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VARIABLE SELECTION USING BAYESIAN STATISTICAL

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Determinants of German outward FDI: variable selection using Bayesian statistical techniques*

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Abstract

This paper provides new evidence on the drivers of German outward foreign direct investment (FDI) stocks for the period 1996-2012. In contrast to previous empirical studies, we adopt a Bayesian model averaging (BMA) approach for a robust selection of those variables. We find evidence that determinants that are associated with horizontal FDI appear to be dominant for explaining bilateral FDI with developed countries while for the group of developing countries covariates associated with vertical FDI motives play a larger role. Within Europe, while the majority of FDI is horizontally driven in "core" countries, for peripheral ones the vertical motivation for FDI seems to prevail. Moreover, our results are compatible with more complex FDI models where vertical determinants and institutional variables are gaining prominence, in parallel with the development of global value chains (GVC). Our results can provide hints for policy-makers' strategies to attract German investment.

Keywords: FDI determinants; Outward Foreign Direct Investment; Germany; Bayesian Model Averaging; Variable selection
JEL classification: F21, F23, C11, C52

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1. Introduction and motivation

German direct investment abroad has increased significantly over the last decades. In 2016, Germany ranked the third largest investor among developed economies measured by FDI stock, only behind the United States and the United Kingdom (UNCTAD (2018)). In comparison with other OECD countries, Germany shows a clear and persistent outward orientation. Indeed, Germany's accumulated outward investment (equivalent to 40% of GDP in 2015) was much larger than its inward stock (23% of GDP in 2015) (OECD (2017)).

The substantial increase in direct investment of German enterprises abroad has developed largely in parallel with international trade, both intra European Union (EU hereafter) and with third countries. Therefore, the relationship between trade and FDI has become increasingly complex, giving rise to a conundrum with intricate issues. Trade-FDI linkages have been of continued interest in the empirical literature, where the recent results generally point to a complementarity relationship between trade and FDI, challenging to some extent the assumptions of the neoclassical trade model (see Camarero and Tamarit (2004) and Camarero et al. (2018)). However, some studies have identified a substitution relationship between exports and outward FDI for Germany (see Egger and Pfaffermayr (2004) and Mitze et al. (2010)). Surveying several empirical contributions, Yang and Mallick (2014) show in a recent meta-paper the key role played by the returns to FDI to explain the relationship between multinationality and exporting, which is in line with the current outbreak of the Global Value Chains (GVC) and the internationalization of production.

Indeed, Germany's global investment and its engagement in international trade are closely linked to its participation in the international production networks. There appears to be three interconnected production hubs of GVCs in the world: North America (especially the United States as core country), East Asia (i.e. China, Japan and the Republic of Korea) and Europe (centered in Germany)(World Bank Group et al. (2017)). In particular, three German key industries— motor vehicles, machinery and equipment and chemicals— drive Germany's integration in complex international production networks through sourcing of intermediates from abroad (often from Central European Countries). In contrast, Germany's participation in services GVCs is driven by downstream links and the use of German intermediates in the exports of other countries (OECD (2017)).

Despite Germany's participation in GVCs, outward foreign direct investment (OFDI) of German firms is mainly concentrated in OECD countries with a special emphasis within the European Union (EU). Around 87% of the value of OFDI from Germany was held in de-

veloped countries at the end of 2012 and the EU accounted for more than half of the overall stocks. The distribution of the stock of German OFDI by regions of destination is shown in Figure 1. One striking feature of German OFDI is the continuos upward trend since the mid-1990s. This growth is explained mainly by the process of world globalization, the liberalization of Eastern Europe in the 1990s and the progress of EU integration. Indeed, the European Monetary Union and the introduction of the Euro in 1999 increased sharply German OFDI. Whereas the Euro area is the largest regional location for German MNEs (as it accounts for 35% of the stock in 2012), non-euro area countries accumulated only 19%. Concerning other developed countries, the United States is the largest recipient, followed by Switzerland. By contrast, OFDI in developing countries has so far not been a significant target of German MNEs activities, with the recent exception of China. Within the European Union, German OFDI distribution displays a core-periphery pattern, as shown in Figure 2 . The "core" accounts for 68% of Germany's total EU investment. Specifically, France, the UK and the Benelux are the most important destinations throughout the period shown. The South and North Periphery are also important locations for MNEs whereas Eastern European countries occupied a less prominent position. A possible explanation for this difference is that German FDI increased once the latter countries joined the EU in 2004; before then, the amount of FDI was negligible. These stylized facts raise the question of whether German MNEs have different internationalization strategies depending on the regions or areas where they operate and whether they have changed over time. Additionally, finding the robust determinants of German OFDI can provide hints for other countries to develop policy strategies helping to attract German investment.

The interest of the present study lies in two main considerations. First, the relative scarcity of studies analyzing German FDI determinants in spite of its relevance as a worldwide investor. Some exceptions are Buch et al. (2003), Egger and Pfaffermayr (2004) and Antonakakis and Tondl (2015). Buch et al. (2003) examines firm-level data to describe regional and sectoral patterns of FDI. Egger and Pfaffermayr (2004) analyzes the effects of distance as a common determinant of exports and FDI in a three-factor New Trade Theory model. Antonakakis and Tondl (2015) conduct a comparative study to examine the determinants of outward FDI from four major OECD investors (the US, Germany, France, and the Netherlands) applying a Bayesian Model Averaging (BMA) approach. They constrain the analysis to developing countries as FDI destinations.[1]

[1]Although they also study the German case, we differ from them in three main respects: first, we focus on

As for the second consideration justifying the interest of the present study is that, although the literature provides a vast amount of applied research on FDI location, its main determinants are still poorly understood.[2] The reason for this is the uncertainty and ambiguity surrounding both theories and empirical approaches to FDI. Traditionally, empirical studies have controlled for the factors considered more explanatory according to certain theories usually using an *ad hoc* approach. If this is the case, the selection of variables can lack statistical motivation and disregard potentially important covariates. Moreover, a theoretical economic variable can be measured, in applied work, using different definitions. The way we discriminate among potential covariates is indeed a relevant question, as it can substantially affect the estimation results and possibly lead to multicollinearity and omitted variable problems (Blonigen (2005)). As Eicher et al. (2012) stated, numerous empirical studies estimate only subsets of particular FDI theories to produce results that are often either inconclusive or outright contradictory. When model uncertainty is not addressed comprehensively as part of the empirical strategy, traditional robustness analyses overstate significance levels and confidence intervals. Therefore, for statisticians it is clear that we need robust statistical methods to select variables and discriminate among them.

The literature that deals with model uncertainty when there is little guidance from economic theory regarding which explanatory variables to consider goes back to Raftery (1995). Each model is defined by the specific subset of variables it includes and is treated as an unknown parameter that lies in the set of models entertained (the model space). Bayesian inference offers the tools to attach probabilities to the different possible models. Raftery (1995) showed that when there are many candidate independent variables, standard model selection criteria based on p-values can be misleading and he promoted the use of Bayesian inference to take into account model uncertainty explicitly. There is a steadily increasing bulk of empirical studies making use of the BMA methodology to address the identification of robust determinants in different contexts (see, among others, Man (2015), Ng et al. (2016), Wei and Cao (2017), Pham (2017) and Desbordes et al. (2018)). The uncertainty surrounding FDI modelling makes the BMA methodology especially suited to discriminate among the large set of candidate regressors that has been posited as possible

one single investor (Germany) and consider different destination country-groups (not only developing ones) with a geographical breakdown; second, we consider a wider set of FDI potential determinants and the most recent period available for bilateral FDI stock data, and third, we apply a different Markov Chain Monte Carlo (MCMC) method in the BMA analysis.

[2]See Blonigen (2005), Faeth (2009) and Assunçao et al. (2011) for a thorough literature review on FDI determinants.

FDI determinants by different theories. Chakrabarti (2001) was the first to put forward this uncertainty in FDI studies using Extreme Bound Analysis. More recently, Blonigen and Piger (2014) and Eicher et al. (2012) use a BMA approach to account for model uncertainty in FDI and show that the robust FDI specification is a more parsimonious one than that previously suggested in the literature. Similarly, we do not condition our study of German OFDI on a single model and instead attach probabilities to different models and thereby identify, in a robust manner, the determinants of FDI.

The aim of this paper is to use robust statistical techniques to select the main determinants of German outward FDI. To this end, we apply a probabilistic model to select the explanatory variables from a large group of potential candidates. However, given the worldwide distribution of German FDI stocks and taking into account the heterogeneity of the destinations, trying to find a general specification would be probably incorrect. Instead, we consider different country-groups taking into account German OFDI distribution. First, we distinguish between developed and developing recipient countries. Then, within developing countries, we distinguish between Latin American and Asian countries. Finally, we focus on FDI allocation within Europe and separate "core" and peripheral countries. Our aim is to shed some light on whether German internationalization strategies differ depending on the characteristics of the countries where they operate. In our case we apply the methodological approach proposed by Bayarri et al. (2012), among others, that was made available in a user-friendly R package developed by García-Donato and Forte (2015) and applied in Camarero et al. (2015) to the case of energy consumption and growth. In the present study, we adopt a BMA approach to select the main determinants of the stock of German OFDI covering the most recent period available for FDI stock data—1996 to 2012—and take into account the heterogeneity of the destinations of German FDI. Although this variable selection exercise is relevant by itself, we also provide some inference for the estimated coefficients of the models considered.

Our analysis shows that robust specification of German OFDI drivers is more parsimonious that previously suggested by the literature. Although the determinants identified highlight that the decision to invest abroad is based on a mixture of FDI theories, we can infer from the results that German investment decisions differ significantly across regions. In particular, we find evidence that determinants that are associated with horizontal FDI motives appear to be dominant for explaining bilateral FDI with developed countries while for the group of developing countries determinants associated with vertical FDI motives

play a larger role. Regarding European Union countries, we find evidence pointing to the benefits associated with the proximity to large euro area markets for "core" countries, while for peripheral countries the determinants identified are mostly associated with vertical FDI motives. Finally, we find some evidence of the relevance of world GVC to explain the FDI determinants in the different areas, from classical horizontal gravity variables, to more complex relationships that include vertical determinants and institutional variables.

The reminder of the paper is organized as follows: in Section 2 we briefly review the main theoretical approaches to FDI determination, with an emphasis in the formulated hypotheses and their differences; Section 3 presents the empirical literature on FDI classified according to the theories described in the previous section, with the purpose of completing the list of potential groups of explanatory variables; we provide a summary of the BMA methodology in Section 4, whereas Section 5 describes the data together with the results; finally, Section 6 concludes.

2. A Brief Literature Review

As we have already mentioned in the Introduction, there is remarkably little consensus on which variables are the most salient in explaining bilateral FDI patterns. In this section we provide a brief survey of the existing FDI theories, the hypotheses formulated and the variables that are most frequently proposed as FDI determinants. We will use the same classification of the theoretical literature proposed in this section to review the empirical work in Section 3 with the purpose of composing a wide set of potential explanatory variables for FDI.

Traditional trade economics, ownership advantages and internalization theory were brought together by Dunning (1977, 1979) who created the well-known OLI framework.

