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Testing Mundell's Intuition of Endogenous OCA Theory*

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Abstract

This paper presents an empirical assessment of the endogenous optimum currency area theory. Frankel and Rose (1998) study the endogeneity of a currency union through the lens of international trade flows. Our study extends Frankel and Rose's model by using FDI flows to test the original theory developed by Mundell in 1973. A gravity model is used to empirically assess the effectiveness of the convergence criteria by examining location-specific advantages that guide multinational investment within the European Union. A fixed effects model based on a panel data of foreign direct investment (FDI) flows within the EU-15 shows that horizontal investment promotes the diffusion of the production process across the national border. Specifically, our results suggest that economic convergence ensured by belonging to the common currency area helps double FDI flows.

1. Introduction

In a recent article, McKinnon (2004) brings attention to a little-known article by Mundell (1973) stating that optimal risk-sharing is attained when countries exhibit a wide degree of heterogeneity. This paper is indeed the major latest refinement, if not a correction of the optimum currency area (OCA) theory, initiated by Mundell (1961) himself. Before this paper, Mundell argued that an economic area has to be optimal before using a common currency or a fixed exchange-rate mechanism. The causality is reversed in 1973 since using a common currency or joining a fixed exchange-rate mechanism may help an economic area become optimal. Thus, there is a chronological anteriority of what is Mundell's intuition in 1973 over what will become known, thanks to Frankel and Rose (1998), as the "endogenous optimum currency area" theory. Our main goal in this paper is to provide an empirical assessment of Mundell's intuition using the Economic and Monetary Union (EMU) as an example. Moreover, our findings will allow us to emphasize that Mundell's intuition is already a good answer to what will become a debate on two definitions of economic convergence between Krugman (1993) on the one hand and the European Commission (1990) on the other.

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According to Mundell's arguments, in the absence of capital controls, credibly fixed exchange rates would encourage international portfolio diversification to share the risks from asymmetric economic shocks (McKinnon, 2004). This would, in turn, reduce asynchronous economic shocks helping the creation of an OCA, thus allowing the OCA to arise endogenously. Mundell's intuition in 1973 over the causality of an OCA is based on allocation of capital. Later, Frankel and Rose (1998, 2002) grasp the concept of "endogenous" optimum currency area: "The OCA criterion might be satisfied *ex post* even if not *ex ante*." They relate this endogeneity to trade integration and show that trade integration reduces the likelihood of asynchronous economic shocks.

Ching and Devereux (2003) consider Mundell's intuition in 1973 to examine from a theoretical perspective the tradeoff between the adjustment benefits of a flexible exchange rate on the one hand, and the risk-sharing benefits of a single currency area on the other, as in Mundell (1973). Our study wants to bring empirical evidence to Mundell's intuition and uses the EMU as an illustration. We examine to what extent the transition to the euro endogenously affected the allocation of capital across the European Union.

Europe designed institutions to assure economic convergence prior to the introduction of the euro abiding by a strict definition of the OCA theory. Initiated in 1993, the Maastricht Treaty set out strict guidelines for member states to follow with the ultimate goal of adopting a single currency. The adoption of the common currency in 1999 concluded the European convergence process.

The first originality of this study is to employ an alternative measure to bilateral trade flows. Indeed, we chose to go back to the original intuition of the endogenous OCA theory found in Mundell (1973) when he refers to the allocation of capital as a result of the use of a common currency. For this purpose, we will use the bilateral foreign direct investment (FDI) flows as a proxy for the allocation of capital as done in Razin et al. (2002) for instance.

The second originality is in the combination of this micro approach (Heckscher–Ohlin variables) with the convergence measure (European macroeconomic aggregates). This approach is inspired by Corsetti and Pesenti (2002) who developed a theoretical model dealing with the micro structure of national economies instead of bilateral trade: imperfect competition, nominal rigidities in the goods markets, and forward-looking price-setting by firms.

The organization of the paper is as follows. Section 2 presents background discussion of the endogeneity argument with respect to European integration. Section 3 presents the methodology of the gravity model used in this study and its connection to multinational firm theory. Section 4 follows with a discussion of the empirical analysis. Finally, section 5 provides some possible policy implications and conclusions.

