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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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Abstract

In this paper, we empirically re-assess the question which theoretical motives and empirical models are most suitable to explain global patterns of foreign direct investment (FDI). Compared with previous studies, we use bilateral FDI positions with a much more comprehensive coverage of emerging and developing economies, the IMF's Coordinated Direct Investment Statistics. We apply cross-validation to assess the performance of the gravity model and the knowledge capital (KK) model and add cultural, institutional and financial factors, as suggested by different theories on FDI determinants. 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. Controlling for surrounding market potential is important to recover the horizontal effect of the gravity model. Our finding that the gravity model for FDI performs well but requires some degree of parameter heterogeneity and the inclusion of surrounding market potential provides a clear baseline for future empirical studies of FDI determinants. Inclusion of institutional, cultural or financial factors seems less relevant and does not improve the model performance distinctly, although results for those variables are mostly in line with theoretical predictions.

KEYWORDS
cross-validation, FDI, foreign direct investment, institutions, international finance, model selection, multinational corporations

1 | INTRODUCTION

Foreign direct investment (FDI) is a key category of international capital flows that largely reflects investment of multinational enterprises. According to the most recent vintage of the data set of Lane and Milesi-Ferretti (2018), FDI stocks accounted for 29 per cent of global cross-border liabilities in 2015 and in more than a third of countries, FDI is the source of over 50 per cent of foreign financing.

In this paper, we use a previously un(der)used bilateral data set on FDI stocks to identify the econometric model that is best-suited to explain the empirical distribution of FDI and is based on theoretical rationales. Therefore, we assess the 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 et al., 2001; Markusen, 2002; Markusen et al., 1996), which integrates horizontal and vertical motives into a joint general equilibrium framework. We further add variables that other FDI theories have emphasised, such as 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 et al., 2007; Ekholm et al., 2007; Yeaple, 2003).

Our key finding and contribution to the literature is that the gravity model performs best in explaining the global allocation of FDI but requires some degree of parameter heterogeneity and the inclusion of surrounding market potential. Such a model improves prediction over a pure fixed effect model by about 25%. We thus suggest that future empirical studies of FDI determinants rely on such a specification for their baseline model.

Econometrically, our contribution is based on two unique features: a cross-validation model selection for the best 'out-of-sample' performance that avoids over-fitting[1] and the IMF's 'Coordinated Direct Investment Statistics' (CDIS), which provides a much more comprehensive country coverage than bilateral FDI data sets previously used in the literature, especially for developing countries. This comprehensive coverage allows us to improve on previous empirical macro analyses of FDI determinants for at least three reasons:

[1]Because we aim to identify one reference model from a series of candidates, our analysis differs from several Bayesian model averaging attempts (e.g. Blonigen & Piger, 2011). Moreover, our econometric application is not a standard identification exercise aiming to pin down structural model variables and resolve endogeneity biases that economists typically have in mind. We are rather interested in an empirical assessment of model performance. Note, however, 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 (2004).

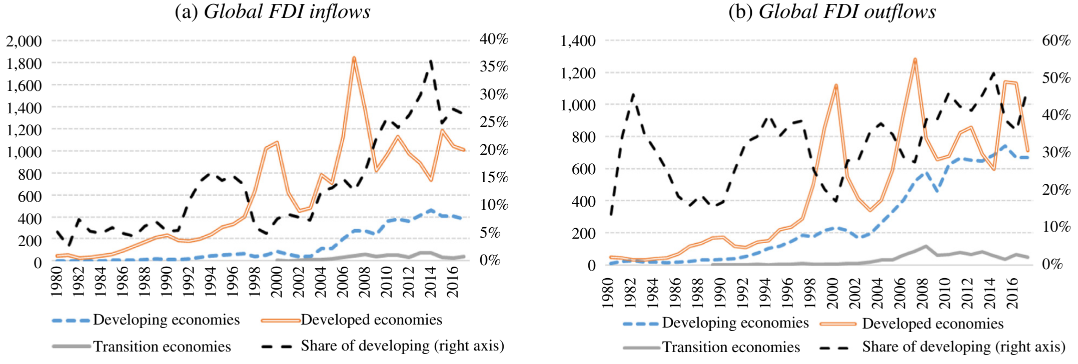

FIGURE 1 Global foreign direct investment in- and outflows by country groups (in billion US-$) [Colour figure can be viewed at wileyonlinelibrary.com]

First, considerable cross-country sample heterogeneity is important for assessing the relevance of vertical vs. horizontal motives for FDI. While earlier studies have emphasised the importance of horizontal FDI motives looking at US outward FDI activities (Brainard, 1997; Helpman et al., 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, Braconier et al. (2005) and Davies (2008) have emphasised 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 et al., 2016; Demir & Hu, 2020; Gold et al., 2017; Kolstad & Wiig, 2012).

Third, studies from international business and more recently international economics have emphasised the role of cultural and institutional distance for FDI (e.g. Aleksynska & Havrylchyk, 2013; Azemar et al., 2012; Bénassy-Quéré et al., 2007; Beugelsdijk et al., 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) emphasise, 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 suggest that there is indeed a relevant degree of heterogeneity in FDI motives between 'North' and 'South' combinations but that the complex yet restrictive KK model dos not provide a promising functional form to capture them and that a simple gravity model with parameter heterogeneity across 'North'–'South' combinations provides better fit to the data while remaining providing parameters that are consistent with theory. The comprehensive bilateral CDIS data set also allows us to estimate the effects of institutional, cultural and financial factors, which are mostly in line with theoretical predictions but do not distinctly improve the models' overall performance.

The remainder of our paper is organised 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 set-up 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.[2]

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 data set, which starts with 2009 data,[3] allows for new dimensions of macroeconomic studies of FDI motives because of its improved quality and coverage compared to the UNCTAD data set. 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 212,844 bilateral FDI positions, out of which 8255 are negative and 118,536 are 0.[4] For comparison, the UNCTAD data set only provides 65,729 bilateral observations, out of which 1926 are negative and 19,479 are 0. This difference in coverage is not only of quantitative relevance. Figure 2 depicts the coverage

[2]OECD also reports bilateral FDI positions but only if either the source or the host country are an OECD member. The data, used among others by Bénassy-Quéré et al. (2007), hence neglect 'South-South' FDI. Note that OECD data are identical to CDIS data for most countries where OECD data are available.