“OLI" stands for Ownership, Location and Internalization advantages, which are three types of special advantages that multinational enterprises (MNEs) have. *Ownership advantages* concern the importance of a MNE owning firm-specific assets which allow it to overcome the costs of operating in a foreign country. Examples include both tangible and intangible assets, such as pioneering technology, specific know-how and management skills. *Locational advantages* refer to all those factors a specific location owns that make it eligible for a MNE. Finally, *Internalization advantages* refer to those kinds of advantages that make more profitable for a firm to carry out transactions internally (i.e.through a wholly-owned subsidiary) rather than other entry modes such as exports, through licensing or

joint-venture agreements. Focusing on locational advantages, the relevant to invest and produce abroad, Dunning (2000) distinguishes between four main motives for FDI: market seeking, resource seeking, efficiency seeking and strategic assets seeking. Market seeking motives correspond to FDI aiming at supplying the local market or markets in adjacent territories. The host market size, its per capita income and consumer demand (all of them to take advantage of the economies of scale) are the main reasons behind market seeking FDI. Resource seeking companies are those investing abroad in order to obtain cheap natural resources and/or unskilled labour. Hence, locational decisions depend on factor endowments differences. Efficiency seeking investment is designed to promote a more efficient division of labor or specialization of assets by MNEs. Finally, strategic asset seeking FDI searches for resources such as technology, skilled workers and assets that can support development of a firm's worldwide and weaken the competitive position of its competitors.

An alternative framework for analyzing FDI arose in the mid-80s with the New Trade Theory which incorporated multinational firms into the general equilibrium trade models. This theory explained the existence of two types of FDI, namely horizontal (market-oriented) and vertical (export-oriented) FDI. The early formal FDI theory put forward byHorstmann and Markusen (1987) shows that MNEs undertaking horizontal FDI (HFDI) face the trade-off between maximizing proximity to customers and concentrating production to achieve scale economies. This is what Brainard (1997) called the proximity-concentration hypothesis.

On the other hand, Helpman (1984, 1985)) showed that countries' differences in relative factor endowments (the so-called factor-proportions hypothesis) explained vertical FDI (VFDI). Thus, the decision of firms to engage in HFDI would be driven by the size and growth of the host country whereas VFDI seeks for cost competitiveness and other factors such as institutions and infrastructure in the host country.

Combining these two motivations for FDI, Ethier and Markusen (1996) and Markusen and Maskus (2002) formulated the *knowledge-capital model*. According to this theory, similarities in market size, factor endowments and transport costs are determinants of HFDI, while differences in relative factor endowments determine VFDI. The *knowledge-capital model* has recently been extended to explain other forms of FDI such as export-platform FDI (see Ekholm et al. (2007); Bergstrand and Egger (2007)) which is used to serve the neighboring markets of the host country. These studies highlight the importance of considering regional trade agreements in the empirical approach. Additionally, Bergstrand and Eg-

ger (2007) and Head and Ries (2008) provide theoretical foundations that motivate the use of gravity equations to analyze FDI patterns. The gravity model states that the closer two countries are (geographically, economically and culturally) the higher will be the FDI activity between them. Thus, geographical location and the size of the country are considered, according to this approach, the main explanatory variables. Kleinert and Toubal (2010) provide the theoretical underpinnings of the gravity equation applied to the analysis of Foreign Affiliate Sales (FAS) showing that gravity equations can be used to discriminate between different theoretical approaches, namely, two proximity-concentration models of HFDI with homogenous (Brainard (1997)) or heterogenous firms (Helpman et al. (2004)) and a two-country factor proportions model of fragmentation that explains VFDI and based on Venables (1999).

Heterogenous firms also explain the behavior of an additional type of MNEs, that is, diversified MNEs. According to the risk diversification hypothesis, firms that are assumed to be risk averse, try to spread business risk. Moreover, based on the heterogenous-firm trade theory of Helpman et al. (2004), there have been extensions to explain how these firms expand into overseas markets either through exports or FDI. According to this approach, firms which invest in foreign markets are more productive. Hence, greater productivity and heterogeneity lead to more FDI sales relative to export sales. MNEs can shift investments between home and host countries when they are faced with changes in the macroeconomic conditions of the domestic or foreign country. Determinants suggested by this theory are, for instance, interest rates, inflation rates or exchange rates. Overseas production can therefore be a substitute for exporting (see Lankhuizen et al. (2011)). Since Helpman et al. (2004), a large body of literature has arisen focusing not only on which parent firms will choose to engage in FDI but also which domestic firms are acquired. Guadalupe et al. (2012) shows that the most productive firms ex-ante will be acquired by MNEs and this increases productivity (i.e. innovation) and exports. Higher productivity levels are mainly due to the fact that acquired firms can benefit from the access to the global market through exporting to their parent firm.

Finally, the institutional approach highlights the important role played by policy variables (such as corruption, corporate tax rates, tax concessions but also the degree of political rights and civil liberties) together with other fiscal and financial investment incentives on attracting FDI. Making a decision about investment in a foreign country requires a multidimensional evaluation. Accordingly, the expectation of earning profit in the country where

investment takes place is determined by economic, social and political factors which make FDI a complex issue. In the literature that examines the institutional quality and FDI relationship, from a theoretical point of view, it is commonly accepted that low institutional quality will negatively affect the investment choices by creating a risk factor (i. ex. bribes, low law enforceability, rent-seeking activities...). However, the opposite can also occur, as corruption can speed up bureaucratic processes or gain access to publicly funded projects (see Egger and Winner (2005)). As we can see in the next Section, this question, that is mainly empirical, is far from being solved.

All in all, the various theories on FDI set out a large number of potential FDI determinants. However, the FDI literature does not have a consensus established model (Blonigen (2005)). In light of this, the presence of model uncertainty can be considered a major econometric problem that should be solved prior to specifying a model and estimating meaningful long-run relationships.

3. Survey of the empirical literature

In this Section, we review the empirical literature to single out the different variables that have been included in the models of previous studies depending on the theoretical approach followed. This will help us to choose the prospective variables and bundle them in different groups. Given the absence of an established theoretical framework to model FDI patterns, the common practice in empirical studies has been to focus on a particular variable or a set of variables of interest to explain a certain theory. This approach leads to an omitted variable bias problem (Blonigen (2005)) and to use determinants that are not robust across alternative specifications and theories. According to the mainstream theoretical approaches described above, this section presents a brief empirical literature review and outlines the variables identified in the major FDI studies and their statistical relationships with FDI. Following Assunçao et al. (2011), we focus on quality of infrastructure in the OLI paradigm as the other determinants that could be included in this theory are the focus of other theoretical approaches (Institutional approach and New Trade Theory) developed afterwards.

3.1. The OLI paradigm

A good quality of infrastructure—often considered an indicator of agglomeration effects—is found to increase potential returns to investment and hence can attract FDI inflows. However, the results concerning their significance are not conclusive neither the choice of the variables used to proxy for the quality of infrastructure distinguishing between physical, financial, and technological infrastructure. Percentage of roads paved and railway networks are often used in the literature as proxies for physical infrastructure. Agiomirgianakis et al. (2003) included these variables in a longitudinal analysis for the first time and found no effect on roads and a positive effect for railway network. These variables can also signal the level of development and the population distribution of the host country. In principle, an extensive network promotes trade within the country and helps a foreign investor to gain access to separate or different markets at the lowest cost. Di Giovanni (2005) and Stein and Daude (2007) use telephone calls as a proxy and found that this variable has a significant and positive effect on FDI. Using the number of internet connections as a proxy, Botric and Skuflic (2006) concluded that the relationship between infrastructure and FDI is negative. This striking result may be explained because internet only became widespread in these countries after 2000. Some studies, such as Demekas et al. (2007), use an Infrastructure index as a proxy and found a positive impact on FDI.

3.2. Institutional approach

The quality of institutions is viewed as a crucial location advantage for MNEs in the recent literature. Good institutions are supposed to promote a healthy investment climate through protection of property rights, political stability and weaken corruption. However, estimating the magnitude of the effect of institutions on FDI is difficult because the quality of institutions is difficult to measure (Blonigen (2005)). Thus, empirical studies often provide mixed results. Some studies have used corruption as a measure of political risk. The early study of Wheeler and Mody (1992) used the first principal component of 13 risk factors as a proxy for good institutions, and find no evidence of a significant positive relationship between good quality of institutions and location of US foreign affiliates.[3] On the contrary, Wei (2000) uses bilateral data on FDI stocks to test the effect of corruption on FDI and finds support for a negative relationship between weak institutions and FDI. Specifically,

[3]Risk factors included indices of political stability, inequality, corruption, red tape, quality of the legal system, cultural compatibility, attitude toward foreign capital, and general expatriate comfort.

Wei (2000) shows that a rise in the level of corruption in the host country reduces inward FDI. However, studies such as Egger and Winner (2005) and Adam and Filippaios (2007) found that corruption has a positive impact on FDI, whilst Harms and Ursprung (2002) and Busse and Hefeker (2007) confirm Wei (2000) results in that MNEs are rather attracted by countries in which civil and political freedom is respected. In line with these studies, Asiedu (2006) provides evidence that not only corruption but also political instability deter FDI. Financial institutions also seem to play a significant role on FDI. Di Giovanni (2005) found that the size of financial markets, as measured by the stock market capitalization to GDP ratio, has a strong positive association with domestic firms investing abroad. A number of studies focus on the different dimensions of governance that can affect the investment decisions of MNEs. Governance infrastructure is usually measured by the six governance indicators estimated by Kaufmann et al. (1999).[4] Empirical evidence confirms that the quality of institutions has positive effects on FDI. However, other studies show that the impact of institutions depends on the specific dimension considered. According to Daude and Stein (2007), Regulatory Quality and Government Effectiveness have a positive and significant impact on the volume of FDI while Voice and Accountability, Political Stability, Rule of Law and Control of Corruption do not. Globerman and Shapiro (2002) shows that good governance impacts positively both FDI inflows and outflows. In the same line, Bénassy-Quéré et al. (2007), relying on a gravity model for bilateral FDI stocks, shows that institutional distance tends to reduce bilateral FDI. More recently, Blonigen and Piger (2014), applying a Bayesian approach to variable selection, find no robust evidence on the role of institutions in bilateral FDI.

3.3. New Trade Theory

The New Trade Theory has proposed a number of key FDI determinants for the different motivations of overseas investment. In terms of HFDI (market seeking), the most important factor is the size and growth of the host country (Horstmann and Markusen (1987), Brainard (1997)). Empirical studies show that market size, usually proxied by GDP or GDP per capita, have a significant positive influence on FDI (Eaton and Tamura (1994), Carr et al. (2001), Chakrabarti (2001), Bergstrand and Egger (2007), Head and Ries (2008)). Indeed, it is considered the most robust FDI determinant in empirical studies. Trade open-

[4]The six governance indicators are: Voice and Accountability, Political Stability and Lack of Violence, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption. In all cases, larger values indicate better institutions.

ness has been other of the factors the New Trade Theory has focused its attention on. Trade openness is identified as a driver of export-platform FDI.[5] Indeed, a range of studies show a significant positive influence of openness (measured mostly by the ratio of exports plus imports to GDP) on FDI (Agiomirgianakis et al. (2003), Talamo (2007), Demekas et al. (2007)). However, the relationship between FDI and trade depends on the type of investment. The general prediction of the economic models is the existence of complementarity between trade and vertical FDI, while substitutability should prevail between trade and horizontal FDI (Markusen and Maskus (2002)). However, these results can be somewhat at odds with those found by Franco (2013), in the sense that market seeking FDI can positively influence export intensity, while resources-seeking or export platform types of FDI are not relevant in enhancing export intensity. Internationalization and firm performance can be jointly rationalized within the "new trade theory" and the "off-shoring of international firms" literature signaling that both country-level and firm-level factors can play a determinant role in the internationalization strategies followed by firms. In a recent paper, Yang and Mallick (2014) uncover the impact of several macroeconomic and firm-specific factors explaining the variation in the learning effect across studies beyond the self-selection effect. Overall, they find that the returns from outward FDI tend to reduce the learning effect.