2. Background Literature

Given the obvious applicability of the OCA theory to European integration, the European Commission (1990) started to work on the steps necessary to enter into an OCA.

To the Origins of the OCA Theory

The OCA theory, first introduced by Mundell (1961), served to frame both the costs and benefits of monetary integration within this political discussion. Since then a vast

literature has developed with notable contributions by McKinnon (1963) and Kenen (1969). According to Frankel and Rose (1998), this literature focuses on four interrelationships between the members of a potential OCA: (1) the extent of trade; (2) the similarity of shocks and cycles; (3) the degree of labor mobility; and (4) the system of risk-sharing, usually through fiscal transfers.

According to Eichengreen (1990), Europe at the time was clearly not an OCA. Consequently, the Maastricht Treaty was implemented in 1993 in order to force convergence to an OCA prior to adoption of a common currency. Five economic proxies were devised to ensure the convergence on the three public policy dimensions: (1) monetary policy (in a closed- and open-economy perspective); (2) fiscal policy; and (3) structural policy. The proxies were respectively: inflation, exchange rate, national debt, public deficit, and long-term interest rates.

The Endogenous OCA Theory: Mundell's Intuition

Although Europe was arguably not an OCA before the inception of the euro (Bayoumi and Eichengreen, 1993, 1997), economic literature started to develop an e-OCA theory known as the endogenous optimum currency area theory. According to Frankel and Rose (1998), adopting the same currency is only one part of the path towards an OCA since using a common currency will also force the economies to become an OCA.

We can already find a similar argument in Mundell (1973): if countries adopt a common currency without substantial changes to their purchasing power parities, and thereby eliminate uncertainty in the exchange rate, then they gain a better allocation of capital. Although this is not yet the endogenous OCA (since Mundell argues that purchasing power parities should demonstrate some steadiness over time), he nevertheless emphasizes that gains in terms of allocation of capital are necessary to *help create an OCA*. We can also find the e-OCA already in the European Commission's (1990) report stating that the EMU will reduce the incidence of country-specific shocks.

3. Methodology and Data

For this study, we propose an empirical analysis of the e-OCA through the use of a different proxy than the bilateral trade used by Frankel and Rose (1998): the bilateral FDI flows. By doing so, we want to measure Mundell's (1973) intuition about the better allocation of capital that would result from the use of a common currency. We use FDI flows as a proxy for the allocation of capital, and—as in Mundell's (1973) argument—we will consider the exchange rates among other variables. This model conforms to the micro-structure approach by Corsetti and Pesenti (2002), as well as De Grauwe and Mongelli's (2005) "intuition" about the rise of FDI when countries belong to the EMU.

We will use a gravity model to analyze bilateral FDI outflows. This model is commonly employed in the study of international trade. FDI is the movement of production activity across the national border. More specifically, FDI is the acquisition of 10% or more of foreign firm assets. According to Feenstra (1999), this internal activity is significantly different from inter-firm linkages that can be established when independent firms interact. The acquisition of a foreign subsidiary for production or branch distribution includes benefits such as lower trade costs and information costs. Barrel and Pain (1997) argue that FDI is not simply an alternative method to increase firm production capacity, but becomes a channel for the transfer of knowledge capital and transaction technology.

According to the convergence criteria, the European integration process is focused on inflation, budgetary, exchange rate, and interest rate convergence. These criteria account for every aspect necessary for monetary, fiscal, and structural stability, yet the effect of these measures on bilateral foreign investment—largely a microeconomic phenomenon—has not been the focus of past empirical research. The following section presents the model used in this empirical analysis and application of the convergence criteria into an econometric framework.

