A Global Database of Foreign Affiliate Activity[1]

Tani Fukui[2]
Csilla Lakatos

Abstract

This paper produces a new dataset to further the literature on the behavior of multinational firms. The Eurostat database, with a large number of sector-level, bilateral observations on foreign affiliate sales, provides a basis from which to extrapolate the relationships between various host and source country factors and the foreign affiliate activity produced by them. This paper exploits the detailed level of the data by introducing sector-specific variables which in turn permit out of sample predictions. Further, the large number of excess zeros in the Eurostat dataset presents added complexity and is handled using techniques borrowed from the trade literature, which also experiences a "zeros" problem. The datasets produced in this paper also serves as an input into the FDI-GTAP model of Lakatos and Fukui (2012). This model integrates the datasets produced in this paper into a model that permits the analysis of the behavior of foreign affiliates within the context of a general equilibrium model. The dataset is combined with other data on foreign affiliate sales and together with an optimization procedure produces a new dataset based on all of these data sources.

I. Introduction

The examination of foreign affiliate data is a relatively new branch of the literature, owing primarily to the paucity of data in this area of research. Foreign direct investment (FDI) statistics are collected by numerous countries, but these do not provide a complete picture of the activities of multinational enterprises. In particular, FDI examines only the international transfer of funds rather than their operations. Without data on operations of multinationals, it is difficult to assess the effect of policy changes on foreign affiliate activity. As foreign affiliate activity grows in importance, this lack of data is slowly being addressed, and research is able to move forward. In particular, the establishment of the Eurostat database provides a much needed boost for in this area of research. Eurostat provides a large amount of data on foreign affiliate activity, rather than data only on investment stocks or flows. This

[1] Formerly "Estimating Foreign Affiliate Activity in European Countries"

[2] Corresponding author. Tani Fukui (tani.fukui@usitc.gov) is an economist at the U.S. International Trade Commission from the Office of Economics. These views are strictly those of the author and do not represent the opinions of the U.S. International Trade Commission or of any of its commissioners. Csilla Lakatos is a Post-Doctoral Research Associate at the Department of Agricultural Economics at Purdue University and Visiting Fellow at US ITC.

paper uses the Eurostat dataset to estimate the behavior of foreign affiliate sales as a basis. It implements an econometric model consistent with the branch of the literature that originated in Markusen, et al (1996) and Markusen (1997) and that includes Bergstrand and Egger (2007) and Carr, Markusen, and Masksus (2001).

Blonigen (2005) provides a comprehensive review of the recent literature on FDI determinants. He concludes that the broad-based relationships between FDI and policies have been difficult to come by.[3] More importantly, he assesses that as FDI research progresses (it is still a relatively new area of research), it will continue to be thwarted in its search for overarching relationships, primarily because the reasons for which firms invest abroad are many and varied.

The economic literature on the drivers of FDI identifies two main types of investment rationales: market access (selling to consumers in the host market) and efficiency seeking (searching for low cost production sources). In addition, the proliferation of global supply chains has led to variations on each of these themes, so that goods (and to a lesser extent services) pass through multiple countries with final consumption sometimes taking place in one of the production countries, so that both efficiency seeking and market access motivate the foreign investment.

This heterogeneity can best be addressed by examining the matter at a less aggregated level—honing in on particular sectors or countries, in which the investment rationale may be more uniform. As a result, the literature has increasingly gone the way of firm-level analysis, which permits the researcher to control more tightly by type of investment rationale. Despite this trend, we follow the literature in examining macro-level FDI statistics. However, in many cases, such as for the project we have taken on, it is necessary to make some assessment of overall macroeconomic behavior, although it may simply be a rough approximation of true firm behavior. Firm-specific effects cannot hope to provide approximations of macro-level activity, as well as a matter of practicality in attempting to estimate these effects for a large number of countries.

A problem presented by this dataset is the existence of a large number of missing values. This is a problem that has not been extensively addressed in the FDI literature. On the other hand, it has been addressed in the trade literature, which also has such problems. We integrate some approaches of that literature in our estimation strategy, in particular, the Pseudo Poisson Maximum Likelihood proposed by Santos, Silva, and Tenreyro (2005) and the zero inflated models discussed in De Benedictis and Taglioni

[3] The study examines both investment stocks and flows as well as operations of multinationals.

(2011). Finally, there has been very little use of sector specific data in foreign affiliate data research, largely because it is not usually available. We take advantage of this extra dimension in the model to attempt to estimate sector-specific differences in foreign affiliate activity using sector specific data.

In addition to the zeros problem, there is also a large number of missing values in the database that prevents the immediate use of these data in the FDI-GTAP model. This is due both to confidentiality or missing values (so that source-host-sector points are not available in many cases), and also to the constrained set of countries in the database. The database documents data to and from European countries only. In order to apply the database to the full FDI-GTAP model, it is necessary to extrapolate to all regions used in the GTAP model. The coefficients generated from the following econometric analysis will be used as a starting point for the extrapolation.

To our knowledge, there has been only one prior attempt, in Hanslow (2000), to construct a large scale, bilateral by sector, fully consistent database of foreign affiliate statistics. The purpose of that database was, as with ours, to use it within a version of the GTAP model modified to include FDI. There are a few key differences between their estimation attempt and ours is as follows. Hanslow (2000) used ratios of foreign affiliates data—total assets to FDI capital and sales to asset ratios—by sector, extracted from U.S. BEA data , and applied those ratios to FDI stocks reported by CEPII. Similar ratios were used for value added. In our method, we broaden the set of underlying countries to include all European countries reported in the Eurostat database (the full list of countries is below) rather than relying solely on U.S. data. In addition we estimate the effects using a fully specified econometric model which does indeed display significant differences across both host and source countries, as well as across sectors. The use of econometrics within this context, therefore, is new. In addition, due to improvements in data collection by Eurostat, it has become possible to examine the cost structure of foreign affiliates using value added and employment costs. Therefore, rather than relying on calculations of value added based on pro rata allocations from sales, we are able to directly estimate the labor and capital shares of value added.

In the second section we provide some background literature on prior estimation of foreign affiliate activity. The third section focuses on the estimation of foreign affiliate sales, including data source and estimation model, with the fourth section discussing the results. A fifth section presents some additional estimates that will be necessary to construct the final database. A sixth section describes the quadratic optimization procedure and presents elements of the final database. The seventh section details the estimation of value added. A final section concludes.

II. Background

In order to properly model the behavior of foreign affiliates, we need to obtain estimates for foreign affiliate sales. The model needs to partition out the activity of domestically-located firms into domestically-owned firms and foreign-owned firms. This requires data on the ownership breakdown in each host country by each source country. Moreover, it requires such data for both the demand (sales) and the supply (production) side of the model. For sales we require foreign affiliate sales data. For production, we obtain data on capital as well as on labor and capital value added. In this section we explain our strategy for constructing a database of foreign affiliate sales, and in section 7, we discuss the value added data for the production side.

There is currently no global database of foreign affiliate sales. The closest such source available to us is the Eurostat database which has detailed sectoral level foreign affiliate sales by source country for many European countries. In order to construct the required database, we first conduct an econometric analysis of the existing data to produce a set of coefficients that provide information about the relationship between various independent variables and foreign affiliate sales. These coefficients are then used to extrapolate to the full set of countries and sectors needed by the GTAP model.[4] Finally, the extrapolated dataset is merged with the original Eurostat dataset in addition to data from the OECD, the U.S. BEA, and UNCTAD. Contradictory information among these data sources is resolved using an optimization procedure explained in detail in section 6.

There is a small but growing set of literature that has in recent years attempted to produce a well-formed model for the use of gravity-like models for FDI and foreign affiliate activity in the way that Anderson and van Wincoop (2003) have done for trade flows. Generally, the literature on FDI follows closely that of trade. The gravity model, frequently employed to explain trade flows, has also been employed to explain FDI. As with trade, the rationale for the gravity model began as a practical matter: the model "worked" in that it had a high degree of explanatory power, but the theoretical foundations were shaky or non-existent. In recent years, however, progress has been made in providing theoretical underpinnings to the model. These theories have naturally also produced modifications that are FDI-specific and warrant close attention.