The implementation of RTAs has also been considered to have an impact on FDI, due to its effect through trade liberalization. However, the empirical results are inconclusive. Some studies such as Bergstrand and Egger (2007) found a negative relationship between trade agreements and FDI, whilst others (for example Berger et al. (2013)) found a positive one. According to VFDI (resource seeking), resource endowments are one of the most important location factors for overseas investments. The reason is that resource-seeking investors want to gain access to locally available natural resources (such as raw materials) or that are available at a lower cost (such as cheaper unskilled labor (Dunning (1977, 1979, 2000))). The ratio of population to land area is often used in the literature to capture agglomeration effects, as confirmed by Eaton and Tamura (1994), that obtained a positive impact on FDI. At the same time, there are mixed results on the impact of country skill abundance on FDI. Some empirical studies used average years of schooling as a proxy for human capital and obtained a positive relationship (see, for instance, Eaton and Tamura (1994) and Razin and Sadka (2007)). The seminal work of Carr et al. (2001) uses a measure of skilled labour to total employment and also finds a positive sign.[6] However, this proxy

[5] See Ekholm et al. (2007) and Bergstrand and Egger (2007)

[6] Specifically, their measure is the percentage of total employment that is employed in categories 0/1 (pro-

has been questioned by Blonigen et al. (2003) because it is affected by the differences in statistics on skill classifications across countries. They propose instead using as a proxy for skilled labour the absolute difference in average years of schooling between source and host country and get opposite results. Finally, concerning the availability of natural resources, oil, for example, has been identified as an important factor for the decision of MNEs to invest in a particular market (Harms and Ursprung (2002), Asiedu et al. (2015)).

3.4. Other

Additional variables, difficult to classify, have also been included in empirical studies for FDI determination. Some of these studies, related to the international finance literature, find that host country economic and financial stability are relevant for FDI. Inflation, exchange rates and volatility of exchange rates are often used as proxies for financial stability. Empirical studies like Blonigen (1997) predict that exchange rate depreciation increases FDI inflows into the host country. A negative relationship is predicted, among others, by Di Giovanni (2005) whereas Cavallari and D'Addona (2013) finds no significant effect. Wei (2000) and Razin and Sadka (2007) argue that corporate tax rates are an important determinant of FDI, and provide evidence of a negative effect, whereas for Wheeler and Mody (1992), for example, this variable is not significant.

4. Econometric methodology

4.1. Bayesian Variable Selection

In Sections 2 and 3 we have argued that there is a lack of consensus in both, the theoretical and the empirical FDI literature, regarding the empirical specification and the potential covariates of bilateral FDI determination. This model uncertainty problem, where the entertained models differ in which explanatory variables, from a given set, should be included in order to explain the response, is known in statistics as *variable selection* problem. In this paper, we apply this methodology and focus on the variable selection problem in linear models.

fessional, technical, and kindred workers) and 2 (administrative workers).

More concisely, following Garcia-Donato and Forte (2018)

$$M_\gamma : y = \alpha 1_n + X_\gamma \beta_\gamma + \varepsilon, \qquad \varepsilon \sim N_n(0, \sigma^2 I) \tag{1}$$

where y is the n dimensional vector of observations for the response variable (i.e. German outward FDI); X_γ is the $n \times p_\gamma$ matrix of potential FDI determinants in X; β_γ is the vector of linear regressors and finally, ε is a white error noise. Following the traditionally specific notation for variable selection we use a p dimensional binary vector $\gamma = (\gamma_1, \ldots, \gamma_p)$ to identify the models. In Eq.1, each competing model M_γ for $\gamma = 0, \ldots, 2^p - 1$ relates the response variable y to a subset of p covariates. Considering p possible potential FDI determinants grouped in the $n \times p$ matrix $X = (x_1, ..., x_p)$, the variable selection problem has a model space of 2^p competing models. The set of all competing models is called the model space and is denoted as M.

In order to compare alternative models, the Bayesian variable selection problem is based on the posterior probability that M_γ is the true model that generated the data. The posterior probability is formally defined by the Bayes theorem:

$$Pr(M_\gamma \mid \mathrm{y}) = \frac{m_\gamma(y)\, Pr(M_\gamma)}{\sum_\gamma m_\gamma(y) Pr(M_\gamma)} \tag{2}$$

where $Pr(M_\gamma)$ is the researcher's prior probability that M_γ is the true model and m_γ is the integrated likelihood with respect to the prior π_γ:

$$m_\gamma(y) = \int f_\gamma(y \mid \beta_\gamma, \alpha, \sigma)\, \pi_\gamma(\beta_\gamma, \alpha, \sigma^2)\, d\beta_\gamma\, d\alpha\, d\sigma^2, \tag{3}$$

In Eq.3, π_γ is the prior distribution for the model-specific parameters of M_γ and the most controversial element in the BMA analysis.

The posterior probability in Eq.2 is the end product of the Bayesian approach and shows how the model probability is distributed across different specifications of the FDI drivers.

In order to summarize the information contained in the posterior distribution, we will make use of the inclusion probabilities for each competing variable.

$$p(x_\gamma \mid y) = \sum_{\{M_l:\, x_\gamma \in M_l\}} P(M_l \mid y), \quad \gamma = 1, 2, \ldots p \tag{4}$$

The inclusion probabilities should be interpreted as evidence (in a probabilistic scale) that x_γ explains the response variable. These probabilities are useful summaries of the posterior distribution and have interesting theoretical properties as shown in Barbieri and Berger (2004). Nevertheless, inclusion probabilities do not provide any information regarding the magnitude and sign of the coefficient β_γ. Such type of information can be obtained by averaging over all entertained models using the posterior probabilities in Eq.2 as weights. In the next section we report the model averaged estimated coefficients (namely, the posterior mean) alongside the inclusion probabilities. However, model averaged estimated coefficients should be interpreted with caution since, as highlighted by Garcia-Donato and Forte (2018), the simulations obtained from the model average estimation can be highly multimodal and thus providing default summaries of it (such as the mean or standard deviation) might be misleading. Thereby, as argued in Camarero et al. (2015), we will focus primarily on the inclusion of the probability for each variable from a large group of potential explanatory variables as the outcome of this methodology.

4.2. The Prior distribution

From a Bayesian perspective, the analysis of the posterior distribution provides the answer of the study under consideration. To obtain the posterior distribution in Eq.2 we need to determine the prior distributions for the parameters within each model π_γ and the prior distribution over the model space $Pr(M_\gamma)$. The choice of the prior will affect the posterior that we get. The subjectivity of this choice when $m_\gamma(y)$ can not be derived analytically given the large number of entertained models 2^p poses a significant challenge. In light of this, substantial research has been conducted on this topic. In this study, we will adopt the Robust prior for the regression parameters following the methodology proposed by Bayarri et al. (2012). The Robust prior for M_γ can be specified hierarchically as

$$\pi^R_\gamma(\alpha, \beta_\gamma, \sigma) = \sigma^{-1} N_{p_\gamma}(\beta_\gamma | 0, g\Sigma_\gamma), \tag{5}$$

where $\Sigma_\gamma = \sigma^2 (V_\gamma^\top V_\gamma)^{-1}$, with

$$V_\gamma = (I_n - X_0 (X_0^\top X_0)^{-1} X_0^\top) X_\gamma, \tag{6}$$

and

$$g \sim p_\gamma^R(g) = \frac{1}{2}\sqrt{\frac{1+n}{p_\gamma + p_0}}(g+1)^{-3/2}, \quad g > \frac{1+n}{p_\gamma + p_0} - 1. \tag{7}$$

The theoretical properties of this prior (see Bayarri et al. (2012) for the details) as well as the computational advantage that arises from the fact that it provides marginal densities in an analytic way (i.e., integral in Eq. 3 can be solved algebraically), make it an attractive choice for this kind of analyses. Concerning the prior distribution over the model space $Pr(M_\gamma)$, we adopt the ScottBerger prior. Multiplicity issues are a concern in variable selection problems and particularly, spurious evidence is high for models with moderate to large p. Thus, we control for multiplicity with the prior probabilities $Pr(M_\gamma)$ as proposed by Scott and Berger (2006):

$$Pr(H_\gamma) = \left((p+1)\begin{pmatrix} p \\ p_\gamma \end{pmatrix}\right)^{-1} \tag{8}$$

The ScottBerger prior assigns the same probability to models of the same dimension (the dimension of M_γ *is* $p_\gamma + p_0$) and it must be inversely proportional to the number of models of that dimension.

The described variable selection approach is implemented in R using the package BayesVarSel described in Garcia-Donato and Forte (2018) and that we apply to the case of German FDI in the next section. In particular, we use the function GibbsBvs to obtain approximations to the posterior inclusion probability of covariates based on the methodology by García-Donato and Martínez-Beneito (2013).

GibbsBvs approximates computation of summaries of the posterior distribution using a Gibbs sampling algorithm to explore the model space and frequency of "visits" to construct the estimates. The Gibbs sampling scheme is a simple (yet very efficient) algorithm proposed by George and McCulloch (1997) and later studied in García-Donato and Martínez-Beneito (2013) in the context of large model spaces (with p > 25).

5. Data and results

5.1. Data

In this Section we apply Bayesian Model Averaging techniques to select the determinants of German outward FDI.[7] For this purpose, we have assembled a large panel dataset covering the period 1996-2012. The data on FDI stocks were obtained from the Bilateral UNCTAD FDI Statistics. Our full sample has 1105 total observations, of which 0.90% are zero FDI stock values. Given that we consider a log-linear regression for the BMA analysis, these zero values create a selection issue as the logarithm of zero is undefined. We have dropped these observations from the sample. This solution might provide misleading coefficient estimates as highlighted by Silva and Tenreyro (2006) who recommend the use of non-linear estimators. More recently, Eicher et al. (2012) provide a methodology to address selection bias and model uncertainty simultaneously. However, despite the potential limitation of our approach, it facilitates the comparison of our results with the majority of previous studies, that usually use a logarithmic transformation to address skewness in the FDI variable.[8]

The FDI dataset was then augmented with 61 additional explanatory variables, although those included in the different country-group analysis may vary depending on the specific countries considered and as well as for statistical reasons (perfect collinearity, for example). The dataset includes first of all, standard gravity variables, and then a series of complementary variables that we have assembled taking into account the survey made in Sections 2 and 3: other related GDP and population measures, factor endowments and productivity, cultural/historical factors, economic risk and exchange rate variables, trade openness measures, infrastructure and political environment and institutions. Table A.1 in the Appendix provides a full list of the variables included, their definition and sources. The dataset contains information about 59 destination countries of FDI stock - 38 developed

[7] Our study ties in with the literature on partial equilibrium analysis of FDI determinants. Restricting ourselves to outward FDI data from a common parent country, Germany, allows us to focus on the investors' motives (i.e. the supply side) in a particular location. However, this approach is not free from limitations: by leaving third country characteristics outside the analysis, our study neglects the interdependence of FDI decisions what may cause some bias in the results obtained. Following the developments in spatial econometric techniques, general equilibrium theories of FDI have recognized the role of the potential interdependence in FDI across locations, suggesting that FDI should be modelled in a multilateral context, that is, considering home, host, and third country characteristics (see, for instance (Baltagi et al. (2007) and Blonigen et al. (2007))). Bearing these limitations in mind, we consider our analyses informative for a given country's policy options to attract investment.