[3]CDIS includes some 2008 observations for Malaysia.

[4]Negative FDI stocks can arise, for example, if the FDI home (investor) takes a loan from the host (affiliate) that is larger than all equity and credit assets home holds in the host.

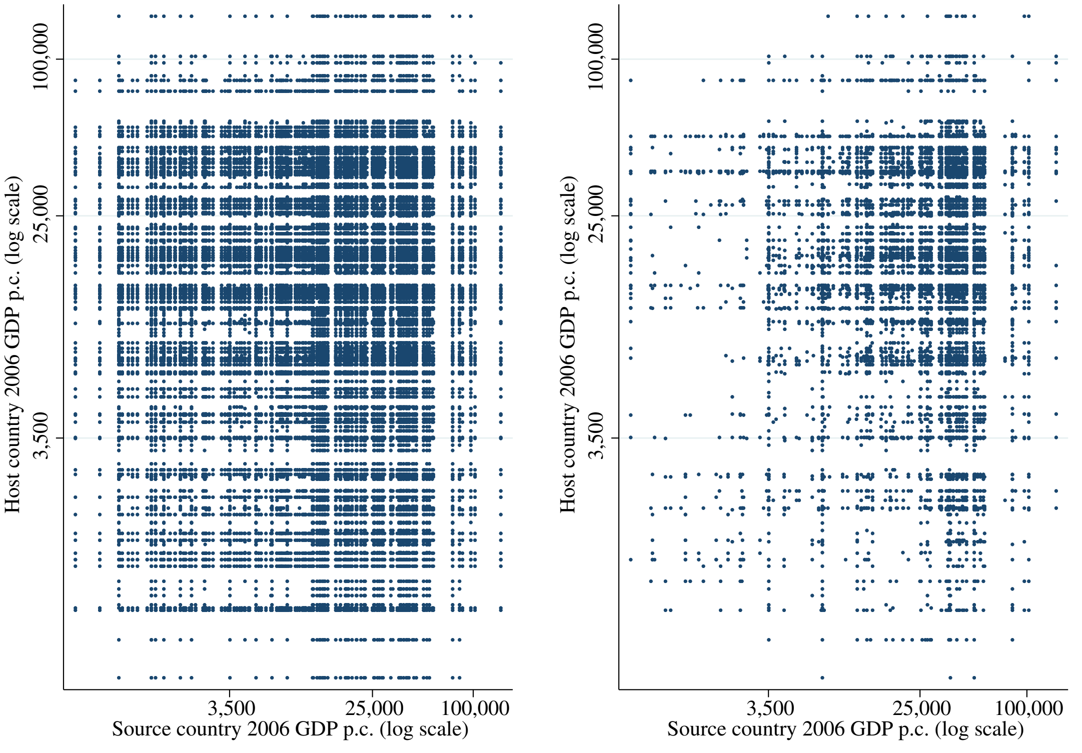

FIGURE 2 Coverage of Coordinated Direct Investment Statistics (CDIS) vs. UNCTAD data [Colour figure can be viewed at wileyonlinelibrary.com]

of the IMF's CDIS data set compared with 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, irrespective of the year for which this observation is recorded. 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, that is 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 data sets overlap, the correlation coefficient of the 20,581 overlapping observations is 0.73.

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, compared with other sources (for the year 2010) and broken down by FDI going to and coming from 'South' countries, respectively.[5] Overall, CDIS covered 23.9 trillion US$ in-

[5]Note that we cannot split up the data in bilateral pairs as the Lane and Milesi-Ferretti EWN data set is not available on a bilateral level.

TABLE 1 Global foreign direct investment (FDI) stocks covered by different data sets (for year 2010)

	EWN (Lane & Milesi-Ferretti, 2007)	UNCTAD Stat	CDIS World	CDIS sample
Inward all countries	23.8 trn US$	19.0 trn US$	23.9 trn US$	16.6 trn US$
Inward South	6.7 trn US$	5.1 trn US$	5.8 trn US$	4.4 trn US$
Outward South	2.2 trn US$	1.5 trn US$	1.9 trn US$	1.4 trn US$

CDIS, Coordinated Direct Investment Statistics.

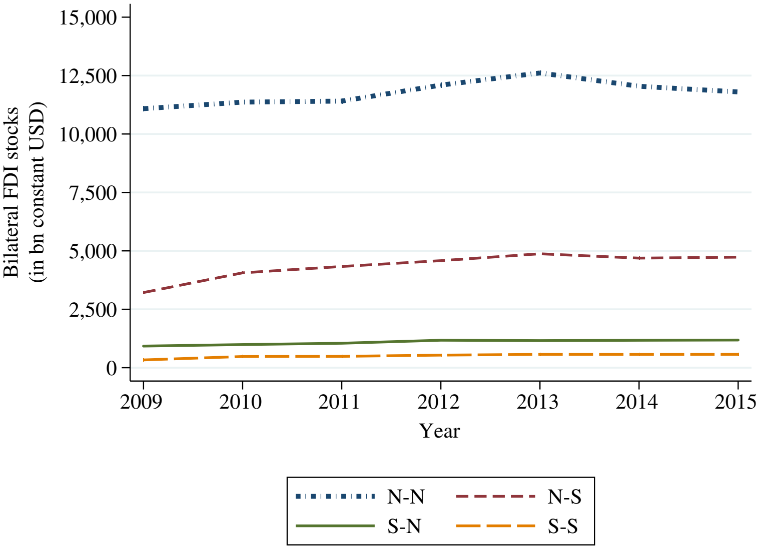

FIGURE 3 Foreign direct investment stocks by income groups over time [Colour figure can be viewed at wileyonlinelibrary.com]