[4] Certain sectors are aggregated from the original GTAP model, including particularly the agriculture sectors.

The set of models described in Markusen (2002) is one of few strands of literature to explicitly examine foreign affiliate sales rather than FDI. Kleinert and Toubal (2010) also present a model on foreign affiliate sales, lending further support to a gravity-type model. The original paper by Markusen discusses a 2 factor, 2 country, 2 good (2 x 2 x 2) knowledge capital model, whose main contribution is to delineate the difference between horizontal multinationals (those firms that establish subsidiaries abroad to sell in those markets) and vertical multinationals (those firms that establish subsidiaries abroad to reduce production costs).

The main predictions are the following. First, foreign affiliate sales reach a maximum when a country is relatively skilled-labor abundant and small: in this case, it will have large foreign sales. This is the story, for example, of Singapore or the Netherlands investing abroad. Second, among countries that have similar relative skill levels, the maximum sales level will occur between two countries that are similarly sized. Affiliate sales in Germany by the U.K. are an example of this. Significantly, this model does not make a stand for either the efficiency or the market access model. When two countries are similarly sized, there may be more of a market access motive; when the source country is smaller, efficiency motives may predominate. However, non-linearities in the model mean that the model does not provide a clear switching point between the two.

The key econometric implications are the inclusion of a skill gap between source and host countries' labor endowments (skilled and unskilled), and an interaction term between the relative size of the host and source countries and their relative labor endowments. This paper postulates a link between the skill gap between source and host country. However, this skill gap has a complex relationship with FDI, rather than a clear monotonic relationship. The skill gap is expected to have a positive coefficient, while the interaction term is expected to have a negative effect on sales.

The idea of the model is to permit both "horizontal and vertical motives for direct investment", although they do not attempt to test which model dominates. The model also fully endogenizes trade via trade costs. There are significant nonlinearities in the model results (not to mention a lack of closed form solution) with the implication that specifying the appropriate econometric equation is a non-trivial matter. In order to address this problem, the authors selected the range of the model to which the observed data belong, and use the relationships in that range.

In Carr, Markusen, and Maskus (2001), a horizontal and a vertical model are nested within the knowledge capital model in order to test whether one or the other is supported by the data. The results of these tests reject the vertical model, and cannot reject the horizontal. That is, at the aggregate level, the data demonstrate more horizontal than vertical characteristics. The data used are U.S.-associated values only (foreign affiliate sales), aggregated to the bilateral level. Rather than an OLS model, they use WLS as well as a Tobit model. The main concern is heteroskedasticity because countries differ so much in size. The weights come from OLS residuals of the sum of GDP values. The Tobit regressions are done in order to address the issue of zeros.

Bergstrand and Egger (2007) (henceforth BE) uses an updated version of the model that advances this literature in a parallel way to the trade literature. This paper presents a 3 factor, 3 country, 2 good knowledge capital model that builds on Carr, et al (2001). The model in BE adds a third country: this permits the examination of third country effects on bilateral trade flows. That is, it attempts to examine whether the gravity relationships found in the trade literature also hold for foreign affiliate sales (and also for FDI). In particular, they attempt to examine essentially whether an Anderson and van Wincoop type effect is present, i.e. the multilateral resistance term. As noted by BE, most models in the FDI literature examine a two country model rather than a multi-country model which does not permit multilateral resistance terms.

In addition, they add a third factor (capital) that together with the third country produces complementarity between country size and the various trade variables (trade, foreign affiliate sales, and foreign direct investment). In the original 2x2x2 model, the national and multinational firms were mutually exclusive so that the existence of multinationals would mean that all single-country firms would cease to exist, which is counter to what is observed in the data.

Yeaple (2003) is a rare example in the literature of a paper that uses sector-specific data to distinguish FDI behavior. He uses U.S. BEA foreign affiliate sales data at the bilateral and sectoral level. Yeaple uses the following sector specific information: transport costs (industry and host country specific), a measure of scale economies (industry specific), and a set of variables that reflect unit costs (industry and host country specific).[5]

III. Data and Econometric Specification

[5] Anderson and van Wincoop (2004) also presents a sector level model, although it is to explain trade flows rather than foreign affiliate activity.

The model we use is based on a modified version of BE and Carr, et al. The BE paper and CMM have largely similar econometric specifications. We modify them in the following ways. First, based on the results presented in the BE paper, the FAS behaves similarly to FDI and so we replace the FDI with FAS. Second, we account for the sector specific nature of our data by replacing the GDP of host countries with the domestic production by sector. We follow Anderson and van Wincoop (2004) in replacing GDP of the host country with domestic production rather than adding this to the regression.

$$\begin{aligned}\ln(FAS_{irst}) = {} & \alpha_0 + \beta_1 \ln(\text{GDP}_{st}) + \beta_2 \ln(\text{GDPROW}_{rst}) + \beta_3 \ln(\text{Production}_{irt}) \\ & + \beta_4 \ln(\text{transport costs}_{rst}) + \beta_5 \ln(\text{investment costs}_{\text{rst}}) + \beta_6 \ln[(S/U)_{rst} / (S/U)_{rst}] \quad (1) \\ & + \sum_t \gamma_t + \varepsilon_{irst}\end{aligned}$$

The subscript i refers to sectors, r refers to host; s refers to source, and t refers to time. The model includes a full set of time dummies, γ_t. All independent variables are listed in table 1, along with the data source used and summary statistics.

GDP is the GDP of the source country. There is considerable variation in the GDP variables, despite the fact that the countries are predominantly European countries, reflecting that both large and small countries are included in the sample. These data are from World Bank World Development Indicators.

GDP RoW is the GDP of the rest of the world, i.e. GDP of the world less GDP of both source and host countries' capital cities. The variation of this variable is quite small, as the size of countries is generally dwarfed by the size of global GDP. These data are also from WDI Online.

Rather than GDP of host, we use domestic production of individual sectors, *Prod*. This includes both domestically- and foreign-owned firms. This also has a large standard deviation, reflecting both varying sizes of countries and of sectors. These data are also from Eurostat and correspond to the same sectors provided in the foreign affiliate sales database.

Other variables used in gravity type models are distance, *Dist,* the distance between source and host, and *Comlang*, a binary variable that takes the value of 1 if source and host share at least one language.

Comlang is predominantly 0, taking on the value 1 in only a handful of cases. Both this and the distance variables were obtained from CEPII.

Table 1. Independent Variable

	Years available	Source	Dimension	Units*	Mean	Median	Minimum	Maximum	Standard Deviation
Foreign affiliate sales	2003-2007	Eurostat (FATS)	sector, source, host, date	$ million	140	0	0	54,100	1,090
GDP, source	through 2009	World Bank	source, date	$ billion	830	233	5	14,000	1,920
Domestic production, host	2007	Eurostat	host, sector	$ million	14,700	1,780	0.4	584,000	49,200
GDP RoW	through 2009	World Bank	source, host, date	$ billion	44,800	45,000	24,500	55,700	6,370
Distance	n.a.	CEPII	source, host	km	3,314	1,727	161	19,539	4,215
Common language (ethno)	n.a.	CEPII	source, host	0 or 1 (1 = common language)	0.03	0	0	1.00	0.16
Economic Freedom: Trade	1995-2008	Economic Freedom Network	host, date	scale of 1 to 10 (1 = most restricted)	8.5	8.5	6.8	9.8	0.6
Economic Freedom: Investment	1995-2008	Economic Freedom Network	host, date	scale of 1 to 10 (1 = most restricted)	6.7	6.7	4.3	8.6	0.9
FDI restrictiveness	2010	OECD (2010)	sector, host	Scale of 0 to 1 (1 = most restricted)	0.02	0	0	1.0	0.1
Skill difference	1989-2008	ILO	source, host, date	skill/unskilled ratio of source less host	-0.6%	0.1%	-38.5%	28.8%	10.4%

* Units are as reported here for ease of notation; for the regressions we use whole dollar values (rather than millions, etc.) for all values. *Note:* Summary statistics include only those observations that were ultimately included in regressions. There were a total of 41,083 observations with a complete set of independent variables, including those for which foreign affiliate sales was zero.