[8] A Shapiro and Wilk (1965) test clearly rejects the hypothesis that FDI is normally distributed.

and 21 developing. See Table A.2 for a detailed presentation of the destination countries included in our sample.

Due to the heterogeneity of the destinations of German FDI, we have considered several country-groups. We distinguish between developed and developing countries to get a first insight of the main motives of German FDI. Yet, we also distinguish between Latin American and Asian countries within developing countries, as well as "core" and "periphery" countries within Europe.

We have decided to focus on the groups of countries because, even if there are not statistical limitations to apply this method to the whole dataset, the average effects obtained from this aggregation would omit information concerning the diversity of reasons to invest in different country-groups (see, Mitchell et al. (2011)for the so-called aggregation bias).

We run the BMA analyses with 100.000 iterations. In order to informally asses the convergence of the posterior inclusion probabilities, Figure A.1 in the Appendix provides trace plots for each of the corresponding subsamples and periods considered in our analyses. The figure shows that the posterior inclusion probabilities in all subsamples stabilize after 8000 iterations.

5.2. Results

In what follows, we present the results for the BMA analysis on the determinants of German outward FDI across regions.[9] We report the inclusion probabilities for each competing variable as a summary of the posterior distribution. These probabilities should be interpreted as the evidence shown by the data that a variable explains German outward FDI once the potential control variables have been taken into account. They provide a summary measure of the marginal importance of different drivers of FDI. We consider robust FDI determinants those variables having a posterior inclusion probability (PIP) above the recommended threshold of 0.50. Following the criterion posit by Raftery (1995), evidence for a regressor with a posterior inclusion probability from 50 to 75% is called weak, from 75 to 95 % positive, from 95 to 99 % strong, and >99 % very strong. Furthermore, the model defined by those variables with an inclusion probability greater than 0.5 is called in the

[9]We have also conducted the BMA analysis for all the host countries, both developed and developing or emerging. The results are available upon request. We have found a large number of variables with large inclusion probabilities mainly due to the heterogeneity of the destination countries. The implicit assumption is that a homogeneous set of FDI determinants governs FDI across all countries. There exists, however, ample evidence that subsamples of countries follow distinctly different FDI patterns (Eicher et al. (2012)).

literature a Median Probability Model (MPM) and the theory in Barbieri and Berger (2004) shows that, under general conditions, the MPM is optimal for prediction purposes.

The inclusion probabilities of each sample considered in this paper are presented in Figures 3, 4 and 5. Given the high number of variables considered we have opted to present the results on a visual basis and we refer the interested reader to Tables A.3, A.4 and A.5 in the Appendix for a detailed report of the estimated probabilities and posterior means. With a few exceptions, the magnitude and sign of the coefficients are in line with the theoretical predictions and previous empirical studies. Nevertheless, one should bear in mind that we consider a log-linear regression for the BMA analysis and thus our results may suffer from selection bias as highlighted by Eicher et al. (2012), thereby model average estimated coefficients need to be interpreted with caution. Needless to say, an appropriate estimation of the coefficients of the robust determinants obtained from the BMA analysis would surely be of sufficient interest, yet we believe it is beyond the scope of this paper. We leave this estimation to future research.

5.2.1. FDI determinants in developed and developing countries

Taking into account the world patterns of German FDI, a first approach to identify investment strategies consists of dividing our sample into developed and developing countries. Figure 3 reports the results of the BMA analysis. We find that 21 variables out of 44 and 22 out of 43 have an inclusion probability over 0.5 for developed and developing countries, respectively. These findings point to a specification more parsimonious (as half of the covariates are dropped out) that previously suggested by the literature, in line with the seminal paper of Blonigen and Piger (2014). Overall, although the determinants identified highlight that the decision to invest abroad is based on a mixture of FDI theories (as argued by Faeth (2009) in her survey), we can infer from the results that the motivations for German FDI in developed and developing countries are different.

Concerning the developed countries (left-hand side graph in Figure 3), the inclusion probabilities of GDP measures point towards the relevance of market size or market potential, suggesting thereby horizontal FDI (HFDI) motivations in developed countries. GDP per capita differences, urban population and population have high inclusion probabilities, that is consistent with the idea that German MNEs invest largely in developed countries, such as the US, due to its market size. Figure 1 reports the importance of the US as destination of German FDI once the "core" and peripheral EU countries are considered separately.

In addition, traditional variables for the gravity model are found to be robust determinants of German FDI in developed countries. Shared Regional Trade Agreements (RTAs) present also high inclusion probabilities and established trade relationships present also statistical support. Another important reason for German overseas investment is to serve as export-platform; MNEs would invest in a host country in order to serve a third one with exports of final goods as argued by Ekholm et al. (2007)). The high PIP of the host country's degree of openness to international trade, exports and the KOF Globalisation index, also support this argument. These findings are also in line with the idea of vertical specialization in the current process of internationalization of the production process where integration strategies into GVC imply intra-firm trade and, thus, MNEs are attracted to relatively open economies. Other vertical motives for FDI are also statistically relevant: the acquisition of advanced technologies and skilled labour (skilled labour, skill differences and productivity) are found to be robust determinants. Covariates related to cultural and historical factors are also selected. The ability to communicate seems to play a major role for overseas investment, as speaking the same language (or a significant proportion of the population speaking it) have the highest inclusion probabilities. Competitiveness (the real exchange rate) as well as the quality of institutions (including voice and accountability, political stability, government effectiveness and control of corruption) have high inclusion probabilities, as in Antonakakis and Tondl (2015), that also found that institutional quality is a German FDI determinant. Finally, we have found no support for geography measures and infrastructure variables.

Regarding German investment in developing countries (see the right-hand side of Figure 3), we find strong statistical support for trade openness and treaties variables, suggesting an export-platform FDI strategy. RTAs, established trade relationships, the host country's openness to international trade and the KOF Globalisation index present high PIP. This supports a complementary relationship between trade and FDI. Other vertically-oriented determinants, such as education and skill differences as well as productivity have high inclusion probabilities. At the same time, the interactions among key variables (trade openness and skilled labour endowments and trade openness and education differences) are also found to be robust determinants. Horizontal FDI indicators, such as similarity index, GDP per capita difference as well as the geography measures have high inclusion probabilities. Thus, these findings are consistent with the idea that traditional gravity variables play a key role in overseas investment. Furthermore, access to natural resources is

found to be important for German investment in these countries, as the oil rents indicator has high inclusion probability. Other covariates, such as competitiveness (measured as the bilateral real exchange rate) and telecommunications infrastructure (fixed telephone and mobile cellular subscriptions) present an inclusion probability of 1. Institutional covariates (voice and accountability and regulatory quality) are also selected. Finally, there is no statistical support for cultural/historical factors. All in all, our results provide evidence in favor of both market-related (HFDI) as well as vertical motives for FDI (VFDI), although the latter are stronger.

In summary, we can conclude from the BMA analysis that MNEs engage in complex integration strategies which involve a mixture of FDI theories, including horizontal and vertical motives. Indeed, our results for both country groups support the capital-knowledge model (KKM), where vertical and horizontal motives may play an important role alike. However, some FDI strategies receive a stronger statistical support than others.

However, the analysis of these two large groups of countries is not completely satisfying, as the mixed strategy that prevails in both developed and emerging countries may be the result of aggregation, masking different strategies for different geographical areas or income groups. For this reason, taking into account the distribution of German FDI, we divide the developing countries into two large areas: Latin America and Asia. For developed countries, we focus on the European continent and separate "core" from "peripheral" European countries. We devote the next two subsections to this disaggregated analysis.

5.2.2. FDI determinants in Latin American and Asian countries

Within developing countries, Asian countries hold the 41.92% of German OFDI along the period 1996-2012, while Latin American countries represent the 35.15%. We hypothesize that German FDI strategies towards these regions might be different and, thereby we split our sample of developing countries into Latin American and Asian countries. The BMA results are presented in Figure 4. In this case, 13 variables out of 40 and 8 out of 40 have an inclusion probability over 0.5 for Latin American and Asian countries, respectively.

Concerning the Latin American countries (see the left-hand side panel of Figure 4), there is some evidence of HFDI indicators. Population, the similarity index, GDP per capita difference as well as the geography measures (such as time zone difference) have an inclusion probability above 0.5. Stronger is the support for vertical FDI motives, as factor endowment variables and other vertical variables, such as the level of education and trade

openness, as well as the interaction of GDP differences with skill differences, present high inclusion probabilities. Moreover, telecommunications infrastructure, as well as institutions (in this case, the political rights, Voice and Accountability and political stability indices with a PIP above 0.8) are statistically relevant. Finally, there is no support for cultural and historical factors, exchange rate/monetary policy and trade and investment treaties.

Similar to the Latin American case, the market-driven (HFDI) motive seems to be relevant for German investment in Asian countries (right-hand side of Figure Figure 4). GDP covariates receive more statistical support: the sum of host and parent GDP and GDP per capita have high inclusion probabilities. Access to the sea is also a robust FDI determinant. Taken together, the gravity model receives support in Asian countries. The evidence is consistent with the idea that German MNEs seek to access large-sized markets in order to expand their production. This might be the case for German investments in China whose high GDP growth and enormous population has boosted its attractiveness as an investment location. In addition, factor endowment covariates, such as the education level, have high PIP, suggesting also vertical FDI motivations. Competitiveness, telecommunications infrastructure (internet users) and institutions (the civil liberties and voice and accountability indices) have all very large inclusion probabilities. Finally, we found no support for other broad categories of variables, specifically those related to cultural/historical factors.

In summary, both vertical and horizontal FDI determinants are present in the two regions, together with a strong importance of the quality of institutions indices to explain FDI patterns in the two country-groups. However, vertical FDI motives are more relevant for Latin America, while horizontal FDI seems to prevail in Asian countries. Finally, as expected in the case of Germany, we find no support for cultural nor historical factors.

5.2.3. FDI determinants in EU regions

As previously shown in Figure 1, the European Union is the single largest regional location for German investments. In order to examine the internationalization strategies of German MNEs within Europe we divide our sample into Core and Peripheral countries following the pattern of German investment shown in Figure 2. The "core" region includes the founding countries plus the first enlargement in 1973 and the Northern countries, excepting Italy, Ireland and Finland. In parallel, the "periphery" comprises the enlargement to the south and east plus Italy, Ireland and Finland. Figure 5 provides the results of the BMA analysis, whereas the specific inclusion probabilities and the posterior means are reported

in the Appendix (Table A.5). For the core countries, 9 variables out of 47 are found to be robust determinants, while for peripheral countries, 16 variables out of 48 have an inclusion probability higher than 0.5.