ward stocks, which is almost identical with the number provided by the 'External Wealth of Nations' database by Lane and Milesi-Ferretti (2007) and about 5 trillion US$ above the bilateral FDI data reported by UNCTAD.[6] Of those 23.9 trn US$, 16.6 are comprised by our final sample, which includes 7759 observations in 2010 after dropping small countries, observations with negative FDI stock values (which our PPML estimator cannot facilitate), and observations for which covariables for the KK and gravity model are not available. This means that our most comprehensive sample covers 70% of global FDI and includes important economies such as Brazil, China, France, Germany, Japan, Mexico, Russia, the United Kingdom and the United States among many other source and host countries. Perhaps, even more important is its broad coverage with respect to the number of observations, particularly for the 'South': of the 7759 FDI observations in our final sample for 2010, 4884 (5305) originate from (go to) the 'South'. This is much higher than the (unconstrained) bilateral UNCTAD sample which includes 2743 (3903) respective observations and implies that CDIS records a much higher

[6]Note that the aggregate UNCTAD Stat FDI data, which does not allow a bilateral breakdown, covers global inward stocks of 20.3 trn US$—slightly more than the sum of FDI stocks recorded in the bilateral UNCTAD data set.

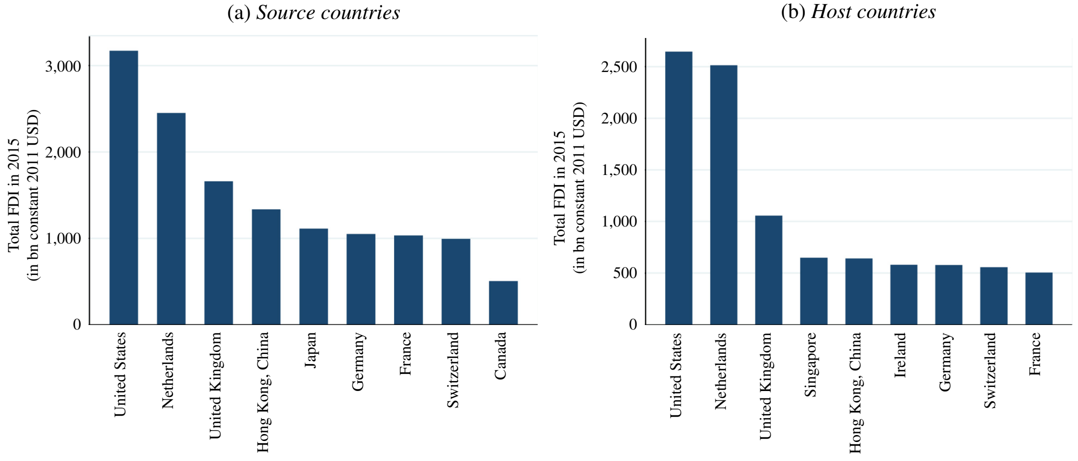

FIGURE 4 Top-10 foreign direct investment source and host countries (in absolute terms) [Colour figure can be viewed at wileyonlinelibrary.com]

number of source countries with low FDI stocks from the 'South' (which is arguably more representative of the developing world).

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.[7]

Figure 3 depicts bilateral FDI positions from our final CDIS sample over time, broken down by different country-groups.[8] Two key features are worth highlighting. First, there seems to be 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 worth highlighting and leads to a scaling in the graph that masks the catch-up of FDI from the 'South'.[9]

Figure 4 shows 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 industrialised economies such as the United States, the United Kingdom, Japan, Germany and France. The existence of relatively small countries such as 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.

[7]Note that our deflators for FDI (using US prices) and GDP (national prices in US-$) are different and hence avoid a spurious correlation that Baldwin and Taglioni (2006) consider a potential problem. Year fixed effects further mitigate this potential issue. While one may argue that those year fixed effects account for global inflation, we consider deflated values more appropriate for nominal variables if they are combined with 'real' variables (e.g. education, institutions), like in our case (and unlike the expenditure function underpinning the gravity equation for trade). We presume that the price level of US output-side GDP is the most appropriate simple deflator for global asset prices.

[8]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. However, we also provide robustness checks with an alternative classification. Country-group doubles are ordered as 'source-to-host', for example 'S-N FDI' is FDI from a Southern source country to a Northern host country.

[9]The flows reported in Figure 1b are only a small magnitude of stocks (which also depreciate over time) such that trends in flows take time to become obvious in stocks. Note that FDI stocks originating from the 'South' grow at double the rate in our sample than FDI stocks from the 'North' (10 vs. 5% p.a.).

Those descriptive statistics generally support the notion that our sample is an adequate representation of global FDI patterns, with all their drawbacks.[10] We think that economics still needs to be explain FDI peculiarities such as Ireland or round-tipping in Asia but also want to avoid that individual outliers considerably 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 A1 in Appendix A (Tables A1 and A2). 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 the United Kingdom, the Netherlands, the United States, Ireland, Hong Kong SAR of PRC and China.[11]

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:

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

where a_s, a_h, and d_t are source-, host-, and time-fixed effects, respectively, and ε is an idiosyncratic error term.[12]

We use FDI stocks as our dependent variable because they are less volatile than flows, thus providing a higher signal-to-noise ratio. While theoretical models for multinationals and FDI are often derived for affiliate sales, such sales data are not comprehensively available on the desired bilateral level with global coverage. However, FDI stocks show a near-unity elasticity with sales data in data sets where both measures are available, suggesting the appropriateness of their use for our analysis (see Wacker, 2016, and Casella et al., 2021, on those measurement issues).

[10]For general discussions about the adequacy of FDI data, refer to Beugelsdijk et al. (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.

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

[12]We are aware of the fact that gravity literature in trade uses more restrictive fixed effect settings but this is not meaningful in our set-up because of the short time dimension and particularly the little over time variation in many variables, notably 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.