Trade openness is a measure of aggregate trade restrictiveness set up by the host country. This index is obtained from the Fraser Institute's Economic Freedom of the World report, which uses primarily quantifiable measures on a range of topics to measure a country's economic freedom. The trade index, "Freedom to Trade Internationally", takes into account total revenues from tariffs, mean tariffs and the variance of tariffs across tariff lines.

It is clear from the summary statistics that the openness observations are dominated by European countries that have extremely low trade barriers. As a result, the minimum trade barrier reported is quite high (6.8 out of a possible 10), and the average, at 8.5, represents something substantially close to free trade. There is little variation in this variable.

Investment openness is a measure of investment restrictiveness of the host country. This is also taken from the Fraser Institute's Economic Freedom of the World report. The investment measure measures international capital market controls, including restrictions on foreign ownership as well as the number of capital controls put in place by a country. There is somewhat more variation of this variable than in the trade openness variable.

FDI restrictiveness was obtained for G20 countries using Koyama and Golub (2006). This is a sector specific restrictiveness index, which takes into account foreign ownership and other national treatment aspects of investment. The index is similar to the EFW investment index but the EFW index offers a time series while the Koyama and Golub index offers sectoral detail.

The variable ΔSK is the skill difference between two countries: the ratio of skilled to unskilled workers in the source country less the same ratio for the host country:

$$\Delta SK_{ijt} = \frac{SK_{it}}{USK_{it}} - \frac{SK_{jt}}{USK_{jt}}$$

where SK is skilled labor, defined as subclassification 1, 2, or 3 (legislators, senior officials and managers; professionals; and technicians and associate professionals) by the ILO.[6] This is a negative number at the mean, so that the average source country has less skilled workers (relative to its stock of unskilled workers) than the average host country. Countries that are in the source list but not in the host

[6] ILO.org's LABORSTA database. Labor force survey data were used for all countries: http://laborsta.ilo.org/

country list include China, Russia and Turkey. There is a great deal of variation among countries in this variable.

The rationale is that countries have a comparative advantage in certain sectors and develop strong multinational firms in those sectors with transferable skills that in turn invest abroad. Domestic production shares are also included as host country variables to capture the effect of a country that has a pronounced comparative advantage that is not transferable. This is most explicit in natural resources, but may also be a factor in manufacturing industries, where countries specialize in specific manufacturing sectors.

Foreign Affiliate Sales Data

The primary data source that we use in our analysis is Eurostat's data on Foreign Affiliates.[7] This is our set of dependent variables. The dataset contains 41 source and 22 host countries (see appendix tables A-1 and A-2). The host countries are the reporting countries, and are all European; most, but not all, source countries are European. The database provides "three dimensional" data: foreign affiliate sales by source country, host country, and sector. A total of 117 sectors and subsectors are covered in the original database. Only a relatively small subset of 21 sectors was selected—this is both because of lack of the corresponding sectoral data of an independent variables, domestic production, and to more closely match the targeted GTAP sectors. The database spans the years 2003 to 2007.

The dependent variable is foreign affiliate sales. These are taken from the Foreign Affiliates Statistics produced by Eurostat. The database has a large number of gaps (see Table 2).

Table 2. Foreign Affiliate Sales Observations

Type	No. Observations	share
Missing	76,703	48%
Zero	74,087	46%
Positive	10,325	6%
Total	**161,115**	

Note: Data are from the Eurostat FATS database, 2003-2007

[7] Variable **fats_g1a_03** under the category "Foreign control of enterprises - breakdown by economic activity and a selection of controlling countries". Accessed May 17, 2011. Data are originally in Euros and presented throughout this paper in US dollars. These data are from the *inward* FATS data collection, so that host countries are the reporting countries.

This is partly because the database is very ambitious: the database aimed to collect data on 117 sectors and subsectors, but very few countries reported on more than a small fraction of these sectors. Just under 50 percent of all possible observations are missing. In addition, over 45 percent of the possible observations are zero values: these are either smaller than the threshold set by Eurostat (500,000 Euros) or actually reported as zero. The presence of these zeros means that the econometric specification must be carefully determined, as discussed in the econometrics section. Some summary statistics for foreign affiliate sales are noted in the appendix.

At the level of disaggregation we use, Eurostat reports $4.3 trillion in foreign affiliate sales in 2007. In 2003, the sales are only $1.5 trillion. However, due to the missing values problem this does not necessarily imply a 30 percent annual growth rate, but rather that the data collection and coverage have expanded over these years.

According to the raw data, approximately two thirds of foreign affiliate sales reported in the dataset takes place in three countries – Germany, the United Kingdom, and Italy. Sector level data is also highly concentrated, with nearly 80 percent reported by two sectors: 46 percent by wholesale and retail trade, and 33 percent in manufacturing. These shares are of course influenced by reporting bias – if these countries or sectors are more likely to be able to report their affiliate sales, then they are overrepresented in these aggregate totals.

Out of the $4.3 trillion in sales, only $1.7 trillion is used in the regressions. This is largely due to the relative paucity of data on domestic production of hosts.[8]

Estimation Strategy

The large number of zero cells in the dataset calls into question the conventional strategy used in the FDI literature. Much of the literature on FDI uses OLS to estimate the relationship between FDI and the dependent variables. The log transformation commonly used in OLS does not permit an explanation for zeros. More problematically, OLS does not model the decision to enter (or not enter) a market as a separate process but rather simply models zeros as part of a linear function.

[8] It should be noted that when the database is constructed, the original $4.3 trillion worth of observations are used to reconstruct it.

Table 3. Foreign affiliate sales data by host country (in $ billions)

Host Country	2003	2004	2005	2006	2007
Austria	64.1	-	-	-	208.0
Bulgaria	3.4	8.7	12.5	14.8	-
Cyprus	-	0.2	0.6	1.4	1.6
Czech Republic	37.8	57.9	61.4	74.2	-
Germany	-	-	-	399.0	1,260.0
Denmark	-	-	-	37.5	77.3
Estonia	1.8	3.5	5.8	7.3	8.7
Spain	162.0	201.0	265.0	235.0	-
Finland	23.1	33.0	57.4	52.0	69.8
France	627.0	748.0	794.0	830.0	-
United Kingdom	-	-	-	994.0	1,160.0
Hungary	24.3	39.4	38.9	89.3	146.0
Italy	325.0	376.0	388.0	506.0	530.0
Lithuania	2.7	3.0	4.6	6.6	-
Latvia	2.7	3.4	5.8	8.2	11.6
Netherlands	98.8	170.0	198.0	-	287.0
Poland	-	-	-	-	188.0
Portugal	26.8	24.4	43.7	49.7	70.8
Romania	6.0	14.5	15.4	79.6	72.9
Sweden	94.1	138.0	158.0	163.0	206.0
Slovenia	3.9	4.7	-	10.0	5.2
Slovakia	12.2	19.2	22.6	20.0	29.4
Total	**1,515.6**	**1,845.0**	**2,071.7**	**3,577.6**	**4,332.3**

Note: Data are for all reported values of Eurostat. Not all observations are used in the regression analysis.

Table 4. Foreign affiliate Sales by sector (in $ billions)

Sector	2003	2004	2005	2006	2007
Mining and quarrying	1.8	1.6	1.6	44.1	52.4
Manufacturing	670.0	751.0	819.0	1,360.0	1,440.0
Electricity, gas and water supply	11.2	19.7	17.0	34.3	38.0
Construction	8.9	14.1	16.9	41.1	56.8
Wholesale and retail trade	550.0	721.0	870.0	1,390.0	2,000.0
Hotels and restaurants	11.8	12.4	16.0	29.1	23.6
Transport, storage and communication	56.3	76.8	80.4	202.0	254.0
Financial intermediation	82.1	63.1	48.2	71.8	29.6
Real estate	124.0	185.0	204.0	404.0	430.0
Total	**1,516.1**	**1,844.7**	**2,073.1**	**3,576.4**	**4,324.4**

Note: Data are for all reported values of Eurostat. Not all observations are used in the regression analysis.

