero (w/o SMP)	1,140	91	74.9%
KK hetero (w/ SMP)	1,144	91	75.1%
Gravity homo (w/o SMP)	1,248	99	82.0%
Gravity homo (w/ SMP)	1,249	100	82.0%
Gravity hetero (w/o SMP)	1,140	89	74.8%
Gravity hetero (w/ SMP)	1,137	88	74.7%

MAD stand for mean of the Mean Absolute Deviation of cross validation. All criteria based on the same sample of $57,687$ observations. MAD derived from 100 iterations with an estimation sample of $0.9 \times 57,687$. RMAD is MAD relative to 'FE only' model.

control, although this improvement is now somewhat smaller for the benchmark models that performed best in the first stage. The best-performing models in the second stage are variants D and E of the heterogeneous KK model, followed by variant E of the gravity model with surrounding market potential. Performances in out-of-sample prediction between those models are not different in a statistical sense. One may suspect that the higher average MAD of the second stage indicates a worse performance of those models but this effect is driven by the fact that the mean of bilateral FDI positions in this considerably smaller sample is much higher. In effect, the best-performing model's average MAD equals 47.5 % of mean FDI in that sample, indicating a somewhat better out-of-sample prediction than in the best models in the first stage (in relative terms).

Figure 7: Distribution of MAD across models (2nd stage)

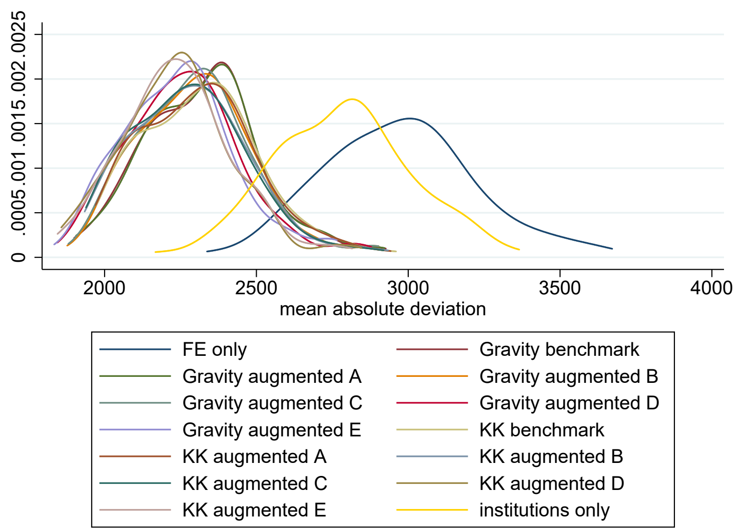


Table 4: Cross validation results (2nd stage)

	MAD	SD(MAD)	RMAD
FE only	2,972	253	100.0%
KK hetero	2,318	199	78.0%
KK hetero A	2,311	197	77.8%
KK hetero B	2,286	198	76.9%
KK hetero C	2,281	196	76.7%
KK hetero D	2,240	189	75.4%
KK hetero E	2,240	186	75.4%
Gravity hetero SMP	2,322	195	78.1%
Gravity hetero SMP A	2,323	195	78.2%
Gravity hetero SMP B	2,303	193	77.5%
Gravity hetero SMP C	2,297	193	77.3%
Gravity hetero SMP D	2,263	195	76.2%
Gravity hetero SMP E	2,245	188	75.5%
Institutions only	2,783	224	93.6%

MAD stand for mean of the Mean Absolute Deviation of cross validation. All criteria based on the same sample of $21,596$ observations. MAD derived from 100 iterations with an estimation sample of $0.9 \times 21,596$. RMAD is MAD relative to 'FE only' model.

6 Conclusion

In this paper, we use a previously un(der)used bilateral dataset on FDI stocks with extensive coverage of emerging and developing economies to empirically re-assess the question which key theoretical models and motives are most suitable to explain global foreign direct investment. We assess the performance of the gravity model and the knowledge capital (KK) model and add cultural, institutional, and financial factors, as suggested by other theories on FDI determinants. Using cross-validation, we found the gravity model to achieve the best theory-consistent out-of-sample prediction, particularly when parameter heterogeneity of South and North FDI is allowed for. Such a model improves prediction over a pure fixed effect model by about 25 %. Controlling for surrounding market potential is important to recover the horizontal effect of the gravity model. Including institutional, cultural, or financial factors does not improve the model performance distinctly although results for those variables are mostly in line with theory. Our results also indicate that the expected error margin for an out-of-sample prediction of the best-performing models is about half of average bilateral FDI positions.