In the case of the core countries, the GDP measures receive some statistical support: similarity index and GDP per capita have inclusion probabilities between 0.5 and 0.6. Distance and other geography measures, namely landlocked host country, are robust determinants for investment in core countries as well, in line with the gravity model. However, there is also a strong statistical support for factor endowment variables, suggesting thus vertical FDI motivations (land area and wages have high inclusion probabilities). This latter finding is in line with those provided by Antonakakis and Tondl (2015) who state that German MNEs are particularly attracted by advanced markets with relatively high wages and productivity. Probably, the reason for the relevance of wages has more to do in this case with it being a proxy for income than with the cost of production. Furthermore, trade openness variables are found to be robust determinants: exports have a high inclusion probability. Taking into account the positive sign of the posterior mean, FDI and exports would be complementary rather than substitutes. In fact, after all the years of deep economic integration in Europe, German's FDI is concentrated in the core countries, as it represents around 40% of its total stock. Finally, fixed telephone subscriptions and internet users (that represent telecommunications infrastructure) have a high inclusion probability, while there is no support for cultural and historical factors, exchange rate/monetary policy, trade and investment treaties and institutions. This is an expected outcome, as these countries are EU members and most of them are in the euro area.

On the other hand, in the case of German investment in peripheral countries, our results point to market-seeking FDI motivations. Similarity index and urban population have high inclusion probabilities. Distance and other geography measures, namely contiguity, receive also statistical support, in line with the gravity model. Productivity has also a high PIP, suggesting VFDI motives, and competitiveness of host country is a robust determinant in this period too. Regional Trade Agreements (RTAs) and all the covariates that capture the integration process, such as CU, PTA and BIT membership, have high inclusion probabilities, as some of the countries in the sample joined the EU during the sample period.[10] We also find statistical support for trade openness variables: exports, imports and trade present high inclusion probabilities, and provide evidence of a com-

[10] As already stated, for this same reason, that they were already members, these variables were not relevant in the group of core countries above.

plementarity relationship between FDI and trade (as the associated posterior mean of the trade variable is positive). Furthermore, these findings are consistent with vertical FDI and complex integration strategies into GVCs. Indeed, Germany was the most important of the three interconnected production hubs in the global trading system in 2000, although since then China has been increasing its weight in the international production networks (Shin (2019)).[11] In addition, there appears to be more statistical support for transport and telecommunications infrastructure for these countries: kilometres of rail lines and fixed and mobile telephone subscriptions have an inclusion probability of 1. Furthermore, the quality of institutions, political stability and absence of violence have all high inclusion probability. Finally, there is also no statistical support for cultural and historical factors.

Overall, the results show that drivers for horizontal FDI to large euro area markets are relatively more important for German investment in "core" EU countries than is the case of the peripheral ones, where vertical motives appear to play a major role.

6. Concluding remarks

Despite of the importance of German Outward FDI, the studies analyzing its determinants are relatively scarce. Moreover, from a theoretical point of view, there is not a unified model to explain FDI determinants, but several theories that postulate different hypotheses. This lack of consensus is extended to the empirical literature, as not only the baseline econometric specification, but also the proxy variables selected to account for the alternative theoretical channels, are heterogeneous. We claim, that in some areas, where there is uncertainty about the true or most adequate theoretical model, model selection should be implemented prior to any causality or regression analysis.

Our contributions to this literature about model uncertainty and variable selection in FDI models are twofold. First, from a methodological point of view, we adopt a Bayesian Model Averaging approach for the selection of the best model, providing an "objective" statistical procedure to model selection in contrast to the subjective-driven approach commonly used in the literature. Accordingly, we do not condition on a single model and instead attach probabilities to different models obtaining a robust identification of the FDI determinants. Using this method, we can select those variables with the highest explana-

[11] There appear to be three interconnected production hubs of GVCs in the world: North America (with its epicenter in the United States), East Asia (i.e. China, Japan and the Republic of Korea) and Europe (being Germany the core country).

tory power from a large group of 61 potential candidates. Second, we take into account the heterogeneity of the destinations of German FDI and consider different recipient-country groups in the analysis.

The results obtained for the country-groups show that only a small proportion of the variables proposed in the literature have high posterior inclusion probabilities. Consequently, we find that a robust FDI specification is rather parsimonious and many variables included in other studies seem to have a relatively low explanatory power. Overall, our results confirm that the decision to invest abroad involves a mixture of FDI theories and that the main internationalization strategies are different across regions. In summary, we find that determinants that are associated with market-seeking or HFDI motives are relatively more important for developed countries. In the case of developing countries, due to the increasing fragmentation of the production process, the factor endowments and thus, cost savings, play a greater role. The disaggregation of our sample of developing countries into Latin American and Asian countries highlights two features. First, HFDI and VFDI motives coexist for German MNEs investment in both, Latin American and Asian countries, together with a strong relevance of the quality of institutions. Second, HFDI seems to play a major role in Asian countries, while German multinational firms access Latin American markets appear looking for lower production costs, in line with VFDI. Concerning German FDI in its European neighbours, a further disaggregation into “core” and “peripheral" countries reveals that market access is the main motivation. However, the growing importance of GVC, where Germany plays a key regional role in Europe, is in line with vertically integrated multinational firms that are more relevant in developing countries as well as in peripheral European countries. Finally, our conclusions concerning the specific variables that are relevant in the vertical or horizontal strategies can provide some hints for policymakers to develop programs oriented to attract German investment.

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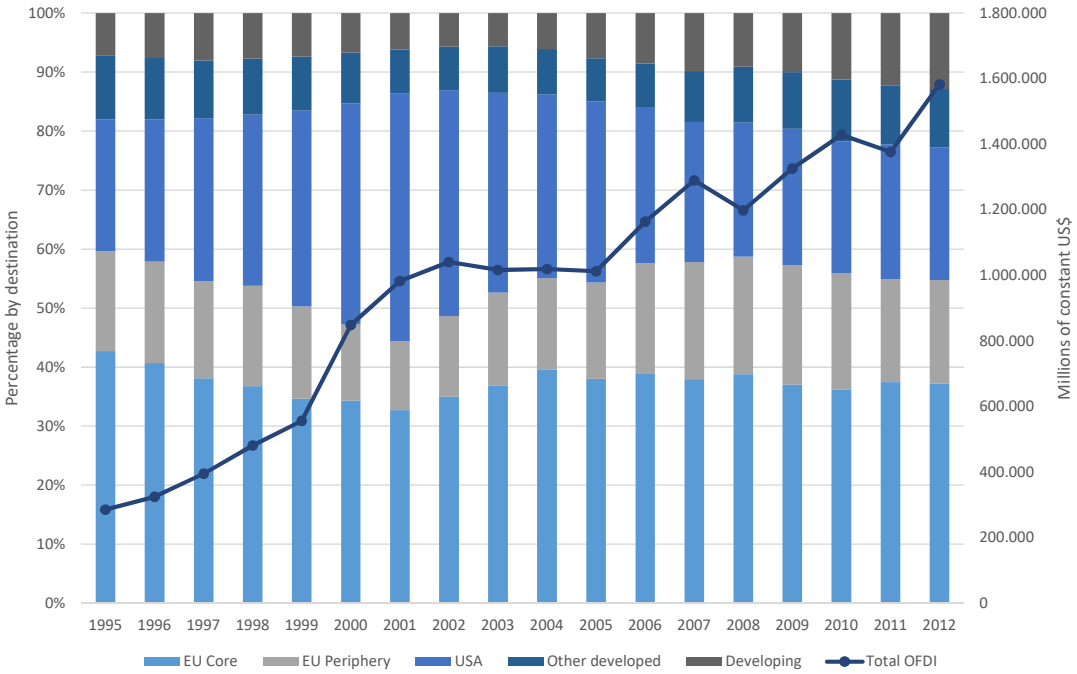
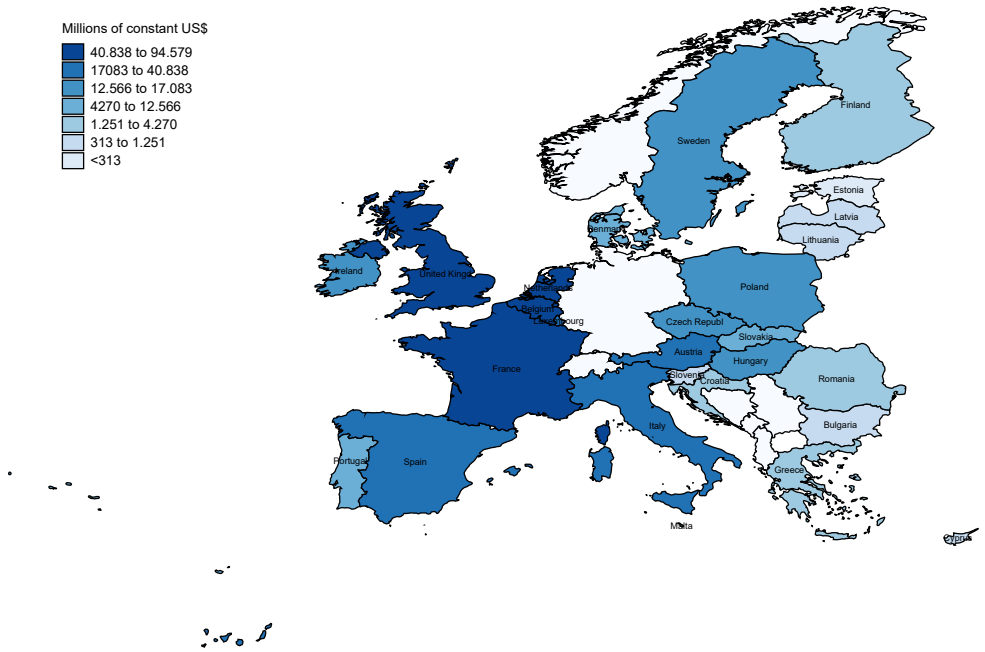
Figure 1: Germany: geographical distribution of outward FDI stock,1995-2012.



Source: UNCTAD database.

Figure 2: German FDI stock distributed across European Union, average 1995-2012.



Source: UNCTAD database.

Figure 3: Inclusion probabilities for each of the potential covariates considered for developed (left) and developing countries (right), 1996-2012.