The trade literature has examined this problem extensively, as trade data also tends to have a large number of zeros. In our estimation procedure, we implement both OLS and several other methods borrowed from the trade literature, modified to include FDI-relevant variables. However two possible

problems have been pointed out by other researchers. First, that it under-predicts the number of zeros; second that there is over-dispersion as PPML requires that mean and variance be roughly equal. Zero-inflated models are proposed to remedy the first problem while negative binomial regressions relax the equality of mean and variance.

Santos Silva and Tenreyro (2005) propose the use of Poisson Pseudo Maximum Likelihood (PPML). The original purpose of this method was to address the pervasive heteroskedasticity in the gravity equations rather than specifically addressing excess zeros. However, the Poisson distribution does permit zeros to occur, allowing an explanation of the prevalence of zeros. They demonstrate that Poisson performs well under certain heterogeneity conditions.

One argument that has been raised against the use of the PPML model is that it does not explicitly model excess zeros. This argument has been put forth in a number of papers such as Martin and Pham (2008) and De Benedictis and Taglioni (2011) , who have proposed other methods such as the zero inflated models ZIP (zero inflated Poisson) and ZINB (zero inflated negative binomial), Zero-inflated models are models that combine a logit model with a Poisson type model. As a result, there are two possible ways in which these models can generate a zero: first, under the logit portion of the model, which predicts a binary go/no go decision; and second under the main part of the model which, conditional on a "go" decision of the logit model, predicts the value of that decision. ZIP and ZINB behave similarly with the one difference that the ZINB does not force equality between mean and variance. Both sufficiently high fixed costs and high variable costs may generate zero foreign affiliate sales. It should be noted that the mere existence of overdispersion does not require the selection of ZINB over ZIP. ZIP, by virtue of its two processes, may yield an over-dispersed set of predicted values.

IV. Results

The results of the main econometric estimation are listed in table 5. Each of the four results in the table use the same set of independent variables. The first column in table 5 uses OLS, the second uses PPML, the third uses ZIP and the fourth column use ZINB.

According to BE, the expected sign of GDP source is positive.[9] In our estimation, this is not the case for any of the estimations (1)-(4) in table 5. The GDP of rest of world (GDP RoW) has a large negative coefficient. That is, the positive effect of GDP source and host are captured in the highly negative coefficient of GDP RoW.

Table 5. Econometric Results

	(1) OLS	(2) PPML	(3) ZIP	(4) ZINB
$Ln(GDP_{st})$	-0.0936**	-0.0112	-0.243***	-0.228***
	(-2.69)	(-0.41)	(-7.67)	(-5.94)
$Ln(Prod_{irt})$	0.373***	0.598***	0.456***	0.319***
	(24.77)	(32.52)	(21.85)	(14.39)
$Ln(GDP\ RoW_{rst})$	-12.95***	-19.07***	-12.69***	-12.21***
	(-21.99)	(-28.05)	(-19.07)	(-20.78)
$Ln(Distance_{rs})$	-0.546***	-1.315***	-0.652***	-0.376***
	(-14.95)	(-26.17)	(-12.64)	(-8.05)
$Comm\ Lang_{rs}$	0.538***	0.288***	0.176*	0.206**
	(6.87)	(3.39)	(2.08)	(2.71)
$Trad\ Open_{rt}$	0.889***	0.626***	0.783***	0.852***
	(19.37)	(8.67)	(10.82)	(13.67)
$Invest\ Open_{rt}$	0.156***	0.0583	0.0836*	0.119***
	(6.46)	(1.80)	(2.57)	(4.21)
$FDI\ Restrict_{ir}$	-1.433***	-1.267***	-1.639***	-1.300***
	(-9.81)	(-7.63)	(-9.29)	(-12.98)
$Skill\ Diff_{rst}$	1.406***	3.408***	0.722	1.635***
	(4.53)	(7.14)	(1.71)	(4.57)
N	6327	43541	43541	43541
R^2	0.388	0.498		

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Note: standard errors are robust for OLS, ZIP and ZINB.

The expected sign of GDP RoW is negative. As noted above, this is indeed the case. When the RoW is large (i.e. the host and source countries are both small) then the host and source countries are relatively more likely to have foreign affiliate sales in countries in the rest of the world rather than with each other.

[9] Note that BE models FDI, FAS, and trade. These three variables generally behave similarly, although the FAS variable is not described in as great detail as FDI or trade, and is not tested against the data. One difference in predictions of variable behavior is in the effect of transport and investment costs: lower transport costs increase trade and increase FDI; higher investment costs decrease trade and increase FDI, and presumably FAS behaves similarly to FDI if only in the sign of their comovement.

Domestic production, ln(Prod), is expected to be positive. This is one of only two variables that are sector-specific (the other being FDI restrictiveness, FDI Restrict). This variables is indeed positive.

We use various proxies for trade costs. Among these are common language and a measure of trade openness. According to BE, transportation costs should be positively related to foreign affiliate sales, i.e. as transportation costs increases, foreign affiliate sales increase. The trade openness variables for the host countries are expected to have positive coefficients, which is the result we find. Trade openness for the source country is expected to be negative but is positive for all but the OLS specification.

Distance is negative, as is the case in gravity equations. BE do not use it in their estimation (they use fixed effects by country pair); however it is used by Carr, Markusen, and Maskus (2001).

We also have two measures of investment barriers: a measure of country-level investment openness from Economic Freedom of the World (EFW), and the OECD measure of sector-level investment restrictiveness. The expected sign on the openness measure is positive: as openness increases, so should foreign affiliate sales. The expected sign on the FDI restrictiveness is correspondingly negative. Our results follow both of these predictions.

In BE, the estimated coefficients are roughly similar.[10] In particular, the signs are the same with the exception of GDP source where our regressions produce the wrong sign, and trade costs for the host country where their regressions produce the wrong sign. The coefficients from BE and from our regressions cannot be quantitatively compared because the two specifications use different measures for trade costs.

We also use certain elements of Carr, Markusen, and Maskus (2001) as the basis for the regression. As another point of comparison, we examine CMM which has similar analysis to ours. In their case, the model is only a 2 country, 2 factor model, but explicitly considers foreign affiliate sales rather than investment. All of the coefficients are as expected by their model.[11] There are some differences that make for difficulty in comparing their results with ours. CMM use the sum of the GDPs rather than source and host GDPs. They also use level effects rather than logs so that coefficients are not

[10] The coefficients reported by BE are on FDI, not FAS. They do not report regression results on FAS data; however they analyze their model results with respect to both FDI and FAS and find that in most dimensions the two variables respond similarly to changes in model variables.

[11] The variables used by Carr, Markusen, and Maskus (2001) are: the sum of GDPs, the difference of GDPs squared, the skill difference, the interaction of skill difference and GDP difference, investment costs of host, trade costs of host, trade costs of host interacted with squared skill difference, trade cost of source and distance.

quantitatively comparable. Distance is negatively related, although in this case as in for BE, the model does not explicitly include a distance variable and therefore does not specifically predict a direction. Skill difference is positive. Trade costs of host countries are positively related to foreign affiliate sales, and investment costs negatively related to foreign affiliate sales. Trade costs of source countries are negatively related to foreign affiliate sales. In addition to these variables, the model also includes GDP times skill difference and trade costs multiplied by skill difference, which act as quadratic terms and are negative as expected.

The positive coefficient on the capital/unskilled labor ratio implies that firms are more likely to invest in countries that are relatively less capital intensive than themselves, or that a relatively large amount of unskilled labor is attractive to foreign investors.

The trade and investment variables are indicators where a larger number indicates greater openness of the host country. A positive coefficient indicates a positive relationship between openness and foreign affiliate production in the host country. Prior studies do not indicate a clear prediction on the trade variable. Trade may or may not be positively related to foreign affiliate activity (there are theoretical reasons for both a positive and a negative variable, and indeed a non-significant variable). Investment openness is expected to be positively associated with foreign affiliate activity. Interestingly, the only case in which this is true is in the OLS specification, and even in this case the effect is not statistically significant.