The empirical analysis is based on a variant of the gravity model, commonly used to analyze bilateral trade flows.[1] The dataset is composed of aggregate annual bilateral flows of foreign direct investment between EU-15 members (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom) from the OECD and are expressed in million euros. There are $N = 14 \times 13 = 182$ bilateral relations per time period (i.e. aggregated cross-sections).[2] The data cover the period from 1994 to 2005, yielding a total sample of $n = 182 \times 12 = 2184$ bilateral observations. Since the dataset includes missing observations, the actual dataset is smaller and unbalanced.[3]

The model is estimated using the following gravity equation and includes Heckscher–Ohlin variables (market size, income similarity, factor endowments, and distance) as well as proxies for capturing the European convergence (interest rate difference, budget difference, and debt difference):

$$\begin{aligned}\ln(FDI_{ij,t}) = {} & \alpha_s + \beta_1 G_{ij,t} + \beta_2 S_{ij,t} + \beta_3 R_{ij,t} + \beta_4 D_{ij,t} + \beta_5 IRDIF_{ij,t} + \beta_6 BGTDIF_{ij,t} \\ & + \beta_7 DBTDIF_{ij,t} + \lambda_0 EMU_t + \lambda_1 (G*EMU)_{ij,t} + \lambda_2 (S*EMU)_{ij,t} \\ & + \lambda_3 (R*EMU)_{ij,t} + \lambda_4 (D*EMU)_{ij,t} + \lambda_5 (IRDIF*EMU)_{ij,t} \\ & + \lambda_6 (BGTDIF*EMU)_{ij,t} + \lambda_7 (DBTDIF*EMU)_{ij,t} + \varepsilon_{ij,t}, \end{aligned} \tag{1}$$

where bilateral country pairs are denoted *ij* = Austria–Belgium, Austria–Denmark, . . . , UK–Sweden [168], and time $t = 1994, 1995, \ldots, 2005$ [7].

EMU is a dummy variable that takes a value of zero for every year when both countries in a pair are not EMU members, and one from when both countries in the pair are EMU members. For pairs with countries that are not yet EMU members, the value will be zero for the whole sample. This approach will make us able to use these pairs as a *de facto* control group, an approach that will be reinforced by the interaction variables. Indeed, moreover we interact this dummy variable with the variables representing market size, market similarity, factor endowments, distance, interest rate, differences in budget deficits, and differences in public debts. This helps us isolate whether being an EMU member matters or not compared to not being a member, while using the exogenous variables we specified.

The explanatory variables[4] take the following forms:

$$\begin{aligned} G_{ij,t} &= \ln(Y_{it} + Y_{jt}), \\ S_{ij,t} &= \ln\left(1 - \left(\frac{Y_{it}}{Y_{it} + Y_j}\right)^2 - \left(\frac{Y_{jt}}{Y_{it} + Y_j}\right)^2\right), \\ R_{ij,t} &= \left|\ln\left(\frac{gcf_{it}}{N_{it}}\right) - \ln\left(\frac{gcf_{jt}}{N_{jt}}\right)\right|, \\ IRDIF_{ij,t} &= |interest_{it} - interest_{jt}|, \\ BGTDIF_{ij,t} &= |budget_{it} - budget_{jt}|, \\ DBTDIF_{ij,t} &= |debt_{it} - debt_{jt}|. \end{aligned} \tag{2}$$

This model with interaction terms is developed to test for a structural shift in the FDI as a result of a country's entry into the eurozone.[5]

Expected signs are given above the respective coefficient.[6] Note that the dependent variable *FDI* represents the flow value rather than stock measurement more commonly used in empirical analysis.[7] In this case, FDI flows capture the creation of new linkages between multinational firms and foreign affiliates.[8] Fixed effects are denoted α_s, and recognize country-specific (symmetric) heterogeneity, but homogeneity when $i = j$ (i.e. when i = Austria or j = Austria, then the dummy variable takes a value of 1, and 0 otherwise). Therefore, heterogeneity models country-specific participation or investment intensity instead of modeling heterogeneity between source and host countries.[9] The error term, $\varepsilon_{ij,t}$, represents all unobserved bilateral effects.

The four Heckscher–Ohlin variables (*G*, *S*, *R*, *D*) resemble the Helpman (1987) specification: *G* is the measure of "market size" (see Table 1) or overall "economic space," *S* is an index that captures the relative size of the two economies that is bounded between absolute divergence in size and equality in country size, called "market similarity," *R* measures the relative difference between the two countries in terms of relative "factor endowments," and *D* denotes the log of the "distance" between the economic centers of the two countries.

The three European convergence variables are as follows: *IRDIF* is the difference in "interest rates" between country *i* and *j*, *BGTDIF* represents the difference in the government "budget surplus or deficit" as a percentage of GDP between the source and host country, and *DBTDIF* is the difference of the "debt-to-GDP ratio" between each country pair.