Given large idiosyncrasies and heterogeneity in bilateral FDI stocks, we do not think that this is a particularly disappointing result. However, it is also clear from those results that there is still considerable scope to improve bilateral empirical models of FDI. Based on our exercise, we think that a simple gravity model, augmented with surrounding market potential and allowing for a modest degree of parameter heterogeneity should be the key starting point for any future empirical assessment of potential determinants of bilateral FDI positions.

A Appendix A

Figure A.1: Outlier identification

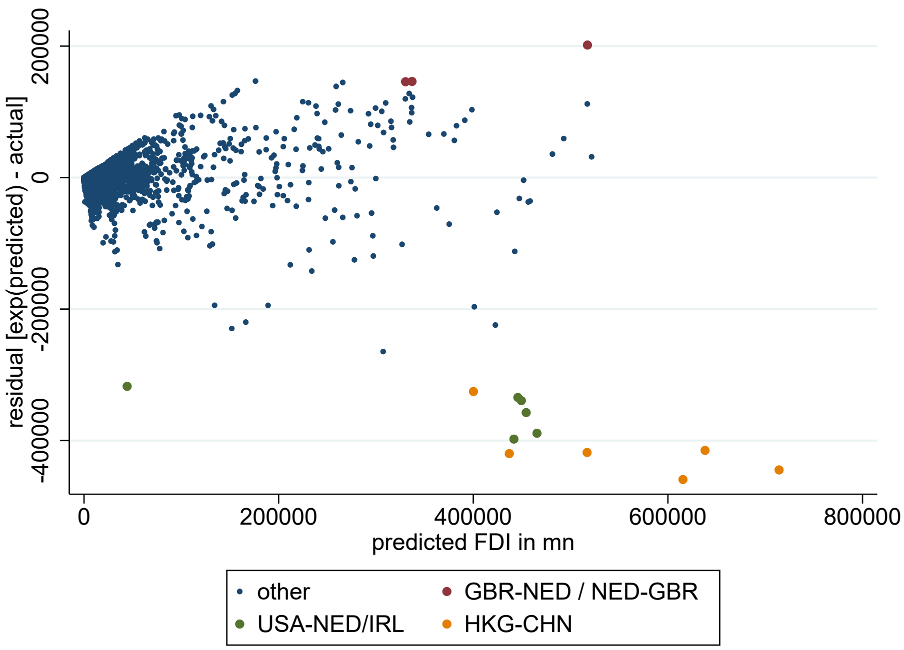


Table A.1: List of variables

Variable	**Description**	**Source**
	Variables of baseline models	
GDP	Real GDP at constant 2011 national prices (in million 2011 US$).	"rgdpna" series of the Penn World Tables (PWT) 9.0
Weighted distance (D)	Population weighted distance between a country pair.	CEPII gravity dataset
Relative skill endowment (RskE)	Measured as the natural logarithm of 'skilled' in source relative to 'skilled' in source and host minus the natural logarithm of 'unskilled' in host relative to 'unskilled' in source and host, where:"skilled" is the sum of 'secondary completed' and 'tertiary total' for source and host.	Barro and Lee (2010)

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Table A.1 – *Continued from previous page*

Variable	Description	Source
Trade costs	Trade costs measured as $100 \times (1 - \frac{X}{GDP} + \frac{M}{GDP})$, while $\frac{X}{GDP}$ and $\frac{M}{GDP}$ denote the export and import shares ('csh_x' and 'csh_m' series from PWT9.0) of merchandise export and imports at PPP.	PWT 9.0
Investment barriers	Investment barriers are proxied for by the investment freedom index which measures the regulations imposed on investment and which takes values between 0 (where the number and scope of restrictions is so high that investment freedom is eliminated) and 100 (where no restrictions are imposed and firms can move capital freely).	The Heritage Foundation
Sur. market potential (SMP)	The surrounding market potential is defined as the sum of inverse-distance-weighted GDPs of all other surrounding countries except for home and host (which are included as separate regressors in the model) for each year.	Based on GDP data from PWT 9.0 and distance from CEPII's gravity dataset
	Institutional and cultural factors	
Institutional distance (InstDist)	Institutional distance, measured as the arithmetic average of the squared difference of each dimension d of the political risk rating (by the ICRG) between two countries relative to the variance of each dimension.	The International Country Risk Guide (ICRG) by the PRS Group (2016)
Common colonizer (post 1945)	Dummy variable equal to one if a pair had a common colonist after 1945 and zero otherwise.	CEPII's gravity dataset
Common off. language	Dummy variable equal to one if a pair has a common official or primary language and zero otherwise.	CEPII's gravity dataset
Colonial relationship (post 1945)	Dummy variable equal to one if a pair had a colonial relationship after 1945 and zero otherwise.	CEPII's gravity dataset
Dist. of long-term vs. short-term orientation	Measures the difference of one dimension of national culture by Hofstede et al. (2010), i.e. long-term versus short term orientation index created by of host minus source. The dimension relates to the people's choice of focus with regard to their efforts and determines if they are driven by the past, present or future. It varies from zero to 100 with scores near zero indicating shorter and near 100 longer term orientation.	Hofstede et al. (2010)