Sectoral production is available for 21 sectors, all but two of which are manufacturing sectors. The two remaining sectors are real estate, renting and business activities and hotels and restaurants

The two zero inflate models, ZIP and ZINB, each have an additional logistic portion of the model that is not displayed. In this portion of the model there are three variables that are meant to summarize the criteria under which a country may invest in a particular sector in another country. The three variables are the FDI restrictiveness index due to Koyama and Golub (2006), the measure of common language, and a measure of border contiguity. The latter is not part of the original model; it is drawn from CEPII's database and takes on the value of one if two countries share a border and zero otherwise. The main portion of the model is very robust to the selection of the "inflate" variables.

Table 6. Examining the Dispersion of Data and Fitted Values

Foreign affiliate sales	Mean ($ million)	Standard Deviation	Coefficient of Variation
Data			
with zeros	136	1.07E+09	7.87
without zeros	936	2.68E+09	2.86
size difference (without/with)	6.88		
OLS			
without zeros	387	8.57E+08	2.21
percent of Data results	41%		77%
PPML			
with zeros	139	7.91E+08	5.69
percent of Data results	102%		72%
without zeros*	387	8.21E+08	2.12
percent of Data results	41%		74%
size difference (without/with)	2.78		
ZIP fitted values			
with zeros	79	3.80E+08	4.82
percent of Data results	58%		61%
without zeros	405	8.77E+08	2.17
percent of Data results	43%		76%
size difference (without/with)	5.13		
ZINB fitted values			
with zeros	64	3.68E+08	5.79
percent of Data results	47%		74%
without zeros	401	8.48E+08	2.11
percent of Data results	43%		74%
size difference (without/with)	6.31		

**taken to mean without estimates less than 500,000*

The data are extremely over dispersed according to table 6. In terms of mean values, the PPML fitted values come very close to the mean value of the data (PPML's mean is 102% that of the data's). However, conditional on zeros, PPML's mean value estimate becomes much smaller. Clearly PPML is underestimating the non-zero values as a way of compensating for the paucity of zeros it generates. By

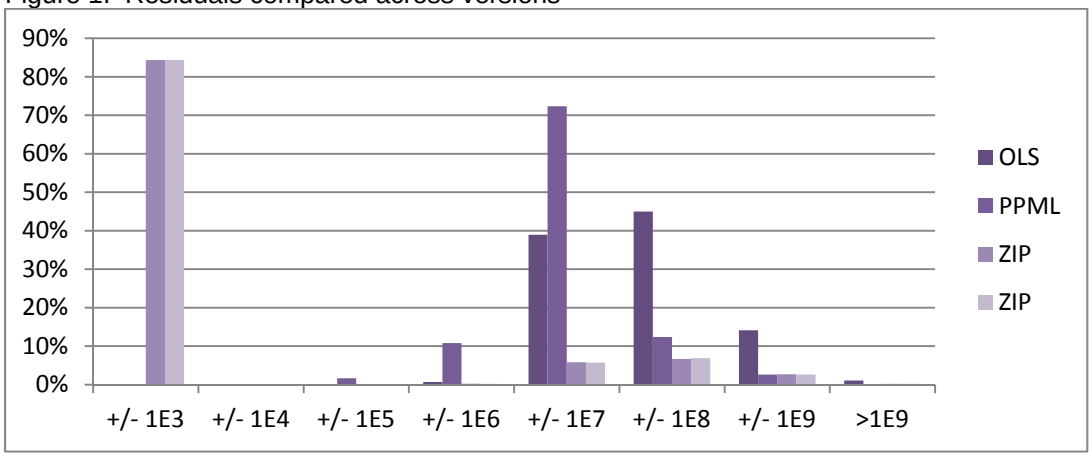
contrast, ZIP and ZINB mean fitted values underpredict the mean data values both unconditionally and conditional on positive values. ZIP underpredicts at 58 percent of the mean data value with zeros and at 43 percent without zeros; ZINB underpredicts at 47 percent with zeros and 43 percent without. ZINB in particular obtains a mean ratio between unconditional and conditional that is similar to that of the data. From the perspective of dispersion, none of the estimation methods manages to capture the high level of dispersion of the data, but each manages to capture approximately three-quarters of the dispersion of the data. The one exception is ZIP which produces slightly less dispersion at 61 percent of that of the data.

Table 7. Zeros

Source	Positive Values	Zeros
Data	15%	85%
PPML	90%	10%
ZIP/ZINB	16%	84%

In fact we find very different zeros for data, PPML and ZIP/ZINB. ZIP and ZINB produce the same number of predicted zeros as the logit regression is the same for both. OLS is not displayed as it predicts no zeros. Clearly PPML produces far too few zeros. The ZIP/ZINB values are targeted to the data by selecting the cutoff point that produces the share of zeros observed in the data. There is no theoretical reason to choose a particular cutoff value.

Figure 1. Residuals compared across versions



We perform several tests of the econometric specifications to formalize the preceding analysis. Examining the (negative) log likelihoods generated by PPML, ZIP and ZINB indicates that ZINB is the most preferred out of the three, given that its log likelihood is the smallest.[12] Additionally we compute a more specific test to examine whether the ZIP or ZINB proves to be a better fit. The likelihood ratio test

[12] We can also examine the consistent Akaike information criterion (CAIC), which in our case presents essentially identical results, as the main difference between the two – adjustments for number of observations and number of parameters – are similar across our models.

for over dispersion between ZIP and ZINB examines whether the estimated mean and variance are equal (as in ZIP) or substantially different (as in ZINB). See Cameron and Trivedi (1998). The LR test yields a result that strongly rejects the null hypothesis that the mean equals the variance.

V. Extrapolation Issues and Modified Estimation Strategy

The results obtained using the theoretical models present certain problems. The variables used in the logistic portion of the zero inflated regressions – the so-called "inflate" variables – present some difficulty in terms of operationalizing the extrapolation of data based on the coefficients produced by the regressions. The regressions described above were based on a set of inflate variables that are known to act as barriers FDI – lack of common language, contiguous borders, and policies that restrict FDI. Although these variables produced estimates that in at least some behave substantially better than either OLS or PPML estimations, a close examination of the logistic portion of the model reveals some peculiarities. The zero inflated methodologies produce thresholds that do not vary sufficiently by country – common language and contiguous borders take the value of one in a minority of the cases. The major variation is across sectors. The clear solution is to add variables that are country specific such as GDP or per capita GDP; however such variables tend to overwhelm the FDI restrictiveness in importance and economic significance; as a result the opposite problem is seen where each country will either receive investment in all of its sectors or receive no investment at all. As a result, despite the promising behavior of the zero inflated models, we proceed with the PPML version of the model.

There are further issues, which require other modifications of the model for pragmatic reasons. The econometric model as specified by the theory produces results that are strongly dependent on the source and host country GDP. As a result, the extrapolation of the model is strongly influenced by the size of the United States to the point that the vast majority of sales are projected to be sourced from and hosted by the United States. This is despite the presence of other large economies in the sample including Japan (on the source side) and the UK and Germany on both the host and source side. As a result, we add a GDP per capita variable for both the host and source and remove the GDP rest of world variable.[13] Under this specification, the econometrics produces results that after extrapolation are substantially closer to data estimates of foreign affiliate sales.

In table 8 below we use the coefficients of the column (4) estimation. Note that column (1) reproduces the PPML estimation of table 5, column (2) for ease of comparison.

[13] The investment openness variable was also dropped as it became insignificant and essentially zero after these adjustments.