A simple OLS estimate of our model would impose strict restrictions that might not be justifiable given the complicated nature of our dataset. Specifically, we expect both temporally-dependent interactions as well as interactions between country panels that contradict OLS assumptions. The presence of serial correlation and panel heteroskedasticity were of key concern in our estimation of this model.

A way to check for autocorrelation is to use Baltagi and Wu's (1999) LBI test or a modified Durbin–Watson test for unequally spaced panel data (Bhargava et al., 1982). If there is autocorrelation, the option would be fourfold: (1) a dynamic panel model (two-way random effect model or error-component model) with first differences, sometimes known as a Prais–Winston transformation or a Cochrane–Orcutt transformation; (2) a dynamic model with lagged dependent variables with two slightly different approaches known as one- or two-step general methods of moments (GMM) estimators as in Arellano and Bond (1991) or Arellano and Bover (1995);[10] (3) a weight-adjusted combination of the White and Newey–West estimator to handle both the heteroskedasticity and the autocorrelation in the model; or (4) a feasible generalized least squares procedure (FGLS, or a two-state generalized least squares model) as in Parks (1967) and Kmenta (1997), in which the model assumes an autoregressive error structure of the first-order AR(1), along with contemporaneous correlation among cross-sections.

The initial set of OLS estimates was subject to several tests to determine the interaction between observations. The assumption of zero autocorrelation was rejected by the Baltagi and Wu (1999) LBI test, while the modified Bhargava et al. (1982) Durbin–Watson proved inconclusive for positive serial correlation. Therefore, the fourth option above was chosen. The model was estimated using the *cross-sectionally heteroskedastic and time-wise autoregressive model* (Kmenta, 1997). Unlike pooled OLS estimation, the Kmenta–Parks method employed here accounts for heteroskedasticity and serial correlation when present.[11]

Table 1. FGLS Estimates, 1994–2005 (double-log specification)

Dependent variable ln(*FDI*); Mean: 5.546547; Std. Dev.: 2.610153			
Variable	*Coefficient*	*Std. error*	*z-Value*
Heckscher–Ohlin variables			
G (market size)	4.314855	0.512326	8.42***
S (market similarity)	2.226209	0.270380	8.23***
R (factor endowment)	–0.549432	0.255997	–2.15**
D (distance)	–0.374466	0.059955	–6.25***
European convergence variables			
IRDIF (interest rate)	0.043582	0.031801	1.37
BGTDIF (budget)	0.006072	0.019587	0.31
DBTDIF (debt)	–0.008472	0.002633	–3.22***
EMU dummy	–6.075481	2.666337	–2.28**
Interaction variables			
G∗EMU	0.400897	0.176866	2.27**
S∗EMU	0.578531	0.190362	3.04**
R∗EMU	0.092518	0.432934	0.21
D∗EMU	0.272843	0.082561	3.30***
IRDIF∗EMU	1.114270	0.427777	2.6***
BGTDIF∗EMU	–0.073306	0.026979	–2.72***
DBTDIF∗EMU	0.006400	0.002738	2.34*
Country fixed effects			
Austria	1.826345	0.526247	3.47***
Belgium/Luxembourg	4.394779	0.456784	9.62***
Denmark	4.320902	0.617082	7.00***
Finland	3.323161	0.671720	4.95***
France	–0.116105	0.120223	–0.97
Germany	–0.238437	0.132065	–1.81*
Greece	1.600035	0.568222	2.82***
Ireland	5.818056	0.720197	8.08***
Italy	–0.788204	0.150330	–5.24***
Netherlands	2.997415	0.359310	8.34***
Portugal	2.031531	0.601689	3.38***
Spain	0.310433	0.213668	1.45
Sweden	4.070427	0.519581	7.83***
Constant	–53.272140	7.437733	–7.16***
$n = 1127$	Likelihood ratio: –1588.169***		

* <0.1 significance; ** <0.05 significance; *** <0.01 significance.

The Kmenta–Parks model is slightly modified. When $T < N$ (here $T = 12$ and $N = 168$) the following assumption is necessary: $E(\varepsilon_{ij,t}, \varepsilon_{ji,t}) = 0$, thereby removing the assumption of contemporaneous correlation among cross-sections.