Continued on next page

Table A.1 – *Continued from previous page*

Variable	**Description**	**Source**
Dist. of indulgence vs. restraint	Measures the difference of one dimension of national culture by Hofstede et al. (2010), i.e. indulgence versus restraint of host minus source. The index relates to the people's gratification versus control of basic human desires relative to enjoying life. Higher values (close to 100) indicate societies which are more indulgent compared to small values where societies are more restraint.	Hofstede et al. (2010)
	International financial aspects	
Exchange rate	Exchange rate reports the exchange rate for each period in national currency relative to US$. Estimated values are used if exchange rates are misaligned.	'xr' series from PWT 9.0
Bil. exchange rate regime	Bilateral de-jure exchange rate regime based on the IMF AREAER. It varies from 1 to 10, with the lowest value denoting hard pegs and the maximum value representing free floating regimes.	Harms and Knaze (2018)
Dist. in corporate tax rate	Distance in the corporate tax rate of host minus source. Missing values are interpolated.	KPMG documents
Dist. financial development	Financial development is proxied by the "Broad based index of financial development", which is an aggregate index measuring the devlopment of financial institutions and financial markets in terms of their depth, access and efficiency. It is a continuous index varying between zero and one with larger values representing higher development. The distance of financial development subtracts the index of host minus source.	IMF; Svirydzenka (2016)

Table A.2: Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
FDI stocks (in mn)	57,687	2152.9	20064.6	0.0	1158873
GDP	57,687	977523.3	2409277	2711.3	1.83e+07
Rel. skill endowment	57,687	-0.031	1.0	-3.5	4.0
Weighted distance	57,687	7382.6	4317.2	114.6	19648.5
Trade costs host	57,687	32.5	54.8	-419.0	103.9
Trade costs source	57,687	26.8	59.3	-419.0	103.9
Investment freedom host	57,687	58.7	21.6	0.0	95.0
Sur. market potential	57,687	22577.1	9841.4	6.3	58628.0
Institutional distance	48,977	1.7	1.1	0.1	875.149
Common colonizer	57,687	0.1	0.2	0.0	1.0
Common language	57,687	0.1	0.3	0.0	1.0
Pair in colonial rel. (post 1945)	57,687	0.0	0.1	0.0	1.0
Dist. of long-term vs. short-term orient.	26,998	-1.1	32.6	-96.0	96.0
Dist. indulgence vs. restraint	25,668	-1.0	30.4	-100.0	100.0
Exchange rate host	57,687	563.8	2268.8	0.3	33468.9
Exchange rate source	57,687	507.6	2313.0	0.3	33468.9
Bil. dejure exchange rate regime	53,989	9.0	2.1	1.0	10.0
Corp. tax rate host	48,715	25.1	7.3	0.0	55.0
Corp. tax rate source	48,986	25.3	7.4	0.0	55.0
Dist. of financial dev.	56,842	-0.0	0.4	-0.9	0.9

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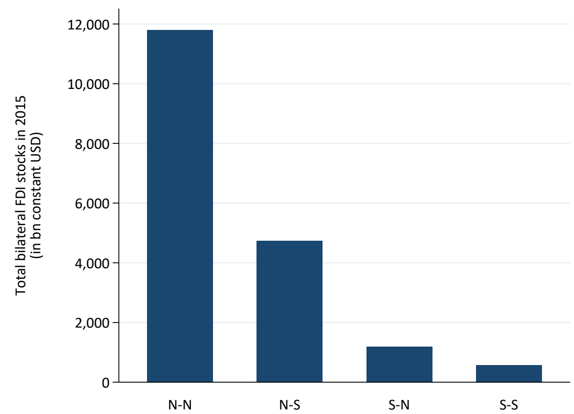
B Appendix B (to be put online)

B.1 FDI stocks by income group

Figure A.2: FDI stocks by income groups



B.2 Detailed results for individual models

Tables A.3 and A.4 report the results for the gravity and KK model, respectively. Each table starts with the homogeneous model in the first column, then adds SMP (surrounding market potential), then moves to the heterogeneous model in column 3, where SMP is added in column 4. All presented models include a full set of time, source and host country fixed effects and control for the above-mentioned bilateral outlier relationships.