The notation of our variables highlights that identification of the parameters collected in the column vectors β_s, β_h, δ 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).[13] Moreover, we allow for some heterogeneity in the parameters β_s, β_h, δ as we detail below. Note that a homogeneity restriction of parameters, which is often implicitly 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

$$b_{s1}\ln\left(GDP_{st}\right) + b_{h1}\ln\left(GDP_{ht}\right) + \delta_1\ln\left(D_{sh}\right) + \delta_2 RSkE_{sht} + \delta_3\ln\left(GDP_{st} + GDP_{ht}\right) \tag{2}$$

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 et al., 2015), D by population-weighted distance from the CEPII gravity data set, and relative skill endowment $RSkE$ as:

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

where ‘skilled’ is the sum of ‘secondary completed’ and ‘tertiary total’ in the Barro and Lee (2010), and ‘unskilled’ is defined as 100-‘skilled’.[14] $RSkE_{sht} > 0$ hence indicates that the source country is more skilled in year t.

The first three terms in Equation (2) are well-known gravity components. In a horizontal FDI model where affiliate sales require some domestic inputs, GDP of source and host capture

[13]More precisely, we mostly relied on the ‘ppml’ command in STATA 15. For the robustness checks with high dimensional fixed effects (MRTs and country-pair FEs), we relied on the novel STATA module ‘ppmlhdfe’ from Correia, Guimarães, and Zylkin (2020). Both commands provided identical estimates (including standard errors) for the key baseline models.

[14]Since Barro-Lee data only come in 5-year intervals, they were interpolated using STATA's ‘ipolate’ function by country, with years as the argument. 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.

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).

supply and demand capacity of the respective economies. In the vertical FDI model, where production of a globally sold good is sliced up over different economies, demand capacity is pinned down by the sum of GDPs while the individual GDPs of source and host capture their supply capacity. Since vertical FDI minimises production costs, source GDP affects FDI negatively in the vertical model (conditional on the sum of GDPs as a demand proxy). This vertical motive increases with skill differences between source and host (*RSkE*) and becomes more costly with geographical distance (*D*) between the two. Conversely, traditional horizontal models see FDI as a substitute for exports based on a 'proximity-concentration trade-off' (Brainard, 1997), suggesting FDI to increase with distance as exporting becomes more costly. Yet, Kleinert and Toubal (2010) suggest that horizontal foreign production needs some domestic inputs and that fixed set-up costs of horizontal FDI in a heterogeneous firm model (Helpman et al., 2004) should increase with distance, leading to a negative effect of distance on horizontal FDI. Table 2 summarises those theoretical predictions for the horizontal and vertical model.[15]

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}, δ_2, δ_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.[16]

Another concern for full-fledged structural estimation of the gravity model, as it has been developed in the trade literature, is our omission of multilateral resistance terms (MRTs) through time-varying directional (source and host) fixed effects (e.g. Anderson & van Wincoop, 2003; Olivero & Yotov, 2012). We omit those MRTs in our main analysis for two reasons. First, there is no clear theoretical interpretation of those terms in the context of a gravity model for

[15]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.

[16]Additionally allowing for parameter heterogeneity in distance shows a more negative coefficient for FDI from source countries in the 'South', particularly 'S–S' FDI. It is not obvious how this can be used to further discriminate between vertical and horizontal motives in the model of Kleinert and Toubal (2010): more negative distance coefficients could reflect a higher share of vertical FDI in FDI from the 'South', or that firms from the 'South' are more sensitive to the search and organization costs that Kleinert and Toubal (2010) assume to increase in distance in their horizontal model. We hence omit this heterogeneity in our paper in the interest of readability.

FDI (and even in the trade literature, the inclusion of exporter-year and importer-year fixed effects leads to theoretically puzzling implications, see Klasing et al., 2015). Second, it would lead us to compare a high-dimensional fixed effect gravity model to a reduced form KK model since there is even less theoretical motivation for those MRTs in the latter. In our view, this would lead to comparison of very different model classes. Moreover, out of sample prediction becomes increasingly worrisome with higher-dimensional fixed effects. However, robustness checks for the gravity model with MRTs is provided in section 4.1 and we think that our results in favor of the gravity model motivate future research how to best motivate and incorporate MRTs in a gravity model for FDI.

3.2 | KK model

The knowledge-capital (KK) model unites different motives of horizontal and vertical FDI into a joint partial equilibrium model (see Markusen, 2002). Both forms of FDI arise at different combinations of market sizes and skill endowments. For example, horizontal FDI dominates if countries are similar in size and skill endowments and trade costs are moderate or high (since horizontal FDI substitutes for exporting). Conversely, vertical FDI will dominate if countries are sufficiently dissimilar in skill endowments, which gives rise to the factor price differences that vertical FDI exploits, but somewhat similar in size (Markusen et al., 1996). Horizontal and vertical motives hence do not lead to contradictory implications concerning central model parameters, as in the gravity representation of Kleinert and Toubal (2010). Heterogeneity across ‘North’ and ‘South’ pairs to account for different FDI motives hence does not appear meaningful in the KK model. Rather, both forms of FDI co-exist in the KK model and add up to the total FDI stock, which hence depends on a complex interaction of relative skill endowments, market sizes, as well as trade and investment costs. Deriving a testable reduced-form equation is thus not straightforward and has been subject to some debate in the literature (Blonigen et al., 2003; Braconier et al., 2005; Carr et al., 2001). Davies (2008) provides an instructive summary of this debate and suggests the following functional form for inclusion into Equation (1):

$$\begin{gathered}\delta_4\left(GDP_{st}+GDP_{ht}\right)+\delta_5\left(GDP_{st}-GDP_{ht}\right)^2+\delta_6\left(skilled_{st}-skilled_{ht}\right)+\\ \delta_7\left(skilled_{st}-skilled_{ht}\right)^2+\delta_8\left(skilled_{st}-skilled_{ht}\right)\left(GDP_{st}-GDP_{ht}\right)+\\ \delta_9 D_{sh}+\delta_{10}\left(skilled_{st}-skilled_{ht}\right)^2 tradecost_{ht}+\beta_3\, tradecost_{st}+\\ \beta_4\, tradecost_{ht}+\beta_5\, investmentbarriers_{ht}.\end{gathered} \tag{3}$$