Table 8. New Estimates

	(1) y_round	(2) y_round	(3) y_round	(4) y_round
$Ln(GDP_{st})$	-0.0112	0.284***	0.280***	0.665***
	(-0.41)	(8.47)	(8.00)	(25.15)
$Ln(Prod_{irt})$	0.598***	0.479***	0.480***	0.463***
	(32.52)	(25.82)	(25.91)	(23.63)
$Ln(GDP\ RoW_{rst})$	-19.07***	-8.558***	-8.612***	
	(-28.05)	(-13.28)	(-12.85)	
$Ln(Distance_{rs})$	-1.315***	-0.901***	-0.895***	-0.721***
	(-26.17)	(-20.90)	(-22.31)	(-22.60)
$Comm\ Lang_{rs}$	0.288***	0.0304	0.0244	0.218*
	(3.39)	(0.33)	(0.25)	(2.43)
$Trad\ Open_{rt}$	0.626***	-0.212*	-0.204*	-0.117
	(8.67)	(-2.14)	(-2.05)	(-1.19)
$Invest\ Open_{rt}$	0.0583	-0.0220		
	(1.80)	(-0.63)		
$FDI\ Restrict_{ir}$	-1.267***	-0.0392	-0.0453	-0.0626
	(-7.63)	(-0.30)	(-0.35)	(-0.47)
$Skill\ Diff_{rst}$	3.408***	0.309	0.379	-3.454***
	(7.14)	(0.62)	(0.73)	(-9.08)
$Ln(GDP_{rt})$		0.526***	0.526***	0.763***
		(18.12)	(18.00)	(24.13)
$Ln(GDP/capita_{st})$	1.888***	1.890***	2.695***	
		(25.43)	(25.42)	(28.90)
$Ln(GDP/capita_{rt})$	0.161	0.145	-0.326***	
		(1.73)	(1.58)	(-3.66)
N	43541	43541	43541	43541
R-sq	0.498	0.523	0.524	0.512

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Several coefficients do change signs between version (1) and version (4) in table 8.[14] The GDP of the source country becomes positive, which is now in line with expectations; trade openness of the host country and skill difference both become negative, against expectations. GDP of host, a variable that is usually included in regressions in the literature but that we had left out due to the alternate inclusion of sector level domestic production, is positively associated with foreign affiliate sales as expected in the literature. GDP per capita of the source country is similarly positively associated with foreign affiliate

[14] The intermediate columns are versions that use an intermediate mix between the two main specifications, in particular to show (from column (1) to column (2)) the changes made to the original coefficients from adding GDP of host and the two per capita GDP variables. The comparison between (2) and (3) highlights the minimal difference made by removing the investment openness index, and the comparison between (3) and (4) highlights the substantial difference made by eliminating GDP of rest of world as an independent variable.

sales; however GDP per capita of the host country is significantly negatively associated with foreign affiliate sales, contrary to usual results of gravity type models.

VI. Quadratic Optimization and Final Database

The first step is to fill in the foreign affiliate sales database with estimates extrapolated from the regression coefficients. Subsequent to filling in the missing values using econometric extrapolation, the final consistency of the database is ensured using quadratic optimization[15] that allows us to incorporate and reconcile information from different sources (econometric estimates, OECD, EUROSTAT and BEA). The objective is to minimize the difference between initial and final values subject to adding up constraints. Thus, for a given sector *i*, host country *h* and source country *s* and reliability weight *w,* the quadratic optimization is implemented as follows:

$$\textbf{minimize}$$

$$\sum_{irs}\left(\mathrm{FATS}^{1}_{ihs}-\mathrm{FATS}^{0}_{ihs}\right)^{2}/\mathrm{w}_{ihs}+\sum_{hs}\left(\mathrm{FATS}^{1}_{hs}-\mathrm{FATS}^{0}_{hs}\right)^{2}/\mathrm{w}_{hs}$$

$$+\sum_{ih}\left(\mathrm{FATS}^{1}_{ih}-\mathrm{FATS}^{0}_{ih}\right)^{2}/\mathrm{w}_{ih} \qquad \textbf{(2)}$$

$$\textbf{subject to}$$

$$\sum_{ihs}\mathrm{FATS}^{1}_{ihs}=\mathrm{FATS}^{\mathrm{UNCTAD}}_{\mathrm{AGG}}$$

$$\sum_{i}\mathrm{FATS}^{1}_{ihs}=\mathrm{FATS}^{\mathrm{EURO+OECD}}_{hs}$$

$$\sum_{s}\mathrm{FATS}^{1}_{ihs}=\mathrm{FATS}^{\mathrm{EURO+OECD}}_{ih}$$

where FATS^{0} denotes the initial sector/host/source specific foreign affiliates turnover data constructed using the econometric estimates and the raw data collected from OECD, EUROSTAT and BEA; FATS^{1} denotes the final values resulting from the optimization. Apart from the three-dimensional data we enrich the dataset with information about host and sectoral totals. The constraints of the optimization are aimed to target these aggregate values such as information about the global activity of foreign affiliates ($\mathrm{FATS}^{\mathrm{UNCTAD}}_{\mathrm{AGG}}$) or sector/host specific totals ($\mathrm{FATS}^{\mathrm{EURO+OECD}}_{ih}$) or bilateral totals ($\mathrm{FATS}^{\mathrm{EURO+OECD}}_{hs}$).

[15] Initial versions of this database have been built using cross-entropy minimization techniques, however quadratic optimization has several numerical advantages in implementing very large models (Canning and Wang, 2005).

Reliability weights are chosen such that to reflect our confidence in the correctness of the underlying data. Thus, we confer the highest reliability to the EUROSTAT data (0.01) and the lowest to the econometrically estimated data (0.0001) while data collected from the OECD is given weights of 0.001. Note that when all weights are equal to one the solution of this model is the constrained least square estimator.

Final Database

The final database has 110 countries and 28 sectors. The extrapolated dataset estimates that approximately 50 percent of global foreign affiliate sales are in manufacturing, while 45 percent are in services (with the remaining in extraction activities). See table 9. Verifying the validity of these results is particularly difficult because sectoral breakdown is particularly scarce and is not available at a global level. To compare with the Eurostat data, the global extrapolated results show a relatively higher weight for manufacturing and for mining than does the Eurostat data. This seems reasonable given that many developing countries are likely to be overweighted in the mining sector and that services (particularly financial services) more likely to take place in European Union countries than in many other countries outside the EU. However, the extent to which the rather substantial difference between the two is a true reflection of sectoral divisions cannot be determined without new data sources.

Table 9. Final Database versus original data input

In $ billions	Eurostat Database		Extrapolation	
Sector	**Value**	**Share**	**Value**	**Share**
Mining	52	1%	1,114,125	4%
Manufacturing	1,440	33%	16,070,960	51%
Services	2,832	65%	14,318,762	45%
Total	**4,324**		**31,503,847**	

Host countries exhibit a reasonable mix of foreign affiliate sales by sector. In table 10 the 110 countries are grouped into eight regions, with Australia and New Zealand grouped together, East Asia (including Japan, S. Korea, and Taiwan) in another group, the ten ASEAN countries in a third, the EU as a fourth region and the United States, India and China each treated separately.

There is heterogeneity across sectors, generated by the sector specific variables in the regression as well as the variance in the hard-coded Eurostat data. According to the extrapolated data, China has a higher share of foreign affiliate sales in the manufacturing sector than any other country. Australia and New

Zealand have very high mining revenues as a share of its total foreign affiliate sales. These observations seem reasonable. India has a relatively low share of its affiliate sales in manufacturing, although potentially even this number is higher than reality. India is shown as being particularly repressed in retail trade which is indeed the case. The data for the United States is largely pinned to U.S. BEA data (although some adjustments occur during the quadratic optimization process).

Table 10. Extrapolated database estimates of host countries by sector, 2007.

Host Country	Mining	Manufacturing	Other Services	Transportation	Wholesale, Retail
ASEAN	5%	51%	20%	8%	16%
Aust/NZ	19%	24%	26%	5%	27%
China	3%	64%	22%	7%	4%
East Asia	1%	52%	26%	8%	13%
EU	2%	44%	24%	7%	23%
India	3%	55%	27%	9%	6%
ROW	7%	47%	27%	9%	10%
US	2%	47%	32%	8%	10%
Total	**4%**	**51%**	**25%**	**8%**	**13%**

The largest source countries, as estimated by the extrapolated dataset, are largely in line with expectations. The United States, United Kingdom, France and Germany are all well-known as significant sources of foreign direct investment capital. Missing from the list of premier sources is Japan. Norway is estimated to be the second most significant source of foreign direct investment, although that is not the case in actuality. The host country data remains problematic. According to the extrapolated dataset, China sees the largest foreign affiliate sales of any host country and nearly 3 times the second largest host of foreign affiliate sales. This is extremely unlikely to be the case. Moreover, the second largest host of foreign affiliate sales is India, which is also improbable. See appendix tables A-6 and A-7 for details.