In table A.3, we summarize the results of the homogenous and heterogenous gravity model. For the homogenous model we do not find strong support for the theoretical predictions. The GDPs of source and host are both positive but only host GDP is significant and it is different from unity, which one would expect for the horizontal model.[14] Only the negative and significant effect of distance is clearly in line with theory. The negative coefficients of relative skill endowment and of the joint size of source and host do not support horizontal FDI but also do not have the appropriate sign to explain vertical FDI. More interesting is that the inclusion of surrounding market potential in column (2)

[14]Whether we expect an exact unity-elasticity depends on the assumption how foreign affiliate sales are related to FDI.

shows a positive effect, which is significant at the 10 percent level. This is indicative of export-platform motives in FDI. Also, the inclusion of SMP lowers the estimated coefficient for host GDP close to unity, as the horizontal model predicts.

The last two columns of table A.3 report results for the heterogeneous gravity model, where we allow parameters to vary between North and South bidirectional relationships. Since SMP also seems to play a considerable role in this specification, we limit our discussion to column (4). Broadly speaking, we interpret the results as strong evidence for the prevalence of horizontal motives in North-North FDI and mixed motives in the other relationships. For North-North FDI, the estimates for both GDP parameters and the distance parameter show the expected direction and the former two are close to the unity elasticity a strict horizontal model would suggest. While the horizontal model would predict no effect of relative skill endowments and combined economic size, the negative and significant estimates cannot be reconciled with a vertical model either. The negative coefficient of the combined market size could also be indicative of some non-linearity in the individual parameters for GDP of source and host. It is again important to stress the unitary elasticity of SMP and the fact that its inclusion brings the host GDP elasticity closer to 1, the value expected for a strict horizontal model. In other words, inclusion of SMP is important in empirical models for FDI determinants as its omission leads to an upward bias of the importance of host country market size.

Moving to the other bidirectional relationships, evidence is mixed. For South-North FDI, the positive parameter estimates for relative skill endowments and combined market size are indicative of vertical motives. The low parameter estimate for source GDP, although insignificantly positive, does at least not contradict the reasonable assumption of vertical motives in S-N FDI. By contrast, surprisingly little evidence can be found for vertical motives in North-South FDI. For South-South FDI, the evidence is mixed: The estimated unity-elasticity of host GDP and the 0-estimate for relative skill endowments are indicative of a horizontal model, whereas the low estimate of source GDP and the positive coefficient on combined market size are indicative of a vertical model or could reflect some non-linearity.

For the gravity model, we hence conclude that adding surrounding market potential is important for empirical models of FDI determinants and that no clear conclusion can be reached concerning the prevalence of vertical vs. horizontal motives. However, given that both will be present in reality, we at least note that results are not at odds with theory and that, by and large, the evidence for horizontal vs. vertical motives in different subgroups of the sample is in line (or at least not in contrast) with theory.

Table A.3: Results Gravity model

VARIABLES	(1) Hom. PPML	(2) Hom. PPML SMP	(3) Het. PPML	(4) Het. PPML SMP
Ln (Source GDP)	0.541	0.518		
	(0.811)	(0.818)		
Ln (Source GDP) North-North			0.992	1.060
			(0.775)	(0.768)
Ln (Source GDP) North-South			0.593	0.627
			(0.846)	(0.839)
Ln (Source GDP) South-North			0.357	0.105
			(0.629)	(0.658)
Ln (Source GDP) South-South			-0.0846	-0.287
			(0.620)	(0.651)
Ln (Host GDP)	1.361***	0.902*		
	(0.486)	(0.536)		
Ln (Host GDP) North-North			2.212***	1.443**
			(0.534)	(0.569)
Ln (Host GDP) North-South			1.732***	1.757***
			(0.508)	(0.572)
Ln (Host GDP) South-North			1.114**	0.392
			(0.546)	(0.576)
Ln (Host GDP) South-South			1.215**	1.214**
			(0.482)	(0.547)
Ln (Bil. Distance)	-0.824***	-0.881***	-0.823***	-0.891***
	(0.0303)	(0.0319)	(0.0238)	(0.0311)
Rel. skill endowment (BL)	-0.383***	-0.388***		
	(0.0986)	(0.0989)		
Rel. sk. endowm. (BL) North-North			-0.104	-0.130*
			(0.0743)	(0.0753)
Rel. sk. endowm. (BL) North-South			-0.710***	-0.727***

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Table A.3 – *Continued from previous page*