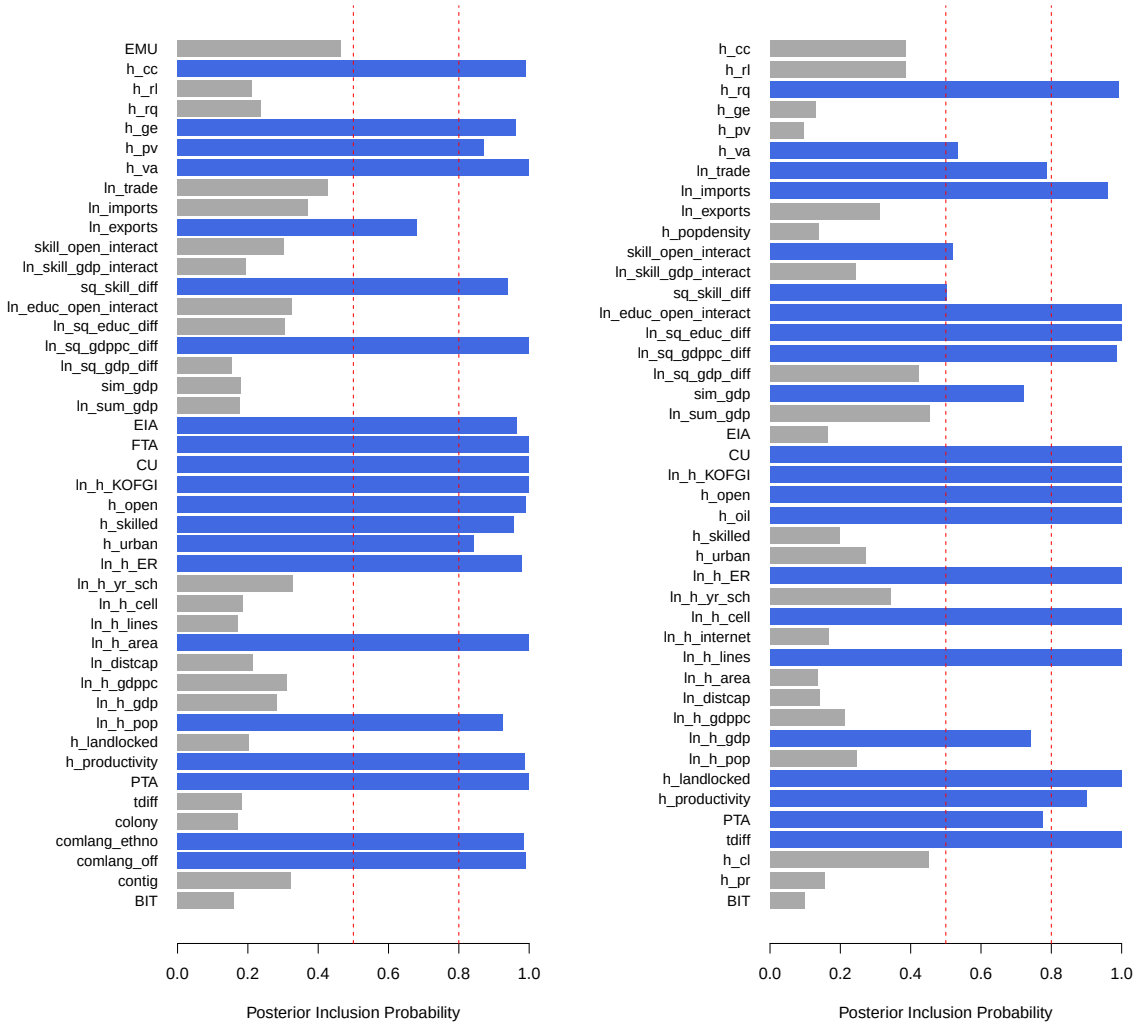


Figure 4: Inclusion probabilities for each of the potential covariates considered for Latin American (left) and Asian countries (right), 1996-2012.

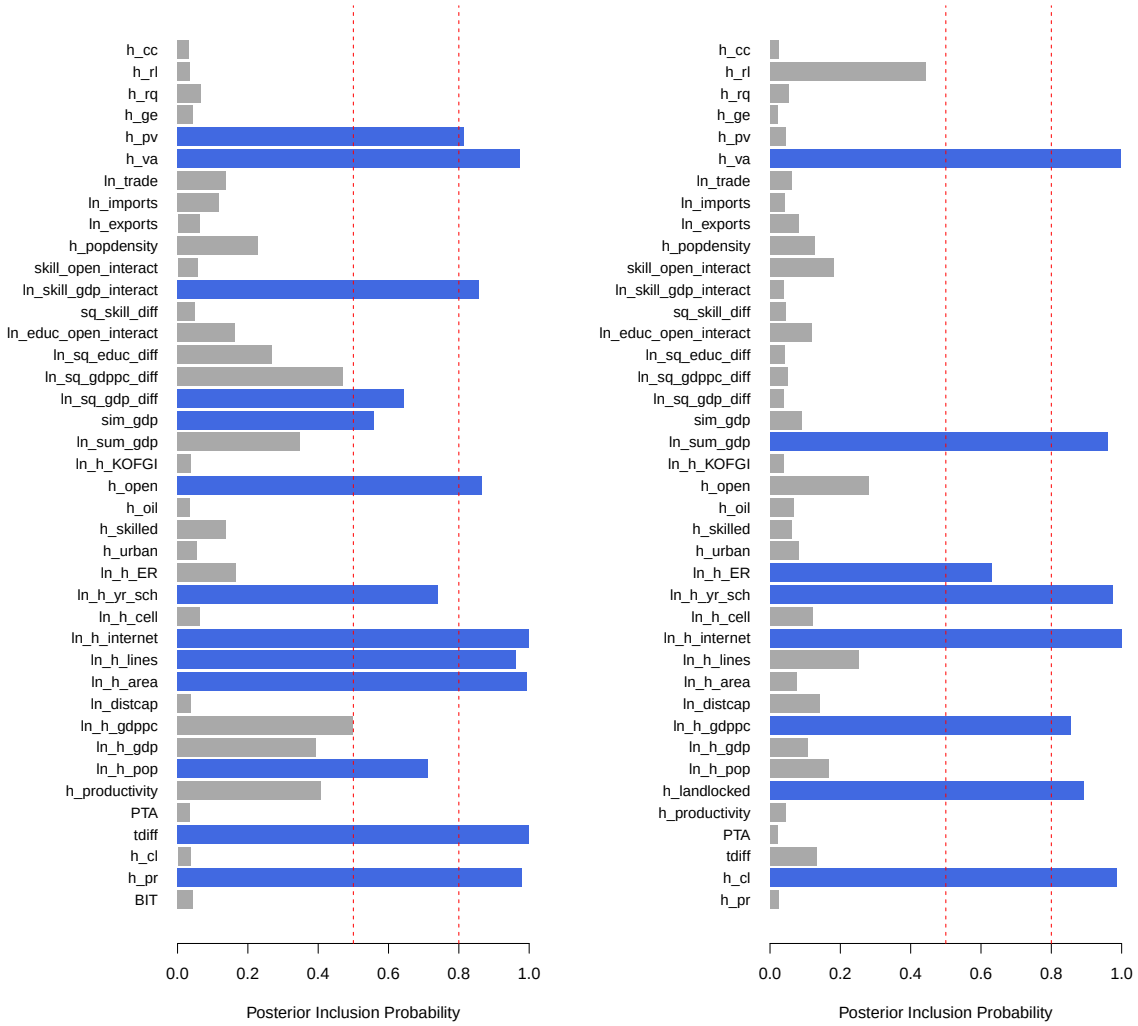


Figure 5: Inclusion probabilities for each of the potential covariates considered for core (left) and peripheral EU countries (right), 1996-2012.

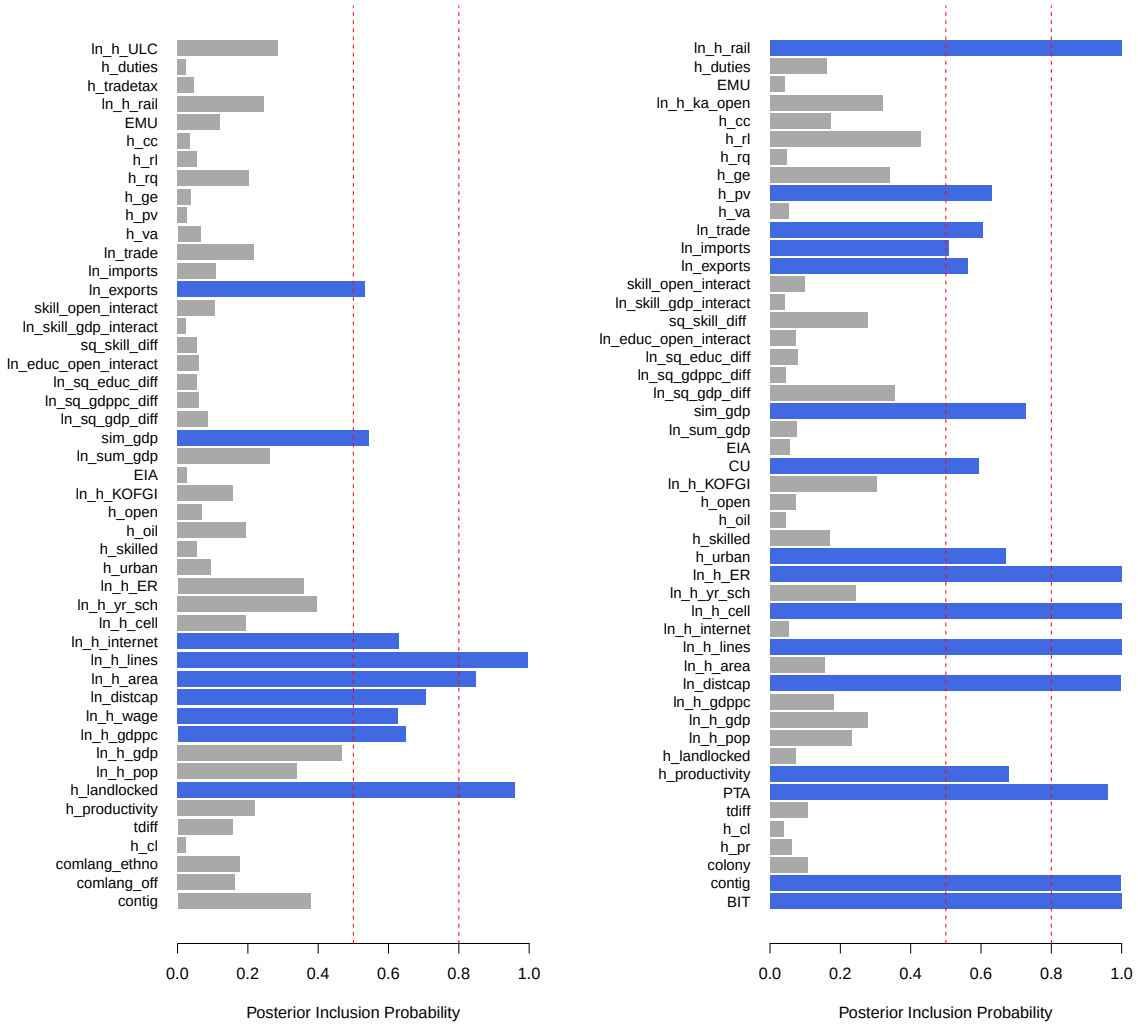


Table A.1: Data description and source

Variable name	Description	Source
ln_ofdistock	Log of bilateral outward FDI stock in millions (constant 2010 US$)	UNCTAD Bilateral FDI database
	GDP and Population Measures	
ln_sum_gdp	Log of sum of HOST and PARENT real GDP	World Development Indicators, World Bank
sim_gdp	Log of share of HOST real GDP in the sum of HOST and PARENT GDP $*$ Share of PARENT real GDP in the sum of HOST and PARENT GDP	World Development Indicators, World Bank
ln_sq_gdp_diff	Log of squared real GDP difference between HOST and PARENT country	World Development Indicators, World Bank
ln_sq_gdppc_diff	Log of squared real GDP per capita difference between HOST and PARENT country	World Development Indicators, World Bank
h_urban	Urban population (% of total) in HOST country	World Development Indicators, World Bank
ln_h_pop	Log of HOST population, total in mn	Gravity database from CEPII
ln_h_gdp	Log of HOST GDP in trillions (constant 2010 US$)	World Development Indicators, World Bank
ln_h_gdppc	Log of HOST GDP per capita in trillions (constant 2010 US$)	World Development Indicators, World Bank
	Distance and other geography measures	
contig	Dummy variable indicating PARENT and HOST countries are geographically contiguous	Gravity database from CEPII
ln_distcap	Log of distance between the capitol cities in the PARENT and HOST country	GeoDist database from CEPII
tdiff	nb of hours difference between PARENT and HOST	Gravity database from CEPII
h_landlocked	1 if HOST is landlocked	GeoDist database from CEPII
	Factor endowments/productivity	
h_skilled	Percent of employment by skilled labor in HOST country	ILOSTAT
ln_h_area	Log of land area (sq. km) in HOST country	Gravity database from CEPII
ln_sq_educ_diff	Log of squared difference in average education years between PARENT and HOST country	PWT 9.0
sq_skill_diff	Squared difference in percent of employment by skilled labor between PARENT and HOST country	ILOSTAT
ln_educ_gdp_interact	Log(sq_gdp_diff $*$ sq_educ_diff)	PWT 9.0, World Development Indicators
ln_skill_gdp_interact	Log(sq_gdp_diff $*$ sq_skill_diff)	ILOSTAT, World Development Indicators
ln_h_popdensity	Log of population divided by land area in HOST country	Gravity database from CEPII
ln_h_yr_sch	Log of average years of schooling in the population aged 25 years and older, HOST country	PWT 9.0
h_oil	Oil rents (% of GDP)	World Development Indicators, World Bank
h_productivity	Share of labour compensation in GDP at current national prices in host country	PWT 9.0
ULC	Log of the average cost of labour per unit of output, index(2010=100)	OECD
ln_h_wage	Log of the average annual wages (In 2016 constant prices at 2016 USD PPPs)	OECD