While our choice of estimation method is not immune to criticism, such as those found in Beck and Katz (1995), the modified FGLS estimates here perform best because of our concern for autocorrelation. One of the main criticisms of the Kmenta–Parks estimates is the possibility of underestimation of standard errors and consequently resulting in an artificially inflated statistical significance. Since the FGLS method could be employed either in a fixed effects or random effects framework

depending on the underlying behavior of cross-sectional heterogeneity, it is essential that an appropriate test be conducted before proceeding with the suitable estimation strategy.[12]

The econometric analysis and discussion of the results are presented in the next section.

4. Interpretation of the Results

We propose to look at the results through the framework of the Heckscher–Ohlin variables (including the interactions), the European convergence variables (including the interactions), and the country fixed effects.

As shown in Table 1, the total market size is highly significant. The positive relation between the estimated coefficient and the dependent variable can be broadly interpreted as the source country's desire to seek out markets that increase the overall access to consumers.

The β_2 coefficient is positive, meaning convergence in terms of income between the country pair results in an increase in FDI outflows. According to these results, multinational firms prefer to invest in markets that are similar in size relative to the host country.

The β_3 coefficient is negative, following the Heckscher–Ohlin conclusions. Convergence in factor endowments (capital and labor) lead to a rise in FDI flows. In other words, the sign of the coefficient suggests multinational firms are not likely to expand production across borders strictly on the premise of lower labor costs in the country of investment within the European Union.

The findings suggest that transportation costs limit intra-EU investment by multinational firms. The β_4 coefficient is negative and statistically significant. Distant markets suffer. Investment, therefore, is not a cost-saving measure in the face of high transportation costs. This is a very standard result capturing the "gravity" feature of international trade.

Being an EMU member more specifically means that these countries converge. The European convergence seen through the usage of the common currency matters: once a country enters the eurozone, market size of the two countries, market similarity, and distance are significant. In other words, a converging Europe measured through the use of the euro reinforces the attractiveness of the eurozone in terms of FDI. Convergence occurs at different levels: at the structural policy level and at the fiscal level.

Our results suggest that a convergence in the long-term interest rate in the source and host countries does not affect multinational firms for the overall sample. However, convergence in terms of interest rate leads to lower FDI flows for the EMU members after 1999 (or at the date of their entry). Indeed, convergence in the long-term interest rate is a sign of a convergence in the structural policies among the EMU countries. In this case, this result suggests that the structural similarity of the countries reduces the interest to invest in these countries.

However, there is also a "reassuring" effect of a European convergence when it comes to the fiscal policy. Management of government debt is determinant of FDI flows for the overall sample: convergence in public debts is significant and negative. Convergence in public debts seems to slightly reassure the investors of a sound situation by raising FDI attractiveness. This "reassuring" effect is reinforced by the results based on the interaction variables: once in the eurozone, FDI seems to flow between EMU countries with a greater difference in debt levels, while market size is still significant, as well as market similarity. This change in sign for the debt variable may find its

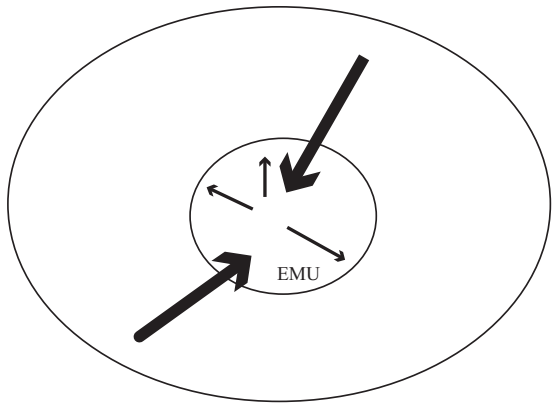

Figure 1. Gravity and Anti-Gravity

explanation in the study of deficits. Within the eurozone, convergence in public deficits are now significant. Convergence in public deficits—constrained by the Stability and Growth Pact—leads to a rise in FDI. Investors indeed seem to be reassured by the homogenization of fiscal policies.