VARIABLES	(1) Hom. PPML	(2) Hom. PPML SMP	(3) Het. PPML	(4) Het. PPML SMP
			(0.0894)	(0.0920)
Rel. sk. endowm. (BL) South-North			0.219	0.333*
			(0.158)	(0.175)
Rel. sk. endowm. (BL) South-South			-0.201	-0.162
			(0.127)	(0.128)
Ln (Sum GDP)	-0.179**	-0.161**		
	(0.0799)	(0.0806)		
Ln (Sum GDP) North-North			-0.641***	-0.625***
			(0.0698)	(0.0708)
Ln (Sum GDP) North-South			-0.0678	-0.0691
			(0.147)	(0.151)
Ln (Sum GDP) South-North			0.420***	0.483***
			(0.116)	(0.123)
Ln (Sum GDP) South-South			0.433***	0.431***
			(0.0928)	(0.0875)
Ln (sur. market pot.)		0.986***		
		(0.294)		
Ln (sur. market pot.) North-North				1.249***
				(0.316)
Ln (sur. market pot.) North-South				0.368
				(0.310)
Ln (sur. market pot.) South-North				1.807***
				(0.331)
Ln (sur. market pot.) South-South				1.002***
				(0.345)
Constant	-11.89	-15.49	-11.01	-18.03*
	(13.29)	(13.22)	(10.78)	(10.76)
Observations	57,687	57,687	57,687	57,687
R-squared	0.836	0.836	0.882	0.883
Source Country FE	Yes	Yes	Yes	Yes
Host Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
outlier pair FEs	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A.4 presents the results of the KK model and follows a similar structure as table A.3, but now differentiating between different skill levels in the heterogenous model.

We cannot find evidence for the KK model in the differences of skill endowment itself. Only the squared skill difference is significant but shows the wrong sign with regard to theoretical expectations. In line with theory, the effect of the squared difference in real GDPs and the joint effect of difference in GDPs and skill difference are negative. The effect of distance is estimated to be negative, indicating that monitoring and investment costs, which increase in distance and lead to a reduction in FDI matter. As predicted by the KK model the joint effect of squared skill difference and trade costs is negative, suggesting that even if trade costs are large (and thus providing incentives for horizontal FDI), an increase in skill difference reduces FDI (as horizontal motives only matter if countries have a similar skill endowment). Trade costs and investment barriers do not show any significant effect on FDI. As shown in column (2) the inclusion of surrounding market potential leads to an unexpected negative parameter estimate, similar to findings by Blonigen et al. (2007).[15]

With regard to the heterogenous KK model in column (3), differentiating between positive and negative skill difference does not distinctly improve the model fit. But together with the inclusion of the squared term of skill difference, it can potentially reveal the presence of vertical FDI. For the negative skill difference, where host is skill-abundant, we find a positive sign of the coefficient as suggested by theory. As skill difference in both countries becomes more similar, this leads to an increase in (horizontal) FDI. Although the effect for skill difference for the skill-abundant source is negative, it is only significant at the 10 percent level in the model where we account for surrounding market potential. Since the effect of squared skill difference turns out to be negative, we do not find supporting evidence for the presence of vertical FDI when skill differences become sufficiently large. Trade costs of source and investment barriers do not show any significant effect. Trade costs in the host show a positive effect, which is significant only at the 10 percent level and in the model without surrounding market

[15] A potential explanation for this results is that our sample includes a considerable number of developing and transition economies, and Blonigen et al. (2007) find export platform FDI to be present primarily in European OECD countries but not in non-OECD countries, which includes developing countries. However, the difference to the SMP-augmented gravity model is striking.

potential. This is in line with theory suggesting that an increase in trade costs in the host provides a motive for FDI to serve the foreign market to save trade costs. But the effect diminishes in the model with SMP. The effects of the surrounding market potential do not distinctly differ from the homogeneous model.

For the KK model, we hence conclude that evidence is mixed. There is no clear picture emerging from the estimates, neither concerning the prevalence of horizontal vs. vertical motives, nor do the results lend clear support to the rather complex KK model, as some parameter estimates are in line with theory, while others are not.