Finally, we compare our inward foreign affiliate sales data with Inward FDI stocks obtained from UNCTAD's World Investment Report data. Although comparing foreign affiliate sales with FDI is problematic as they are substantially different objects, there generally is positive correlation between FDI and foreign affiliate sales, and a comparison with FDI may provide some clues as to the appropriateness of the new dataset. The shares will provide better comparability than levels. The two sets of data are compared for the eight regions in table 11. It is clear from this comparison that there are substantial differences between the two. Again, China is clearly overweighted in the extrapolated database, as is India.

Table 11. Comparison of extrapolated database with inward FDI stocks, 2007.

Host Country	Extrapolated Value	share	Inward FDI Stocks Value	share
ASEAN	1,244,109	*4%*	654,614	*4%*
Aust/NZ	126,909	*0%*	453,473	*3%*
China	6,887,405	*22%*	327,087	*2%*
East Asia	1,987,931	*6%*	1,360,001	*8%*
EU	9,190,118	*29%*	7,515,798	*42%*
India	2,602,801	*8%*	105,790	*1%*
ROW	7,495,204	*24%*	4,989,185	*28%*
US	1,969,371	*6%*	3,551,307	*20%*
	31,503,847		**17,849,168**	

Source: Inward FDI Stocks taken from UNCTAD's World Investment Report, Annex table 3. http://www.unctad.org/Templates/Page.asp?intItemID=5823&lang=1 Accessed 2/29/2012.

VII. Value Added

In order to have foreign affiliates modeled within GTAP, it is necessary to assign some of the value added of a given sector to the foreign affiliates. In Hanslow (2000), value added is distributed on a pro rata basis to firms under different ownership. There is an extensive literature that indicates this is not the case (see Lipsey 2002 for an overview of this literature). In this section we will specify an estimation equation that will allow us to partition value added into its labor and capital components in a way that includes more detailed information about host and source country as well as by sector.

Value added is calculated by Eurostat as sales less cost of goods sold plus changes in inventories in addition to other adjustments. In addition, Eurostat provides personnel costs, which correspond to the value added of labor.

As with the production data, there are many missing and zero values. A cross-check of the value added data with production data shows that 98.9 percent of the observations are consistent. That is, in 98.9 percent of all observations of value added and production data both show either missing values, zeros, or value data. Because of the high degree of consistency between the two dataset, we rely on the production data to provide information on zeros, and use value added data to focus on the division between labor and capital.

As a second consistency check, we examine the properties of value added and value added of labor. We find that in 98.4 percent of the observations, these two variables produce consistent data. In addition to the criteria mentioned above (i.e. that both variables display missing, zero or non-zero values consistent with one another), the data are checked to see whether total value added is greater than labor value added.

This may happen for accounting reasons but cannot be accommodated in the GTAP model. There are a few instances of this, but they occur only in 0.8 percent of all observations.[16]

The value added ratio is used as the dependent variable. Some summary statistics are listed in table 12.

Table 12. Summary Statistics for Value Added

Number of host countries	22
Number of source countries	41
Number of NACE categories (r.1)	115
Year coverage	2000-2008
Summary statistics: VA(labor) / VA(total)	
Mean	0.593
Median	0.605
Standard deviation	0.198
Min	0.004
Max	0.999

As a first pass, we examine the effects of a series of dummy variables on the value added ratio. We use a plain OLS specification. The specification is as follows:

$$\frac{VA\_L_{ijtk}}{VA_{ijtk}} = \alpha_0 + \beta_i + \gamma_j + \delta_t + \eta_k + \varepsilon_{ijtk} \tag{3}$$

The results of this are summarized in table 13.

Table 13. Value added regressions

	(1)	(2)	(3)	(4)	(5)
Dummy Variables used:	Host countries	Source countries	Years	Sectors	All
R-sq	0.176	0.032	0.01	0.218	0.411
adj. R-sq	0.176	0.031	0.01	0.215	0.407

There were 28,096 observations in each regression. In the first four regressions, only the specified set of dummy variables is used. Clearly the sector dummy variables and the host dummy variables have substantially greater explanatory power than the other dummy variables.

As a large number of variables are added in the last two regressions both the R^2 and the adjusted R^2 are presented.

[16] This 0.8 percent is already included in the consistency check that resulted in a 98.4 percent share of consistent data.

In order to prepare the data set for extrapolation to countries not in the current dataset, we performed regressions using GDP per capita for host and source countries rather than dummy variables. The estimated equation was:

$$\frac{VA\_L_{ijtk}}{VA_{ijtk}} = \alpha_0 + \beta_1 \ln(GDPPC_{it}) + \beta_2 \ln(GDPPC_{jt}) + \delta_t + \gamma_k \quad (4)$$

The results are in table 14.

Table 14. Value added regressions (2)

	(1)	(2)	(3)	(4)
Independent Variables (log form):				
GDP per capita, host	0.0677***		0.0863***	0.0840***
GDP per capita, source		0.0380***		0.0132***
Dummy Variables:	none	none	years, sectors	years, sectors
R-sq	0.07	0.01	0.328	0.329
adj. R-sq	0.07	0.01	0.325	0.326

For the extrapolation calculation we will use version (4), using both host and source. The estimation yield the result that a doubling of per capita GDP of the host country will yield a 0.084 percentage point increase in the share of labor in value added. Although developed countries tend to invest in relatively capital intensive production processes rather than labor intensive production, the positive coefficient here may be due to the relatively high wage bill of workers in a given country. Other research has also observed that wages are relatively higher for multinational workers than for individuals working for domestically-owned firms.

VIII. Conclusion

The purpose of this study has been to bring as much data as is currently available to bear on the problem of constructing a large global database of foreign affiliate sales. The newer methods of handling zeros proved to be substantially better at handling the Eurostat dataset than prior methods. In this sense, we present empirical evidence to suggest that future work with foreign affiliate sales and indeed foreign direct investment should be performed using models that take into account the information that the zeros in the dataset provide. However, as a practical matter for extrapolating values from the coefficients, there remains considerable work to be done. Obtaining probabilities from the logistic regression that produce

realistic patterns proved elusive. As a result, PPML remained the most useful technique for both addressing zeros and providing plausible numbers for extrapolation.

Future work will be done on the estimation, in particular to attempt to identify relevant variables that can render zero inflated models operational. Additionally, there is a great lack of data that hinders the construction of the database. Although there is an increasing amount of data on the investment side there is not a sufficiently strong correlation between the two to permit their interchangeability. There is a great need to improve the availability of data on the foreign affiliate side.

Appendix

Table A - 1. Source Countries

Australia	France	Liechtenstein	Slovakia
Austria	Germany	Lithuania	Slovenia
Belgium	Greece	Luxembourg	Spain
Bulgaria	Hong Kong	Malta	Swede
Canada	Hungary	Netherlands	Switzerland
China (incl. HK)	Iceland	New Zealand	Turkey
Cyprus	Ireland	Norway	United Kingdom
Czech Republic	Israel	Poland	United States
Denmark	Italy	Portugal	
Estonia	Japan	Romania	
Finland	Latvia	Russia	

Source: Eurostat. Note that Liechtenstein and Luxembourg are excluded from the regression analysis.

Table A - 2. Host Countries

Austria	Finland	Lithuania	Slovenia
Bulgaria	France	Netherlands	Spain
Cyprus	Germany	Poland	Sweden
Czech Republic	Hungary	Portugal	United Kingdom
Denmark	Italy	Romania	
Estonia	Latvia	Slovakia	

Source: Eurostat.