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

We focus on the role of skill differences to give a flavor of the KK model and refer the interested reader to the literature referenced above for further detail. For small skill differences, horizontal FDI motives will dominate because source and host are similar and multinationals replicate home activity abroad. This horizontal motive will decline as skill differences grow, suggesting $\delta_6 < 0$. To what extent horizontal FDI is a viable substitute for exporting depends on trade costs, giving rise to the non-linear interaction with parameter δ_{10}. If economies and their skill endowments become more similar, horizontal FDI will rise faster if trade costs are high, suggesting $\delta_{10} < 0$. However, if skill differences grow further, this gives increasingly rise to vertical FDI motives, which suggests $\delta_7 > 0$

for squared skill differences. While this may give a flavor of the KK models' ability to jointly explain vertical and horizontal motives, it also illustrates its complexity.

For the remaining model parameters, we expect a positive effect for the *sum of real GDPs* and a negative one for the *squared difference in real GDPs*. 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. 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).

As argued by Blonigen et al. (2003) and Davies (2008), the effect of skill differences should be different depending on whether the source or host country is relatively skill abundant. We hence compare the 'homogeneous KK' specification in Equation (3) to a 'heterogeneous KK' model variant, where parameters for variables involving skill differences are allowed to differ between skill-intensive host vs. source country pairs.

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 similar to Blonigen et al. (2007) 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 internalisation 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 et al., 2010; Desbordes et al., 2011). Their rationale can be summarised 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.[17] Recent work by Demir and Hu (2016) is, in our view, the most elaborate empirical assessment of

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

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

$$\delta_{11} InstDist_{sht} + \delta_{12}\mathbf{1}(InstDist)_{h>s,t} \times InstDist_{sht}, \tag{4}$$

where $1(InstDist)_{h>s,t}$ 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):

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

where V_d is the variance of each dimension d. Additionally, we provide a robustness check with the World Bank's World Governance Indicators (WGI).

Similarly, especially the international business literature has emphasised that cultural distance makes firm integration more difficult and thus detracts FDI (e.g. Beugelsdijk et al., 2018). We thus control for a number of cultural factors, including the dummy variables common coloniser, common official language, colonial relationship after 1945 from the CEPII gravity data set, and two dimensions of cultural distance from the traditional measure of Hofstede et al. (2010). We chose the measures for ‘long-term orientation vs. short-term orientation’ and ‘indulgence vs. restraint’ because the other three 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 data set. Similar to the model component (4), 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 et al., 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): a devaluation of the host relative to the source currency makes host assets cheaper and FDI hence more attractive for the source investor. Yet, the exchange rate may influence horizontal and vertical FDI motives for various other reasons and also has valuation effects on FDI stocks such that we have no strong prior about the sign and magnitude of our included series xr for source and host from PWT9.0.

Moreover, expected exchange rate volatility and thus the *exchange rate regime* may matter. For example, Harms and Knaze (2021) show that in the presence of price rigidities in an otherwise traditional 'proximity-concentration' trade-off model for horizontal FDI, exporting becomes increasingly attractive relative to FDI if expected exchange rate volatility increases, that is when the exchange rate becomes increasingly floating. 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 et al., 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.[18] Again, we additionally interact this difference with a dummy variable equal 1 if the host tax rate is higher than the source tax rate.

Donaubauer et al. (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 S1.2. 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 S1, 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.

[18]We interpolate some missing values of corporate tax rates using STATA's 'ipolate' function by country, with years as the argument.

By contrast, some of the results for the KK model are conflicting with theory (Table A2). 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: the model and its functional form are much more complex and difficult to interpret than a gravity model, which also comprises horizontal and vertical motives, and several estimated KK model parameters are at odds with theory.[19]

We also look at baseline models augmented with all other factors previously discussed (Tables S8 and S9). Overall, we find that financial and cultural factors play a role for FDI. Especially, the bilateral de-jure exchange rate regime significantly affects FDI: higher exchange rate flexibility makes exporting more attractive relative to FDI (see Harms & Knaze, 2021). 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 relationship between institutional differences and FDI is only estimated to be significantly different from 0 in the augmented KK model, when institutional quality is proxied by ICRG. Higher FDI levels are associated with higher institutional differences for country pairs with better institutions in the host country in this case. Table S10 provides additional results, where institutional quality is proxied by WGI instead of ICRG. This increases the statistical significance of some results but does not qualitatively alter them.[20] Since pinpointing those institutional parameters is not essential to our model-selection exercise we do not further elaborate on those results and proceed with the ICRG measure, which is consistent with Demir and Hu (2016) and has slightly higher explanatory power (as measured by the R^2).

4.1 | Robustness checks

Country classification into 'North' and 'South' is not straightforward. So far, we classified 'emerging markets' or 'low income countries', as classified by the IMF, as 'South' and

[19]This seemingly contrasts with the main conclusion of Braconier et al. (2005). Note, however, that their sample almost exclusively covers high-income OECD countries and their support for the KK model is not robust to the critique of Blonigen et al. (2003) concerning the empirical specification. They reconcile this lack of robustness with the KK model by referring to the fact that their prediction for the vertical part of the KK model is out of their high-income sample. This highlights why inclusion of lower-income countries is important to obtain direct evidence on the vertical part of the KK model.