Table A.4: Results KK model

VARIABLES	(1) Hom. PPML	(2) Hom. PPML SMP	(3) Het. PPML	(4) Het. PPML SMP
Sum of GDPs	1.58e-08	2.43e-08		
	(4.02e-08)	(3.96e-08)		
Sum GDP (skilled host)			1.34e-08	2.29e-08
			(3.48e-08)	(3.45e-08)
Sum GDP (skilled source)			1.15e-09	8.94e-09
			(3.70e-08)	(3.68e-08)
Sq. diff. of GDPs	-0.000***	-0.000***		
	(0.000)	(0.000)		
Sq. diff. GDP (skilled host)			-0.000***	-0.000***
			(0.000)	(0.000)
Sq. diff. GDP (skilled source)			-0.000*	-0.000**
			(0.000)	(0.000)
Skill Difference sh	0.00482	0.00360		
	(0.00371)	(0.00359)		
Skill diff. (skilled host)			0.0144***	0.0129***
			(0.00400)	(0.00387)
Skill diff. (skilled source)			-0.00578	-0.00665*
			(0.00380)	(0.00381)
Sq. skill difference	-0.000127***	-0.000121***		
	(2.55e-05)	(2.50e-05)		
Sq. skill diff. (skilled host)			-0.000523***	-0.000522***
			(9.96e-05)	(9.68e-05)
Sq. skill diff. (skilled source)			-0.000212**	-0.000187**
			(9.10e-05)	(9.10e-05)

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Table A.4 – *Continued from previous page*

VARIABLES	(1) Hom. PPML	(2) Hom. PPML SMP	(3) Het. PPML	(4) Het. PPML SMP
Sk. diff. (BL) × GDP diff.	-1.13e-09***	-1.19e-09***		
	(1.18e-10)	(1.15e-10)		
Skill diff. × diff. GDP (skilled host)			-4.93e-10**	-5.47e-10**
			(2.50e-10)	(2.38e-10)
Skill diff. × diff. GDP (skilled source)			-1.15e-09***	-1.22e-09***
			(1.64e-10)	(1.68e-10)
Weighted distance	-0.000209***	-0.000202***	-0.000203***	-0.000197***
	(4.97e-06)	(5.32e-06)	(4.64e-06)	(5.19e-06)
Sq. skill diff. × trade costs host	-2.54e-06***	-2.50e-06***		
	(3.03e-07)	(2.90e-07)		
Sq. skill diff. × trade costs host (skilled host)			-3.79e-06***	-3.72e-06***
			(3.23e-07)	(3.09e-07)
Sq. skill diff. × trade costs host (skilled source)			3.95e-07	2.67e-07
			(7.04e-07)	(7.03e-07)
Trade costs source	0.000313	7.94e-05	0.00113	0.000958
	(0.00178)	(0.00183)	(0.00164)	(0.00168)
Trade costs host	0.00241	0.00217	0.00256*	0.00234
	(0.00177)	(0.00171)	(0.00152)	(0.00148)
Investment freedom host	-0.00190	-0.00138	-0.00236	-0.00192
	(0.00368)	(0.00365)	(0.00356)	(0.00352)
Sur. market potential		-2.62e-05**		-2.52e-05***
		(1.07e-05)		(9.63e-06)
Constant	5.930***	6.823***	5.925***	6.785***
	(0.295)	(0.512)	(0.285)	(0.462)
Observations	57,687	57,687	57,687	57,687
R-squared	0.884	0.884	0.894	0.894
Source Country FE	Yes	Yes	Yes	Yes
Host Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
outlier pair FEs	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Augmented models

We now move to the augmented model – that is 'best performing' from the first stage of cross validation (see section 5) augmented with all other factors (see tables A.5 and A.6). In each case, the first column reports the results of the benchmark model without augmenting factors. This is important because the sample considerably changes due to the fact that augmented variables are not available for all countries/years. Most observations we lose are from developing countries.

The reduction of the sample slightly changes the results of the benchmark gravity model (table A.5). Again, we see more evidence for horizontal FDI than for vertical FDI. Source GDP now shows significant positive effects for all country pairs. Host GDP does not show a significant effect for FDI going from South to North. The sum of GDPs does not matter for FDI from the South suggesting mostly horizontal motives for foreign investment originating from developing countries. The sample reduction also leads to an insignificant effect of surrounding market potential for South-South FDI, while FDI going to the North appears to be driven by the surrounding market potential.

With regard to the added explanatory variables, we find that financial and cultural factors play a role for FDI, while institutional differences between host and source do not seem to matter.

Especially the bilateral de-jure exchange rate regime significantly affects FDI. The negative effect supports what we expect. An increase in distance, which indicates a more flexible regime in the host and thus is expected to involve a higher exchange rate volatility and consequently leads to lower FDI. Similarly, the distance in corporate tax negatively affects FDI when interacted with the dummy indicating a higher tax of the host relative to source. This is also what we expect as higher taxes drive up the costs and thus reduce attractiveness of the respective market for investment.