From equation (1), the EMU effect can be obtained by partially differentiating ln(*FDI*) with respect to "*EMU*" and evaluating at the sample means yields 0.7075. This result suggests that belonging to the EMU has a strong effect on FDI from EMU countries to other EMU countries. Our estimation suggests that FDI flows double in this context (an increase of 102%).[13] This number is interesting to consider in line with the results found by Frankel and Rose (2002), who suggest that trade has tripled among currency union members. When it comes to FDI, we show with our interaction model that Mundell's intuition was right, as well as provide an empirical assessment to De Grauwe and Mongelli's (2005) "intuition" about the rise of FDI in Europe when countries belong to the EMU.

Another interesting point is distance. Distance for countries within the eurozone play an interesting role here: the farther the host EMU country the better. So this result suggests that within the eurozone, investors seem to be reassured by the adhesion to the EMU and care less about proximity (see Figure 1). Indeed, one could note from our results that the interaction between distance and the EMU dummy (*D*∗*EMU*) is positive (0.272843 with a significant *z*-value) even though the overall effect is still negative (–0.374466 + 0.272843 = –0.101623). In other words, the "gravity" feature is still there: proximity in the overall sample matters displaying gravity, but once in the eurozone "anti-gravity" forces appear. This result is reinforced by the fact that eventually convergence in factor endowments do not seem to matter anymore once in the eurozone.

Lastly, we briefly mention the symmetric country dummy variables that proxy country participation (both inflow and outflow) of FDI within the region. Interestingly, the most active countries in terms of multinational investment during the period observed have been Ireland, Belgium/Luxembourg, and Denmark for the overall period. These findings are plausible as, comparatively speaking, the home markets of these countries are small relative to those of the region's larger economies. Consequently, multinational firms based in those countries would be the most willing to expand to other markets.

5. Policy Implications and Conclusions

The primary results of this empirical analysis find evidence of growing horizontal integration of the EU-15 based predominantly on market access and consumer income. These intra-industry linkages are the main factors that deepen market integration and allow for synchronization of demand and trade-based shocks. The magnitude of the Heckscher–Ohlin variables, specifically market size and income similarity, allows for a more visible role in determining the creation of horizontal linkages. Europe is indeed becoming an optimum currency area in terms of allocation of capital, as formulated in Mundell (1973).

Convergence thus seems to have occurred supporting the European Commission's (1990) view, instead of Krugman's (1993) comparative argument.

The convergence process of the European member states in the 1990s presents several factors that will guide the future entry of member countries into the monetary union. In May 2004, the European Union expanded to include 10 Central and Eastern European accession candidates. In January 2007, Bulgaria and Romania became EU members. The findings here suggest key characteristics that are necessary to attract intra-EU multinational investment during their accession into the EMU.

Recent studies by Brenton et al. (1999) and Janicki and Wunnava (2004) show that trade between the European Union and these accession candidates is still based primarily on differences in factor endowments—such as labor costs—where production is aimed at re-export back to the EU market, rather than consumption in the candidate countries. Brenton et al. (1999) refer to this as the integration of the accession candidates into the European production process. The results presented here, however, suggest that the structure of current EU production process is quite different. The entry of the accession candidates into the EMU will not depend on the timetable presented by the European Commission; entry will depend on the development of intra-industry linkages and the continued creation of horizontal intensity of investment.

Future empirical research could be useful in further exploring the convergence hypothesis presented in Markusen and Venables (1996). Specifically, the results here follow the hypothesis suggesting that growth in multinational firms is determined by convergence of income levels, relative factor endowments, and size. A future analysis of intra-European imports and exports in modeling domestic firm behavior might be useful in finding further support of European convergence relative to growth in multinational firm activity.

Appendix A: Description of Independent Variables

As the measure of "market size" or overall "economic space," G serves as a proxy for investment that is motivated by market-expansion reasons (Helpman, 1987). The expected value is positive for investment flows under circumstances of horizontal firm integration.

S: if two countries have roughly equal GDP, the coefficient should approach $-0.69 = \ln(0.5)$. Perfect dissimilarity yields a coefficient value that approaches $\ln(0)$.[14] A positive coefficient is evidence of horizontal firm integration, as presented by Brainard (1997) and Markusen and Venables (1998). Similarity in country size is one of the main theoretical determinants of multinational expansion to determine market similarity.