[20]$\hat{\delta}_{11}$ turns positive in the augmented heterogeneous gravity model but is not statistically different from 0 in either specification. If cultural and financial aspects are omitted, which drastically increases the sample size, δ_{11} is estimated to be smaller than 0 but larger than δ_{12} in absolute size, suggesting that FDI decreases with institutional distance, no matter if the host country has higher institutional quality or not (columns 5 and 6 of Table S10). Both parameters lie within ± 1.96 standard errors of each other and hence cannot be distinguished in absolute magnitude from a statistical perspective.

considered the remaining countries as 'North'. Given the role that potential parameter heterogeneity plays in our analysis, we also consider an alternative classification, noting that there is no clear 'best practice' on country classification. In our alternative classification, we only consider countries as 'North' if they surpass the World Bank's high income threshold for 2012 (GNI p.c. equal or above 12,616 US-$) and are a member of the OECD. This alternative classification reflects the idea that countries may achieve high-income levels but operate under different institutional environments, such that they should not be considered as part of 'North'. The results from this alternative classification, which are reported in Table S3, show slight quantitative changes for some market size variables (including surrounding market potential) but do not alter our conclusions.

For the gravity model to be more aligned to estimation standards in the trade literature, we also provide results including multilateral resistance terms (i.e. source-year and host-year fixed effects) in Table S4 and source-host pair fixed effects (together with year fixed effects) in Table S5. The addition of those fixed effects generally improves the precision of those estimates which are not eliminated by the additional fixed effects. Otherwise, they are mostly in line with our baseline results, despite some minor qualitative differences (such as a larger negative coefficient for the relative skill difference in the MRT specification). The key differences worth noticing arise in the model with source-host pair fixed effects, where the sum of GDPs now also turns negative for South–North FDI and, more importantly, the surrounding market potential coefficient turns mostly negative and insignificant (except for South–North FDI). Together with the above finding that parameters of surrounding market potential change if 'North' requires OECD ownership, this calls for more thorough analysis of surrounding market potential in future research.[21]

We further considered replacing negative values (which are dropped in PPML estimation) with zeros in another robustness check since one may argue that those observations rather resemble a 'true zero' observation than typical characteristics of a missing. However, we carefully checked these 6744 negative observations and for the most relevant of them it is not meaningful to consider them as zeros. For example, among the 3532 observations that had all necessary covariables available to be included in our estimation, the 10 most negative FDI positions are from the United States in Belgium (5), from Ireland in Belgium (4) and from Brazil in Switzerland (1). From the 100 most negative of those 3532 observations, the most frequent host countries are Belgium (in 61 cases), Switzerland (8) and the Netherlands (6), while high-income countries are also the most relevant source countries for those observations. Hence, a key part of those negative observations is most likely due to peculiar financing and tax-optimisation considerations that can hardly be considered as a zero observation. We also refrained from further addressing missing values, given the fact that our data set is much more comprehensive than those used in previous studies and since there is no straightforward solution to address missing data in our setting. Moreover, the issue of missing observations concerns the KK and gravity model similarly, which allows for consistent model selection in the following section.

[21]Possible explanations are agglomeration economies and associated regional clustering and production sharing (e.g., Alfaro & Chen, 2014). For example, high surrounding market potential may correlate with countries being located in Europe (and associated non-geographical market proximity, e.g. in terms of institutions and infrastructure). The host-source pair fixed effect may then capture this intra-regional FDI agglomeration which is otherwise captured by surrounding market potential. Also notice changes in sample size in Table S5. Spatial processes are often prone to sampling issues (Conley, 2008) and differences in spatial FDI motives for OECD vs. non-OECD countries are also found in Blonigen et al. (2007, 4.2.1).

5 | CROSS-VALIDATION

A key goal of our paper is to assess the performance of key theories in explaining the empirical distribution of FDI positions. This requires analysing 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 data set 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 per cent of the original observations.[22]
2. Use this 'estimation sample' to estimate the parameters for each candidate model.
3. Apply the estimated parameters to predict $\widehat{FDIstock}_{sht}$ for each candidate model in the remaining 10 per cent of observations that are not part of the estimation sample (the 'calibration sample').
4. For each model and calibration observation, calculate the residual

$$\hat{\varepsilon}_{sht} \equiv FDIstock_{sht} - \widehat{FDIstock}_{sht} \tag{5}$$

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

$$MAD \equiv \frac{1}{N_c} \sum_{i}^{N_c} |\hat{\varepsilon}_i|, \tag{6}$$

where $i = 1, \ldots, N_c$ are all s, h, tcombinations 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). Of these 8 models evaluated, the 'best performing' gravity and KK model (with the lowest average MAD) proceed to a second stage.

In the second stage, the two 'best performing' models from the first step are augmented with the following variables, respectively:[23]

A Institutions
B Financial development, exchange rate, & FX regime, corporate tax rate
C A & B
D A, B, ComColoniser, ComLanguage, & Col45
E D & Hofstede cultural distance (smallest sample)

[22]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.

[23]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).

At both stages, we compare the model performance relative to a 'fixed effect only' model, which only includes separate source, host and time fixed effects as well as the country-pair identifiers for outliers. Moreover, given the emphasis on institutional distance in FDI research, we compare the models in the second stage to a 'institutions only' model, which includes $InstDist, 1(InstDist)_{h>s,t} \times InstDist, ComLang, ComCol, \; Col45$,and the 'FE only' parameters.

Table 3 and Figure 5 summarise the results from the first stage. Looking at Figure 5, 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 5, we see that the heterogeneous gravity model (with and without SMP) and all variants of the KK model perform equally well

TABLE 3 Cross validation results (1st stage)

	MAD	SD(MAD)	RMAD
FE only	1523	127	100.0%
KK homo (w/o SMP)	1167	96	76.7%
KK homo (w/ SMP)	1171	97	76.9%
KK hetero (w/o SMP)	1140	91	74.9%
KK hetero (w/ SMP)	1144	91	75.1%
Gravity homo (w/o SMP)	1248	99	82.0%
Gravity homo (w/ SMP)	1249	100	82.0%
Gravity hetero (w/o SMP)	1140	89	74.8%
Gravity hetero (w/ SMP)	1137	88	74.7%

Note: 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 × 57,687.

RMAD is MAD relative to 'FE only' model.