The most important cultural factors are *having the same official language* and *being in a colonial relationship (post 1945)*. Both variables have the expected positive sign. The cultural measures by Hofstede also play a significant role, although the coefficients are smaller compared to common language and colonial relationship. But considering that Hofstede's indices take values between 0 and 100, there is more variation compared to the dummy variables and thus smaller coefficients translate into larger effects.

Table A.5: Results augmented gravity model

	(1)	(2)
VARIABLES	Het. PPML	Het. PPML
Ln (Source GDP) North-North	1.515**	1.394**
	(0.671)	(0.612)
Ln (Source GDP) North-South	1.370**	1.194*
	(0.670)	(0.615)
Ln (Source GDP) South-North	1.644***	1.797***
	(0.579)	(0.583)
Ln (Source GDP) South-South	1.508***	1.695***
	(0.531)	(0.541)
Ln (Host GDP) North-North	1.573**	1.721***
	(0.635)	(0.590)
Ln (Host GDP) North-South	2.971***	3.459***
	(0.431)	(0.400)
Ln (Host GDP) South-North	0.852	1.065*
	(0.656)	(0.606)
Ln (Host GDP) South-South	2.544***	3.099***
	(0.439)	(0.410)
Ln (Bilateral Distance)	-0.769***	-0.680***
	(0.0237)	(0.0267)
Rel. sk. endowm. (BL) North-North	-0.135*	-0.0753
	(0.0750)	(0.0745)
Rel. sk. endowm. (BL) North-South	-0.840***	-0.675***
	(0.101)	(0.0939)
Rel. sk. endowm. (BL) South-North	-0.419*	-0.286
	(0.217)	(0.219)
Rel. sk. endowm. (BL) South-South	-0.503***	-0.338**
	(0.157)	(0.157)
Ln (Sum GDP) North-North	-0.693***	-0.629***
	(0.0746)	(0.0933)
Ln (Sum GDP) North-South	-0.549***	-0.432***
	(0.0793)	(0.0798)
Ln (Sum GDP) South-North	-0.169	-0.105
	(0.283)	(0.273)
Ln (Sum GDP) South-South	-0.159	-0.103
	(0.149)	(0.155)
Ln (sur. market pot.) North-North	1.039***	0.851***

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Table A.5 – *Continued from previous page*

VARIABLES	(1) Het. PPML	(2) Het. PPML
	(0.287)	(0.276)
Ln (sur. market pot.) North-South	-0.388	-1.378***
	(0.298)	(0.303)
Ln (sur. market pot.) South-North	1.746***	1.406***
	(0.303)	(0.299)
Ln (sur. market pot.) South-South	0.0783	-1.112***
	(0.338)	(0.344)
Institutional distance (t-1)		-0.00615
		(0.0437)
$D_{h>s}$ × Institutional distance (t-1)		0.111
		(0.0709)
Dist. financial dev. (host-source)		0.513
		(0.514)
$D_{h>s}$ × Dist. financial dev. (host-source)		-0.452
		(0.427)
Bil. de-jure exchange rate regime		-0.0234***
		(0.00715)
Exchange rate (nat. cur./USD) source		-0.000271**
		(0.000136)
Exchange rate (nat. cur./USD) host		-3.53e-05
		(5.48e-05)
Dist. corporate tax (host-source)		0.0213***
		(0.00701)
$D_{h>s}$ × Dist. corporate tax (host-source)		-0.0214***
		(0.00755)
Common language		0.589***
		(0.0504)
Common colonizer (post 1945)		-0.161
		(0.146)
Pair in col. relationship (post 1945)		0.474***
		(0.0946)
Dist. Hofstede short-term vs. long-term orient.		0.0231
		(0.0774)
$D_{h>s}$ × Dist. Hofstede short-term vs. long-term orient.		0.0110***
		(0.00294)
Dist. Hofstede indulgence vs. restraint		-0.578
		(0.467)
$D_{h>s}$ × Dist. Hofstede indulgence vs. restraint		-0.0163***
		(0.00236)
Constant	-42.87***	-41.58***
	(8.968)	(8.981)

Continued on next page

Table A.5 – *Continued from previous page*

VARIABLES	(1) Het. PPML	(2) Het. PPML
Observations	21,596	21,596
R-squared	0.883	0.898
Source Country FE	Yes	Yes
Host Country FE	Yes	Yes
Year FE	Yes	Yes
outlier pair FEs	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The major difference with regard to the results of the KK model in the reduced sample is that joint size of country pairs is now positive and significant for skilled host and skilled source, which is in line with the KK model (table A.6). Another aspect that changes in the reduced sample is that skill difference and squared skill difference do not show any significant effects anymore, suggesting that those effects are related to the inclusion of a sufficiently large number of developing countries in the analysis as also noted by Davies (2008).