R in this study is the ratio of gross fixed capital formation and country population. The factor endowments variable takes a minimum value of 0, representing equality in relative factor endowments, and a maximum value that approaches 1, the largest

possible difference in relative factor endowments. As mentioned in the preceding section, the importance of factor endowments varies significantly depending on the trade theory hypothesis examined. Horizontal firm integration theory dictates that factor endowment differences are irrelevant and should not be significant (or even exist) among developed countries. As the EU represents a set of well-developed and relatively wealthy countries, movement toward equalization of relative factor endowments is expected to yield an increase in bilateral FDI outflows.

D is a proxy for trade and transportation costs, which has a negative impact on investment and trade flows. Markusen and Venables (2000) argue that distance is not relevant, but transportation costs are important for entry of multinational firms. Investment that promotes production for the foreign market *a priori* should not be greatly influenced by distance. Yet, if distance and transportation costs are inextricably linked, the coefficient on *D* should be negative. The costs associated with distance, such as communication and coordination costs, reduce incentives to new investment.[15] Distance data were obtained from Jon Haveman's website.[16] The variable is defined as the distance between the economic center of one country to another. Note that this does not lead to a value of 0 when countries are adjacent to each other. In the empirical study, we loosely follow Polak (1996) who addresses the built-in bias of the gravity model that is "downward" for "far-away countries" and "upward" for "close-up countries." The solution is to make the distance variable relative to the size of the host country economy. The variable therefore is weighted by the host country population.

IRDIF measures the long-term cost of borrowing. A negative coefficient is expected. Financing of assets and affiliate purchases is likely to come from both the source or target country; convergence in rates of both markets would see an increase in investor confidence and positive FDI flows. In other words, convergence could likely result in tight correlation of the interest rates.

BGTDIF: a convergence in the balance of the budget surplus is expected to increase investment. The intuition behind the expectation is clear: the variable attempts to capture the effect of government fiscal responsibility. Presumably, a multinational firm wishing to expand horizontally will be induced to invest in a market characterized by a similarity in government finances relative to the source country.

DBTDIF represents long-term stability of the government. Since FDI is considered a long-term transaction (as compared to exports, for example), a reduction in the debt differential between countries is likely to lead to an increase in investment flows.

Appendix B: Data Sources

Lastly, we detail the data sources of the variables. FDI outflow data are from the OECD. The flow of FDI is cross-border investment in which the investor has a long-term interest in an enterprise or market in another economy. Investment is composed of two parts: equity capital and other capital. Equity capital includes all branches and ordinary shares in subsidiaries and associates. Other capital is comprised of inter-company debt, such as loans and trade credits, between the investor and the subsidiary (branch or associate). Data are weighted with 2000 as the base year by the CPI provided by Ameco (European Commission).

GDP data are taken from Ameco (European Commission) and expressed in million euros using purchasing power parity (PPP) rates. Data are also converted to a 2000 base year through the CPI provided by Ameco. The total labor force (used in the capital per worker ratio) is defined as the economically active population that contributes to the

production of goods and services in the formal economy. The variable was obtained from the World Bank.

Interest rates represent central government bond yields on the secondary market with a residual maturity of 10 years (Eurostat). Budget surplus/deficits as a percentage of a country's GDP were obtained from Eurostat. The budget of the consolidated central government includes operations of budgetary central government, extra budgetary units, and social security funds. Debt data are compiled by Eurostat. Debt is defined as consolidated gross debt of the central government and subsectors including state government, local government, and social security debt.

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Notes

1. The model was first independently derived by Tinbergen (1962) and Poyhonen (1963). For a theoretical background, see Deardorff and National Bureau of Economic Research (1995). Please see Egger and Pfaffermayr (2004) for an excellent overview of different estimation techniques that are routinely employed for the gravity models.
2. For the empirical study, Belgium and Luxembourg are combined yielding 14 member states. The number of bilateral trading partners is always one less than the number of member states because domestic investment is not considered.