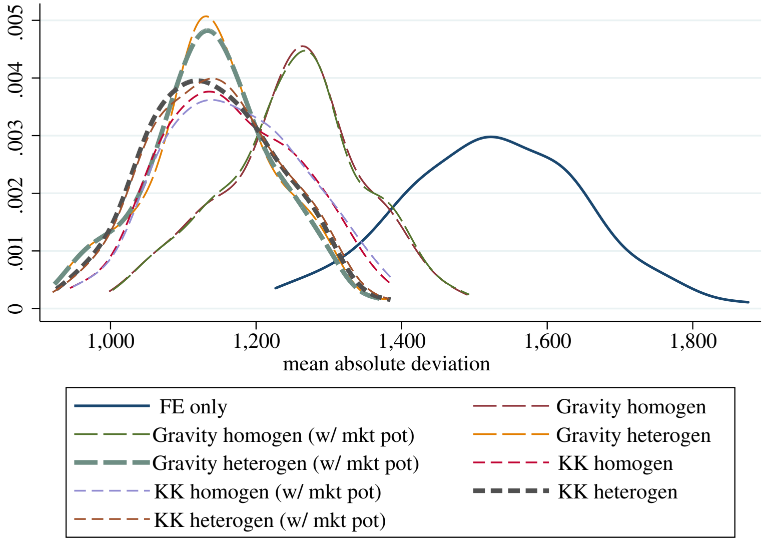

FIGURE 5 Distribution of mean absolute deviation (MAD) across models (1st stage) [Colour figure can be viewed at wileyonlinelibrary.com]

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 with a pure fixed effect model with 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 1137 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.

Table 4 and Figure 6 summarise 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 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

TABLE 4 Cross validation results (2nd stage)

	MAD	SD(MAD)	RMAD
FE only	2972	253	100.0%
KK hetero	2318	199	78.0%
KK hetero A	2311	197	77.8%
KK hetero B	2286	198	76.9%
KK hetero C	2281	196	76.7%
KK hetero D	2240	189	75.4%
KK hetero E	2240	186	75.4%
Gravity hetero SMP	2322	195	78.1%
Gravity hetero SMP A	2323	195	78.2%
Gravity hetero SMP B	2303	193	77.5%
Gravity hetero SMP C	2297	193	77.3%
Gravity hetero SMP D	2263	195	76.2%
Gravity hetero SMP E	2245	188	75.5%
Institutions only	2783	224	93.6%

Note: 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 × 21,596.

RMAD is MAD relative to 'FE only' model.

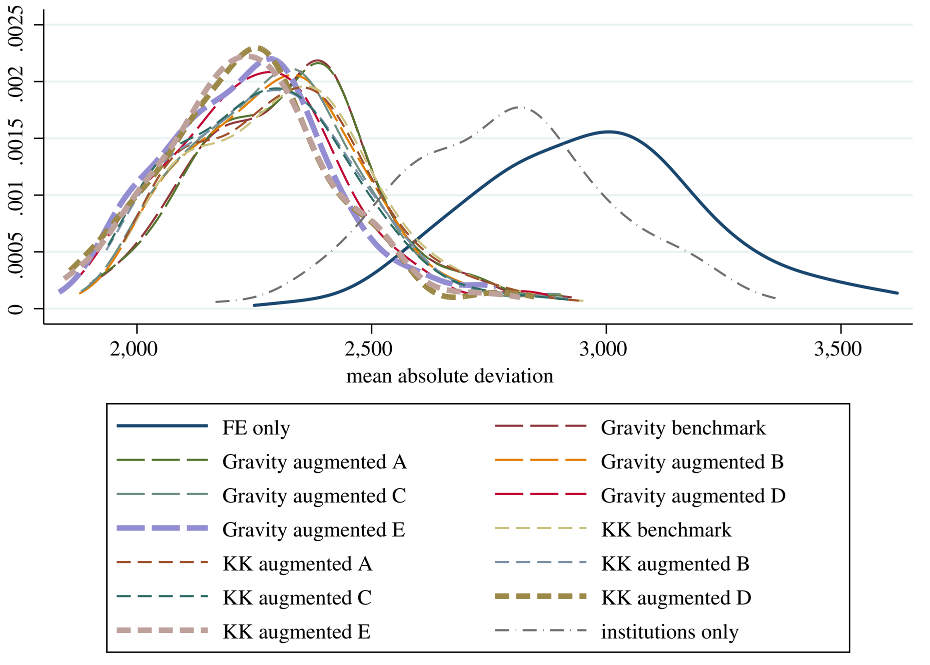

FIGURE 6 Distribution of mean absolute deviation (MAD) across models (2nd stage) [Colour figure can be viewed at wileyonlinelibrary.com]

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).

Overall, our cross-validation results suggest that out-of-sample predictive performance of most KK and heterogeneous gravity models is similar and significantly better than a 'FE only' model that merely summarises mean FDI flows by source and host (plus a global non-linear time trend and outliers). They also highlight the need for some degree of parameter heterogeneity across countries in the gravity model for FDI. We also found during our analysis that excluding fixed effects from predictions (but absorbing them in estimation) leads to much worse predictive performance for all gravity models but not so much for the KK model.[24] This aligns with the intuition of the KK model that FDI may be driven by complex interactions in country and factor differences or may simply reflect the flexibility of those interactions to capture source and host country peculiarities. While the inclusion of such complex interactions may hence provide an appealing alternative to ad-hoc or data-driven heterogeneity (including the intercept fixed effects), our overall results clearly suggest that the functional form of the KK model does not provide a convincing economic rationale for them.

[24]This result, which is not reported in the paper, is based on absorbing fixed effects with the 'ppmlhdfe' command but not using them for prediction.

5.1 | Alternative 'North'–'South' classification and sample

We also considered the alternative classification of countries into 'North' and 'South' (see section 4.1) for our second-stage cross-validation exercise to see if this affected relative performance of out-of-sample prediction. Results are presented in Table S6 and show very similar results, with the the heterogeneous KK model D and E and the heterogeneous gravity model E (including SMP) performing best (and with MADs almost identical to the above benchmark cross validation). This confirms that our main conclusions are not driven by country classification. At the same time, future research may elaborate on optimal classification in the context of heterogeneity of FDI motives, building on the dynamic econometric literature on group heterogeneity and clustering algorithms (e.g. Bester & Hansen, 2016; Su et al., 2016).