Extending the KK model reveals that in this framework institutional distance plays a role. Although, in general, institutional distance does not show any significant effect if we do not distinguish between positive and negative institutional distance of host/source. Including a dummy for a higher institutional quality of host relative to source, reveals a positive effect of institutional distance, which is in line with our expectations that better institutions in the host country promote investment.

With regard to financial aspects, distance in financial development and distance in the corporate tax rates show significant effects on FDI. The negative effect of distance in financial development when interacted with a dummy indicating higher financial development in the host, makes sense in the way that we expect financial development in the source to be higher than in the host. So small distances should promote investment. Furthermore, a positive distance in the corporate tax rate with regard to the host negatively affects FDI, which is in line with our expectations. If taxes in the host increase, this prevents foreign investment.

The importance of cultural distance are in line with the overall results of the augmented gravity model.

Table A.6: Results augmented KK model

	(1)	(2)
VARIABLES	Het. PPML	Het. PPML
Sum GDP (skilled host)	1.78e-07***	1.46e-07***
	(4.96e-08)	(4.92e-08)
Sum GDP (skilled source)	1.82e-07***	1.55e-07***
	(5.13e-08)	(4.99e-08)
Sq. diff. GDP (skilled host)	-0.000***	-0.000***
	(0.000)	(0.000)
Sq. diff. GDP (skilled source)	-0.000***	-0.000**
	(0.000)	(0.000)
Skill diff. (skilled host)	0.000890	0.00297
	(0.00541)	(0.00589)
Skill diff. (skilled source)	-0.00260	-0.00627
	(0.00553)	(0.00492)
Skill diff. × diff. GDP (skilled host)	-6.55e-10*	-8.31e-10*
	(3.65e-10)	(4.59e-10)
Skill diff. × diff. GDP (skilled source)	-4.73e-10**	-4.61e-10**
	(2.00e-10)	(2.00e-10)
Sq. skill diff. (skilled host)	-0.000181	-5.54e-05
	(0.000114)	(0.000122)
Sq. skill diff. (skilled source)	-0.000127	3.75e-05
	(0.000102)	(8.54e-05)
Sq. skill diff. × trade cost (skilled host)	-2.99e-06***	-2.09e-06**
	(7.35e-07)	(8.20e-07)
Sq. skill diff. × trade cost (skilled source)	-1.18e-06	-1.22e-06
	(8.41e-07)	(7.60e-07)
Trade cost host	-0.00116	-0.00101
	(0.00157)	(0.00162)
Trade cost source	-0.00183	-0.00158
	(0.00118)	(0.00118)
Investment freedom host	-0.00606*	-0.00673**
	(0.00319)	(0.00299)
Weighted distance	-0.000183***	-0.000172***
	(3.86e-06)	(4.08e-06)
Institutional distance (t-1)		-0.0516
		(0.0393)
$D_{h>s}$ × Institutional distance (t-1)		0.150**
		(0.0659)

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Table A.6 – *Continued from previous page*

VARIABLES	(1) Het. PPML	(2) Het. PPML
Dist. financial dev. (host-source)		1.003**
		(0.444)
$D_{h>s}$ × Dist. financial dev. (host-source)		-1.073***
		(0.281)
Bil. de-jure exchange rate regime		-0.00228
		(0.00660)
Exchange rate (nat. curr./USD) source		-0.000237
		(0.000159)
Exchange rate (nat. curr./USD) host		6.53e-06
		(5.54e-05)
Dist. corporate tax (host-source)		0.0343***
		(0.00728)
$D_{h>s}$ × Dist. corporate tax (host-source)		-0.0619***
		(0.00715)
Common language		0.760***
		(0.0462)
Common colonizer (post 1945)		-0.108
		(0.142)
Pair in col. relationship (post 1945)		0.386***
		(0.0906)
Dist. Hofstede short-term vs. long-term orient.		0.0889***
		(0.0144)
$D_{h>s}$ × Dist. Hofstede short-term vs. long-term orient.		0.00742***
		(0.00280)
Dist. Hofstede indulgence vs. restraint		0.0667***
		(0.0159)
$D_{h>s}$ × Dist. Hofstede indulgence vs. restraint		-0.0130***
		(0.00227)
Constant	5.960***	6.807***
	(0.307)	(0.313)
Observations	21,596	21,596
R-squared	0.897	0.907
Source Country FE	Yes	Yes
Host Country FE	Yes	Yes
Year FE	Yes	Yes
Outlier pair FEs	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1