(Continued)

Table A.1: Data description and source *(Continued)*

Variable name	Description	Source
	Cultural/Historical factors	
comlang_off	Dummy variable indicating PARENT and HOST countries share a common official language	Gravity database from CEPII
comlang_ethno	Dummy variable indicating PARENT and HOST countries share a language which at least 9% speak in each country	Gravity database from CEPII
colony	Dummy variable indicating PARENT and HOST countries have had (or do have) a colonial link	Gravity database from CEPII
comcol	Dummy variable indicating PARENT and HOST countries have had a common colonizer since 1945	Gravity database from CEPII
curcol	Dummy variable indicating PARENT and HOST countries are currently in a colonial relationship	Gravity database from CEPII
col45	Dummy variable indicating PARENT and HOST countries have had a colonial link since 1945	Gravity database from CEPII
smctry	Dummy variable indicating PARENT and HOST countries were (or are) the same country	Gravity database from CEPII
	Trade and investment treaties	
PTA	1 if preferential trade agreement signature	Hofmann et al. (2017)
CU	1 if CU or CU & EIA	Hofmann et al. (2017)
FTA	1 if FTA or FTA & EIA	Hofmann et al. (2017)
EIA	1 if EIA or FTA & EIA or CU & EIA	Hofmann et al. (2017)
BIT	1 if BIT was signed in this year or earlier	Neumayer(2017); IIA Unctad
	Exchange Rate/Monetary policy	
ln_h_ER	Log of real exchange rate in host country, national currency/USD	PWT 9.0
EMU	1 if both belong to the euro area in year t	Own elaboration
	Trade openness	
h_tradetax	Taxes on international trade (% of revenue) in HOST country	World Development Indicators, World Bank
h_duties	Customs and other import duties (% of tax revenue) in HOST country	World Development Indicators, World Bank
ln_educ_open_interact	Log(sq_educ_diff $*$ h_open)	PWT 9.0, World Development Indicators
skill_open_interact	sq_skill_diff $*$ h_open	ILOSTAT, World Development Indicators
ln_exports	Log of 5-years lag of bilateral exports (of i to j) in mn (constant 2010 US$)	CHELEM database from CEPII
ln_imports	Log of 5-years lag of bilateral imports (of i from j) in mn (constant 2010 US$)	CHELEM database from CEPII
ln_trade	Log of 5-years lag of bilateral exports plus imports in mn(constant 2010 US$)	CHELEM database from CEPII
h_open	Trade (% of GDP)	World Development Indicators, World Bank
ln_h_KOFGI	Log of HOST KOF Globalization Index	Gygli et al.(2018)
ln_h_ka_open	Log of HOST Chinn-Ito index, normalized (0-1)	Chinn et al. (2006)

(Continued)

Table A.1: Data description and source *(Continued)*

Variable name	Description	Source
	Infrastructure	
ln_h_rail	Log of kilometers of rail lines per sq km of land area in HOST country	World Development Indicators, Gravity database from CEPII
ln_h_phone	Log of telephone lines (per 100 people) in HOST country	World Development Indicators, World Bank
ln_h_internet	Log of internet users (per 100 people) in HOST country	World Development Indicators, World Bank
ln_h_lines	Log of fixed telephone subscriptions (per 100 people) in HOST country	World Development Indicators, World Bank
ln_h_cell	Log of mobile cellular subscriptions (per 100 people) in HOST country	World Development Indicators, World Bank
	Institutions	
h_pr	Political rights index for HOST country (Ranges from 1 to 7 with highest score indicating the lowest level of freedom)	Freedom House
h_cl	Civil liberties index for HOST country (Ranges from 1 to 7 with highest score indicating the lowest level of freedom)	Freedom House
h_va	Voice and Accountability, in percentile rank (Ranges from 0 (lowest) to 100 (highest))	World Governance Indicators (WGI), World Bank
h_pv	Political Stability and Absence of Violence/Terrorism, in percentile rank (Ranges from 0 (lowest) to 100 (highest))	World Governance Indicators (WGI), World Bank
h_ge	Government Effectiveness, in percentile rank (Ranges from 0 (lowest) to 100 (highest))	World Governance Indicators (WGI), World Bank
h_rq	Regulatory Quality, in percentile rank (Ranges from 0 (lowest) to 100 (highest))	World Governance Indicators (WGI), World Bank
h_rl	Rule of Law, in percentile rank (Ranges from 0 (lowest) to 100 (highest))	World Governance Indicators (WGI), World Bank
h_cc	Control of Corruption, in percentile rank (Ranges from 0 (lowest) to 100 (highest))	World Governance Indicators (WGI), World Bank

Table A.2: Countries included in the study disaggregated by country-groups.

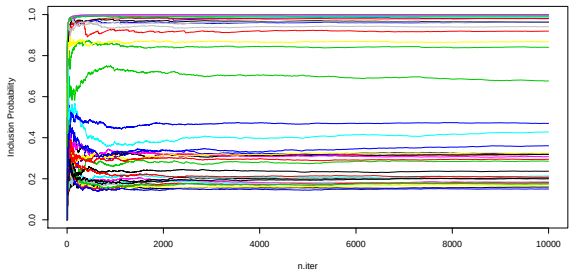
Destination countries				
Developed				
Australia	Iceland	New Zealand	Romania[a]	Switzerland
Canada	Israel	Norway	Singapore	United States
Hong Kong	Japan			
	EU Core			
	Austria	Denmark	Luxembourg	Sweden
	Belgium	France	Netherlands	United Kingdom[b]
	EU Peripheral			
	Bulgaria	Finland	Latvia	Portugal
	Croatia	Greece	Lituania	Slovak Republic
	Cyprus	Hungary	Malta	Slovenia
	Czech Republic	Ireland	Poland	Spain
	Estonia	Italy		
Developing				
Argentina[c]	Morocco	Saudi Arabia	Turkey	Ukraine
Egypt	Russian Federation			
	Latin American			
	Brazil	Colombia	Mexico	
	Chile	Ecuador	Uruguay	Venezuela
	Asian			
	China	Indonesia	Korea, Republic of	Thailand
	India	Kazhastan	Malaysia	

[a] Although Romania is a EU member since 2007, it is not included in the group of peripheral EU because it is classified as an outlier concerning the level of skilled labour endowments.

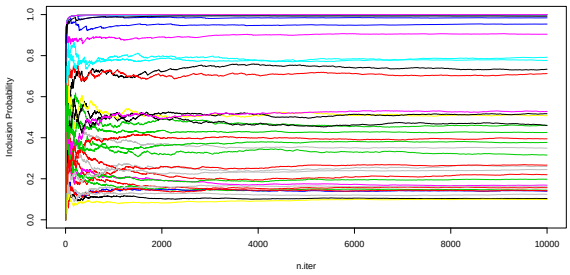
[b] Since the 2016 referendum vote to leave the EU, the UK is on course to leave the EU.

[c] Argentina is not included in the Latin American countries' group because German FDI shrank sharply in the year 2000 due to the economic depression that hit the country.

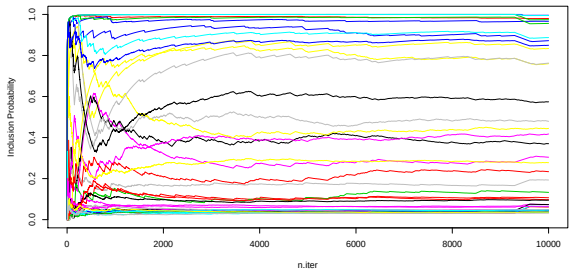
Figure A.1: Evolution of the inclusion probabilities with the iterations in Gibbs sampling, 1996-2012.



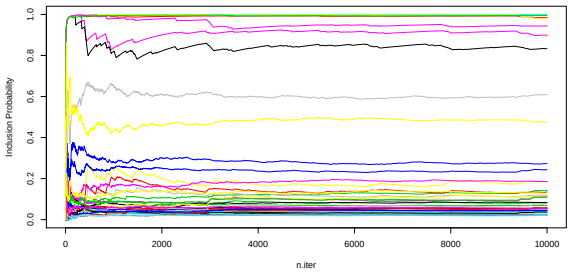
(a) Developed



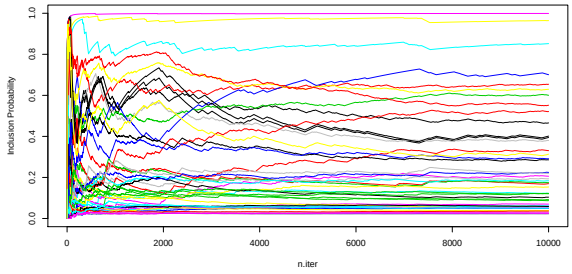
(b) Developing



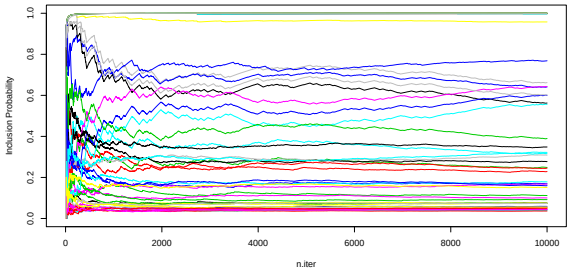
(c) Latin America



(d) Asia



(e) EU Core



(f) EU Periphery

Table A.3: Determinants of FDI in developed and developing countries

	1996-2012			
	Developed		Developing	
Variable	*incl prob*	*post mean*	*incl prob*	*post mean*
ln_sum_gdp	0.1783	0.000	0.4547	0.000
sim_gdp	0.1802	0.000	**0.7201**	-0.656
ln_sq_gdp_diff	0.1537	0.000	0.4237	0.000
ln_sq_gdppc_diff	**1.0000**	0.175	**0.9850**	0.840
h_urban	**0.8439**	-2.070	0.2710	0.000
ln_h_pop	**0.9269**	1.347	0.2465	0.000
ln_h_gdp	0.2816	0.000	**0.7405**	0.950
ln_h_gdppc	0.3114	0.000	0.2116	0.000
contig	0.3228	0.000	C	C
ln_distcap	0.2144	0.000	0.1404	0.000
h_landlocked	0.2036	0.000	**1.0000**	-1.624
tdiff	0.1840	0.000	**0.9996**	0.172
h_skilled	**0.9571**	-6.679	0.1982	0.000
ln_sq_educ_diff	0.3068	0.000	**0.9986**	1.031
sq_skill_diff	**0.9390**	-33.636	**0.5023**	0.000
ln_educ_gdp_interact	LD	LD	LD	LD
ln_skill_gdp_interact	0.1949	0.000	0.2438	0.000
ln_h_wage	NA	NA	NA	NA
ln_h_popdensity	LD	LD	0.1393	0.000
ln_h_yr_sch	0.3281	0.000	0.3424	0.000
ln_h_area	**0.9984**	-0.340	0.1358	0.000
h_oil	NA	NA	**0.9991**	-2.554
ln_ULC	NA	NA	NA	NA
h_productivity	**0.9880**	-4.971	**0.9000**	-1.313
comlang_off	**0.9922**	2.867	C	C
comlang_ethno	**0.9846**	-2.401	C	C
colony	0.1732	0.000	C	C
comcol	C	C	C	C
curcol	C	C	C	C
col45	C	C	C	C
smctry	C	C	C	C
ln_h_ER	**0.9799**	-0.239	**1.0000**	-0.112
EMU	0.4651	0.000	C	C