Another concern is the considerable drop in sample size to 21,596 observations in the second stage of our cross validation exercise, which is mostly driven by low availability of the cultural variables from Hofstede et al. (2010) in model E. We hence re-calibrate our sample to those 35,889 observations where all variables in models A–D are available and run the second stage cross validation for those models. Results are reported in Table S7 and show a familiar picture, with the heterogeneous gravity model D (including SMP) now obtaining a slightly lower RMAD (73.7%) than the best KK model D (74.1%).

6 | CONCLUSION

In this paper, we use a previously un(der)used bilateral data set 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, provided that 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 future empirical assessments of potential determinants of bilateral FDI positions. From a theoretical perspective, our finding of vertical and horizontal FDI motives in different 'North'–'South' combinations, reflected in parameter heterogeneity, highlight the need to nest both motives in a joint model. Such bilateral econometric models for FDI would particularly benefit from theoretical extensions on how to incorporate and interpret multilateral resistance terms in a theory-consistent manner, such that they reflect trade-substituting horizontal and trade-complementing vertical FDI and export-platform motives. While the KK model theoretically combines horizontal and vertical FDI motives in a 'North'–'South' setting, our results suggest that its functional form seems inappropriate to describe those motives in the comprehensive data set we studied.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are derived from public domain resources as referenced in our paper. Data are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

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APPENDIX A

Countries in the sample (* *indicates countries classified as 'South' in the baseline classification; a indicates that country only appears as source country, not as host*): Albania *, Algeria*, Argentina*, Armenia*, Australia, Austria, Bahrain*, Bangladesh*, Belgium, Benin*, Bolivia*, Botswana*, Brazil*, Bulgaria*, Burundi*, Cambodia*, Cameroon*, Canada, Central African Republic*, Chile*, China P.R.: Hong Kong, China P.R.: Mainland*, Colombia*, Congo Republic of*, Costa Rica*, Cote d'Ivoire*, Croatia*, Czech Republic, Denmark, Dominican Republic*, Ecuador*, Egypt*, El Salvador*, Estonia, Finland, France, Gabon*, Gambia*, Germany, Ghana*, Greece, Guatemala*, Haiti*, Honduras*, Hungary*, India*, Indonesia*, Iran Islamic Republic of*, Iraqa, Ireland, Israel, Italy, Jamaica*, Japan, Jordan*, Kazakhstan*, Kenya*, Korea Republic of, Kuwait*, Kyrgyz Republic*, Lao People's Democratic Republic*, Latvia, Lesotho*, Liberia*, Lithuania, Malawi*, Malaysia*, Mali*, Mauritania*, Mauritius*, Mexico*, Moldova*, Mongolia*, Morocco*, Mozambique*, Myanmar*, Namibia*, Nepal*, Netherlands, New Zealand, Nicaragua*, Niger*, Norway, Pakistan*, Panama*, Paraguay *, Peru *, Philippines*, Poland*, Portugal, Qatar*, Russian Federation*, Rwanda*, Saudi Arabia*, Senegal*, Sierra Leone*, Singapore, Slovak Republic, Slovenia, South Africa*, Spain, Sri Lanka*, Sudan*, Swaziland*, Sweden, Switzerland, Syrian Arab Republic*, Tajikistan*, Tanzania*, Thailand*, Togo*, Trinidad and Tobago*, Tunisia*, Turkey*, Uganda*, Ukraine*, United Arab Emirates*, United Kingdom, United States, Uruguay *, Venezuela*, Vietnam*, Yemen Republic of*, Zambia*, Zimbabwe.

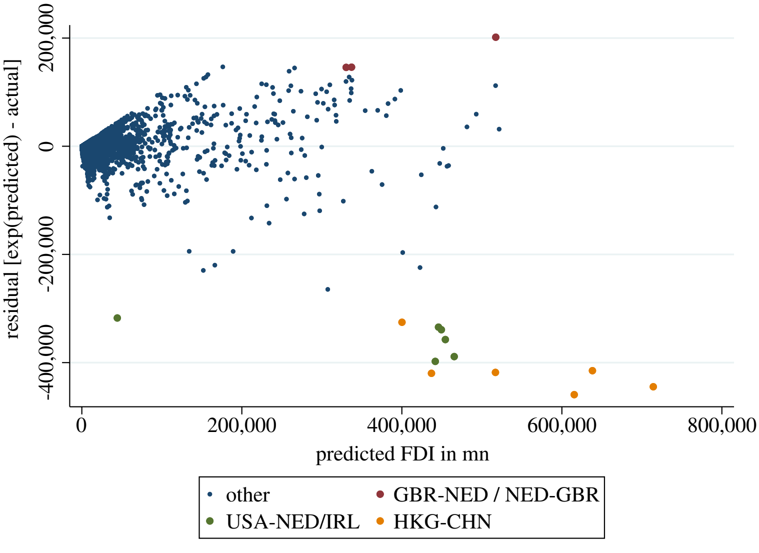

FIGURE A1 Outlier identification [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE A1 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)
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 PRS Group
Common coloniser (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

TABLE A1 (Continued)

Variable	Description	Source
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)
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 (2021)
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)

(Continues)

TABLE A2 Summary statistics

Variable	Obs.	Mean	SD	Min	Max
FDI stocks (in mn)	57,687	2152.9	20,064.6	0.0	1,158,873
GDP	57,687	977,523.3	2,409,277	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	19,648.5
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	22,577.1	9841.4	6.3	58,628.0
Institutional distance	48,977	1.7	1.1	0.1	875.149
Common coloniser	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	33,468.9
Exchange rate source	57,687	507.6	2313.0	0.3	33,468.9
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