Table A - 3. Covered Sectors

Manufacturing Sectors

- Food products, beverages and tobacco*
- Textiles*
- Wearing apparel; dressing; dyeing of fur*
- Leather and leather products*
- Wood and wood products*
- Pulp, paper and paper products; publishing and printing*
- Coke, refined petroleum products and nuclear fuel
- Chemicals, chemical products and man-made fibers*
- Rubber and plastic products*
- Other non-metallic mineral products*
- Basic metals*
- Fabricated metal products, except machinery and equipment*
- Machinery and equipment n.e.c.*
- Office machinery and computers*
- Electrical machinery and apparatus n.e.c.*
- Radio, television and communication equipment and apparatus*
- Medical, precision and optical instruments, watches and clocks*
- Motor vehicles, trailers and semi-trailers*
- Other transport equipment*
- Manufacturing n.e.c.*

Other Sectors

- Mining and quarrying
- Electricity, gas, steam and hot water supply
- Collection, purification and distribution of water
- Construction
- Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
- Wholesale trade and commission trade, except of motor vehicles and motorcycles
- Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
- Hotels and restaurants*
- Transport, storage and communication
- Financial intermediation, except insurance and pension funding
- Insurance and pension funding, except compulsory social security
- Activities auxiliary to financial intermediation
- Real estate, renting and business activities*

Source: Eurostat. Note that * denotes sectors included in the regression analysis.

Table A – 4. Eurostat data on foreign affiliate sales by source country.

Source Country	in $ billions	share
United States	589	34.6%
Netherlands	190	11.2%
Germany	187	11.0%
France	183	10.8%
Switzerland	136	8.0%
United Kingdom	102	6.0%
Sweden	48	2.8%
Italy	40	2.3%
Finland	38	2.2%
Austria	36	2.1%
Japan	32	1.9%
Denmark	29	1.7%
Belgium	26	1.5%
Norway	18	1.0%
Spain	16	1.0%
Ireland	16	0.9%
Canada	4	0.3%
Russian Federation	2	0.1%
Cyprus	2	0.1%
Czech Republic	2	0.1%
Israel	1	0.1%
Greece	1	0.1%
Australia	1	0.1%
Portugal	1	0.0%
Turkey	0	0.0%
Iceland	0	0.0%
Hungary	0	0.0%
Estonia	0	0.0%
Hong Kong	0	0.0%
Slovenia	0	0.0%
Poland	0	0.0%
Romania	0	0.0%
Malta	0	0.0%
Lithuania	0	0.0%
Romania	0	0.0%
Slovakia	0	0.0%
Hong Kong	0	0.0%
Bulgaria	0	0.0%
Latvia	-	0.0%
New Zealand	-	0.0%
Latvia	-	0.0%
Total	**1,702**	**100.0%**

Note: Data are for 2007 only, and for only observations used in the regressions. Some countries did not report data for 2007.

Table A – 5. Eurostat data on foreign affiliate sales by host country.

Host country	**in $ billions**	***share***
Germany	579	*34%*
United Kingdom	329	*19%*
Italy	239	*14%*
Netherlands	108	*6%*
Poland	97	*6%*
Sweden	97	*6%*
Austria	73	*4%*
Hungary	65	*4%*
Finland	27	*2%*
Denmark	25	*1%*
Portugal	24	*1%*
Romania	20	*1%*
Slovakia	14	*1%*
Estonia	3	*0%*
Latvia	2	*0%*
Slovenia	1	*0%*
Cyprus	0	*0%*
Total	**1,702**	***100%***

Note: Data are for 2007 only, and for only observations used in the regressions. Some countries did not report data for 2007.

Table A – 6. . Extrapolated data: the top 10 source countries

Source Countries	**Value ($ millions)**	**Share**
United States	5,814,523	18%
Norway	3,062,858	10%
United Kingdom	2,419,518	8%
France	2,126,432	7%
Germany	2,125,404	7%
Luxembourg	1,906,644	6%
Netherlands	1,798,227	6%
Denmark	1,358,716	4%
Switzerland	1,327,214	4%
Sweden	1,303,970	4%

Note: Estimated based on Eurostat data, OECD, BEA and UNCTAD data as described in section VI

Table A – 7. . Extrapolated data: the top 10 host countries

Host Country	Value ($ millions)	Share
China	6,887,405	22%
India	2,602,801	8%
Germany	2,162,359	7%
United States	1,969,371	6%
Russian Federation	1,654,126	5%
United Kingdom	1,297,314	4%
Japan	1,232,845	4%
France	1,064,555	3%
Italy	882,219	3%
Turkey	697,962	2%

Note: Estimated based on Eurostat data, OECD, BEA and UNCTAD data as described in section VI

Bibliography

Anderson, James E. and Eric van Wincoop. 2003. "Gravity with Gravitas: A Solution to the Border Puzzle". *The American Economic Review,* Vol. 93(1): 170-192.

Anderson, James E. and Eric van Wincoop. 2004. "Trade Costs". *Journal of Economic Literature,*Vol. 42: 691-751.

Blonigen, Bruce A. 2005. "A Review of the Empirical Literature on FDI Determinants." *Atlantic Economic Journal.* Vol. 33: 383-403 2005.

Bergstrand, Jeffrey H. and Peter Egger. 2007. "A Knowledge-and-physical-capital Model of International Trade Flows, Foreign Direct Investment, and Multinational Enterprises." *Journal of International Economics.* Vol. 73(2): 278-308.

Cameron, A. Colin and Pravin K. Trivedi. 1998. *Regression analysis of count data.* Econometric Society Monograph, Cambridge University Press.

Carr, David L., James R. Markusen, and Keith E. Maskus. 2001. "Estimating the Knowledge-Capital Model of the Multinational Enterprise." *The American Economic Review.* Volume 91, No 3: 693-708.

De Benedictis, Luca, and Daria Taglioni. 2011. "The Gravity Model in International Trade." In *The Trade Impact of European Union Preferential Policies,* Ed. Luca De Benedictis and Luca Salvatici. Springer-Verlag.

Fukui, E. Tani, and Csilla Lakatos. 2012. "Measuring Economic Globalization: a Database on the Activities of Foreign Affiliates", mimeo.

Hanslow, Kevin. 2000. "The Structure of the FTAP Model". *Conference Paper, Third Annual Conference on Global Economic Analysis,* Melbourne.

Kleinert, Jörn and Farid Toubal. 2010. "Gravity for FDI." *Review of International Economics,* 18(1);1-13.

Koyama, Takeshi, Stephen S. Golub. 2006. "OECD's FDI Regulatory Restrictiveness Index: Revision and Extension to more Economies." *OECD Working Papers on International Investment,* 2006/94, OECD Publishing.

Lipsey, Robert E. 2002. "Home and Host Country Effects of FDI." *NBER Working Paper 9293.*

Markusen, James R. " Trade versus Investment Liberalization." 1997. *NBER Working Paper No. 6231.*

Markusen, James R. 2004. "Multinational Firms and the Theory of International Trade." *MPRA Paper 8380*, University Library of Munich, Germany.

Markusen, James R. and Keith E. Maskus. 2002. "Discriminating Among Alternative Theories of the Multinational Enterprise," *Review of International Economics.* Vol. 10(4): 694-707.

Markusen, James R., Anthony J. Venables, Denise Eby-Konan, and Kevin Honglin Zhang. "A Unified Treatment of Horizontal Direct Investment, Vertical Direct Investment, and the Pattern of Trade in Goods and Services." 1996. *National Bureau of Economic Research Working Paper No. 5696.*

Martin, Will and Cong S. Pham. 2008. "Estimating the Gravity Model When Zero Trade Flows are Frequent." Mimeo.

Santos Silva, Joao and Silvana Tenreyro. 2005. "The Log of Gravity." *CEP Discussion Paper No. 701*.

Santos Silva, Joao and Silvana Tenreyro. 2011. "Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator." *Economic Letters.* Vol. 112: 220-222.

Yeaple, Stephen Ross. 2003. "The Role of Skill Endowments in the Structure of U.S. Outward Foreign Direct Investment." *The Review of Economics and Statistics.* Vol. 85 (3): 726-734.