(Continued)

Table A.3: Determinants of FDI in developed and developing countries *(Continued)*

	1996-2012			
	Developed		Developing	
Variable	*incl prob*	*post mean*	*incl prob*	*post mean*
PTA	**1.0000**	-2.784	**0.7758**	-0.204
CU	**1.0000**	1.742	**0.9998**	1.362
FTA	**1.0000**	2.596	LD	LD
EIA	**0.9657**	0.651	0.1636	0.000
BIT	0.1596	0.000	0.0986	0.000
h_tradetax	NA	NA	NA	NA
h_duties	NA	NA	NA	NA
ln_educ_open_interact	0.3261	0.000	**1.0000**	-1.554
skill_open_interact	0.3036	0.000	**0.5200**	-1.016
ln_exports	**0.6820**	0.360	0.3103	0.000
ln_imports	0.3699	0.000	**0.9598**	-0.394
ln_trade	0.4290	0.000	**0.7853**	0.585
h_open	**0.9899**	0.826	**1.0000**	1.949
ln_h_KOFGI	**1.0000**	8.874	**1.0000**	-2.809
ln_h_ka_open	NA	NA	NA	NA
ln_h_rail	NA	NA	NA	NA
ln_h_phone	LD	LD	LD	LD
ln_h_internet	NA	NA	0.1660	0.000
ln_h_lines	0.1732	0.000	**1.0000**	-0.430
ln_h_cell	0.1873	0.000	**1.0000**	0.370
h_pr	NA	NA	0.1550	0.000
h_cl	NA	NA	0.4513	0.000
h_va	**0.9999**	0.054	**0.5338**	0.003
h_pv	**0.8715**	0.013	0.0961	0.000
h_ge	**0.9636**	0.058	0.1303	0.000
h_rq	0.2378	0.000	**0.9920**	0.012
h_rl	0.2115	0.000	0.3849	0.000
h_cc	**0.9918**	-0.061	0.3844	0.000

Notes: posterior inclusion probabilities larger than 0.5. LD and C stand for variables dropped for being linear dependent and constant, respectively. NA stands for variables not included because of data availability.

Table A.4: Determinants of FDI in Latin American and Asian countries

	1996-2012			
	Latin America		Asia	
Variable	*incl prob*	*post mean*	*incl prob*	*post mean*
ln_sum_gdp	0.3488	0.000	**0.9595**	2.885
sim_gdp	**0.5574**	0.000	0.0902	0.000
ln_sq_gdp_diff	**0.6432**	-1.140	0.0378	0.000
ln_sq_gdppc_diff	0.4709	0.000	0.0486	0.000
h_urban	0.0541	0.000	0.0819	0.000
ln_h_pop	**0.7135**	-6.100	0.1665	0.000
ln_h_gdp	0.3950	0.000	0.1054	0.000
ln_h_gdppc	0.4991	0.000	**0.8545**	-1.070
contig	C	C	C	C
ln_distcap	0.0383	0.000	0.1400	0.000
h_landlocked	C	C	**0.8926**	-2.480
tdiff	**0.9989**	1.871	0.1330	0.000
h_skilled	0.1369	0.000	0.0614	0.000
ln_sq_educ_diff	0.2698	0.000	0.0424	0.000
sq_skill_diff	0.0484	0.000	0.0447	0.000
ln_educ_gdp_interact	LD	LD	LD	LD
ln_skill_gdp_interact	**0.8580**	0.520	0.0385	0.000
ln_h_wage	NA	NA	NA	NA
ln_h_popdensity	0.2285	0.000	0.1269	0.000
ln_h_yr_sch	**0.7398**	-2.310	**0.9745**	4.034
ln_h_area	**0.9949**	5.101	0.0753	0.000
h_oil	0.0343	0.000	0.0664	0.000
ln_ULC	NA	NA	NA	NA
h_productivity	0.4088	0.000	0.0436	0.000
comlang_off	C	C	C	C
comlang_ethno	C	C	C	C
colony	C	C	C	C
comcol	C	C	C	C
curcol	C	C	C	C
col45	C	C	C	C
smctry	C	C	C	C
ln_h_ER	0.1667	0.000	**0.6292**	-0.090
EMU	C	C	C	C

(Continued)

Table A.4: Determinants of FDI in Latin American and Asian countries *(Continued)*

	1996-2012			
	Latin America		Asia	
Variable	*incl prob*	*post mean*	*incl prob*	*post mean*
PTA	0.0361	0.000	0.0226	0.000
CU	C	C	C	C
FTA	LD	LD	LD	LD
EIA	LD	LD	LD	LD
BIT	0.0427	0.000	C	C
h_tradetax	NA	NA	NA	NA
h_duties	NA	NA	NA	NA
ln_educ_open_interact	0.1621	0.000	0.1190	0.000
skill_open_interact	0.0568	0.000	0.1793	0.000
ln_exports	0.0624	0.000	0.0808	0.000
ln_imports	0.1173	0.000	0.0407	0.000
ln_trade	0.1389	0.000	0.0598	0.000
h_open	**0.8668**	-2.685	0.2812	0.000
ln_h_KOFGI	0.0393	0.000	0.0377	0.000
ln_h_ka_open	NA	NA	NA	NA
ln_h_rail	NA	NA	NA	NA
ln_h_phone	LD	LD	LD	LD
ln_h_internet	**0.9991**	0.391	**0.9995**	0.240
ln_h_lines	**0.9620**	-0.733	0.2519	0.000
ln_h_cell	0.0627	0.000	0.1213	0.000
h_pr	**0.9804**	0.171	0.0247	0.000
h_cl	0.0368	0.000	**0.9847**	0.398
h_va	**0.9749**	-0.028	**0.9966**	0.027
h_pv	**0.8135**	0.010	0.0427	0.000
h_ge	0.0450	0.000	0.0210	0.000
h_rq	0.0660	0.000	0.0522	0.000
h_rl	0.0349	0.000	0.4436	0.000
h_cc	0.0331	0.000	0.0235	0.000

Notes: posterior inclusion probabilities larger than 0.5. LD and C stand for variables dropped for being linear dependent and constant, respectively. NA stands for variables not included because of data availability.

Table A.5: Determinants of FDI in EU regions

	1996-2012			
	Core		Periphery	
Variable	*incl prob*	*post mean*	*incl prob*	*post mean*
ln_sum_gdp	0.2626	0.000	0.0750	0.000
sim_gdp	**0.5445**	0.617	**0.7252**	0.554
ln_sq_gdp_diff	0.0862	0.000	0.3535	0.000
ln_sq_gdppc_diff	0.0617	0.000	0.0441	0.000
h_urban	0.0943	0.000	**0.6696**	-2.130
ln_h_pop	0.3385	0.000	0.2322	0.000
ln_h_gdp	0.4688	0.000	0.2760	0.000
ln_h_gdppc	**0.6483**	1.742	0.1797	0.000
contig	0.3782	0.000	**0.9975**	1.345
ln_distcap	**0.7074**	2.790	**0.9970**	1.563
h_landlocked	**0.9584**	1.012	0.0735	0.000
tdiff	0.1562	0.000	0.1054	0.000
h_skilled	0.0551	0.000	0.1683	0.000
ln_sq_educ_diff	0.0548	0.000	0.0768	0.000
sq_skill_diff	0.0556	0.000	0.2780	0.000
ln_educ_gdp_interact	LD	LD	LD	LD
ln_skill_gdp_interact	0.0231	0.000	0.0399	0.000
ln_h_wage	**0.6277**	1.455	NA	NA
ln_h_popdensity	LD	LD	LD	LD
ln_h_yr_sch	0.3969	0.000	0.2420	0.000
ln_h_area	**0.8482**	-0.570	0.1544	0.000
h_oil	0.1952	0.000	0.0447	0.000
ln_ULC	0.2857	0.000	NA	NA
h_productivity	0.2200	0.000	**0.6793**	-2.795
comlang_off	0.1626	0.000	C	C
comlang_ethno	0.1784	0.000	C	C
colony	C	C	0.1077	0.000
comcol	C	C	C	C
curcol	C	C	C	C
col45	C	C	C	C
smctry	C	C	C	C
ln_h_ER	0.3583	0.000	**1.000**	0.331
EMU	0.1216	0.000	0.0420	0.000

(Continued)

Table A.5: Determinants of FDI in EU regions *(Continued)*

	1996-2012			
	Core		Periphery	
Variable	*incl prob*	*post mean*	*incl prob*	*post mean*
PTA	C	C	**0.9595**	0.674
CU	C	C	**0.5923**	-0.400
FTA	C	C	LD	LD
EIA	0.0264	0.000	0.0544	0.000
BIT	C	C	**0.9997**	-0.989
h_tradetax	0.0480	0.000	NA	NA
h_duties	0.0247	0.000	0.1601	0.000
ln_educ_open_interact	0.0607	0.000	0.0724	0.000
skill_open_interact	0.1061	0.000	0.0990	0.000
ln_exports	**0.5320**	0.156	**0.5620**	0.000
ln_imports	0.1099	0.000	**0.5089**	0.000
ln_trade	0.2178	0.000	**0.6035**	0.255
h_open	0.0691	0.000	0.0716	0.000
ln_h_KOFGI	0.1574	0.000	0.3026	0.000
ln_h_ka_open	NA	NA	0.3208	0.000
ln_h_rail	0.2462	0.000	**1.000**	1.162
ln_h_phone	LD	LD	LD	LD
ln_h_internet	**0.6296**	0.122	0.0532	0.000
ln_h_lines	**0.9977**	-1.174	**1.000**	-1.072
ln_h_cell	0.1939	0.000	**1.000**	0.360
h_pr	C	C	0.0601	0.000
h_cl	0.0247	0.000	0.0380	0.000
h_va	0.0653	0.000	0.0527	0.000
h_pv	0.0263	0.000	**0.6289**	-0.008
h_ge	0.0376	0.000	0.3407	0.000
h_rq	0.2044	0.000	0.0483	0.000
h_rl	0.0563	0.000	0.4290	0.000
h_cc	0.0359	0.000	0.1713	0.000

Notes: posterior inclusion probabilities larger than 0.5. LD and C stand for variables dropped for being linear dependent and constant, respectively. NA stands for variables not included because of data availability.