3. Note that 14 cross-sections are missing in the dataset. The majority of these bilateral flows originate from Finland or Ireland, or are destined to Greece. Therefore, $N = 168$ and $n = 2016$. However, after accounting for missing data, our final sample is 1127.
4. Please refer to Appendix A for a description of our independent variables, and Appendix B for sources of the data.
5. The convergence period started in 1993 and finished in 1998. We start in 1994; however, not using 1993 should not be an issue, since the relevant years for the entry into the EMU were 1997 and 1998.
6. An exchange rate variable and an absolute inflation-rate variable were included in the initial analysis to account for all Maastricht Treaty criteria. Both variables yielded statistically insignificant results and were excluded from the final model.
7. See Brenton et al. (1999), and Egger and Pfaffermayr (2004) for empirical research employing FDI stock values.
8. The dependent variable for FDI is in log form, reflecting only positive investment; disinvestment is recorded as 0. A value of 1 is added to each FDI value to avoid ln(0). This does not bias the estimates as $\ln(1 + FDI_{ij,t}) \approx \ln(FDI_{ij,t})$ when $FDI_{ij,t}$ is large. But, where $\ln(FDI_{ij,t}) = 0$, then $\ln(FDI_{ij,t} + 1) = 0$.
9. For a generalized fixed effects gravity model, see Baltagi et al. (2003).
10. GMM is usually robust to deviations of the underlying data-generation process to violations of heteroskedasticity and normality, insofar as they are asymptotically normal, but they are not always the most efficient estimators.
11. First, OLS is used to obtain the regression residuals, which are then used to obtain a transformation that has an asymptotically non-autoregressive and homoskedastic error term. The other characteristics of the general Kmenta–Parks model are as follows:

$$\mathrm{E}(\varepsilon_{ij,t}) = \sigma_{ij}^2 \text{ (heteroskedasticity)};$$
$$\mathrm{E}(\varepsilon_{ij,t}, \varepsilon_{ji,t}) = 0 \text{ (where } ij \neq ji \text{ denotes cross-sectional independence)};$$
$$\varepsilon_{ij,t} = \rho\varepsilon_{ij,t-1} + \mu_{ij,t};$$
$$\mu_{ij,t} \sim N\left(0, \sigma_{\mu_{ij}}^2\right);$$
$$\varepsilon_{ij,t} \sim N\left(0, \frac{\sigma_{\mu_{ij}}^2}{1-\rho^2}\right);$$
$$\mathrm{E}(\varepsilon_{ij,t-1}, \mu_{ji,t}) = 0, \quad \text{for all } ij, ji.$$

12. According to the Hausman specification test, the cross-sectional heterogeneity can be treated as random, if the null hypothesis H_0: $\mathrm{E}(\mathbf{Z}'_{ij,t}, \varepsilon_{ij,t}) = 0$ cannot be rejected, signifying a lack of correlation between the explanatory variables and the disturbance term. However, with $\chi_7^2 = 61.6$, which is significant at the < 0.01 level, the stated null hypothesis could be rejected, signifying correlation between the explanatory variables and the disturbance term. Accordingly, a fixed effects model is preferred. The reported test statistic is based on our sample employed in Table 1 empirical analysis. This finding is in accordance with Egger and Pfaffermayr (2004). Specifically, the cross-sectional heterogeneity dimension is captured by employing 13 symmetric dummies given a total of 14 countries included in the sample. As suggested by Greene (2003), a maximum likelihood estimation method is employed for obtaining the FGLS estimates reported in Table 1.
13. $(e^{0.7075} - 1) = 1.02891$ (i.e. 102.891%). Given the log–lin nature of the empirical model, the coefficients scaled as $(e^{\beta} - 1)$ could be interpreted as partial elasticities (i.e. a resulting percentage change in FDI flows when all countries—sources and hosts—are EMU members).
14. In the case of a country pair approaching perfect dissimilarity, the coefficient approaches $-\infty$.
15. It is worthwhile to point out that if horizontal FDI is aimed as a substitute for exports due in part by higher transportation costs, then the expected value should be positive. This argument is in line with theory presented in Markusen and Venables (1998). This study does not look at lower FDI transportation costs relative to bilateral trade transportation costs; instead, the variable is focused on measuring significance of absolute barriers to investment.
16. http://www.macalester.edu/research/economics/page/haveman/trade.resources/TradeData.html.