Fixed Costs, Foreign Direct Investment, and Gravity with Zeros

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Abstract

Fixed costs play a crucial role in current models of foreign direct investment (FDI), yet they are almost entirely ignored in empirical treatments of FDI. We fill this gap by using a 1989-2001 panel of FDI flows into Iceland to examine the determinants of fixed costs for multinational firms and how these influence aggregate patterns of investment. Our additions to research in the field include usage of several natural resource variables, and the analysis of data on initial entry of FDI into a developed country. We use Heckman two step procedure, which allows us to account for fixed costs and their impact on estimation. Taken together, we find that the standard OLS approach to the data incorrectly links the quantity of FDI to source country variables while in fact most of their role is in determining whether FDI takes place at all.

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1. Introduction

In the theory of foreign direct investment (FDI), fixed costs have long held an important place. In Markusen's (1984) seminal presentation of the horizontal multinational enterprise (MNE), one of the main benefits of the multinational firm structure is that a single firm that operates multiple plants reduces the average cost of covering firm-level fixed costs. Furthermore, in recent models of FDI, including the knowledge-capital model of Markusen (2002), fixed costs work to determine the equilibrium number of firms in these free-entry, imperfectly competitive models.[2] In the empirical work, however, little attention has been given to fixed costs. In particular, in datasets where there are a large number of "no FDI" observations (as is common in disaggregated data), ignoring the decision of whether or not to undertake FDI can lead to a sample selection bias. In this paper, we explore the possibility of such problems using a unique dataset on Iceland that, although it mirrors that of the major FDI recipients in many ways, differs due to its large number of zeros. We find that controlling for this using the Heckman (1979) two-step method yields qualitatively different results for many variables, indicating that ignoring these "no FDI" observations is potentially problematic.

Most studies ignore fixed costs because the vast bulk of FDI data represents aggregate, country level investment information, and then primarily for FDI coming from the large, developed nations.[3] As such, there is almost always FDI, leaving the researcher at a loss to examine what aggregate conditions play into the decision of the first MNE to enter a given market. Even when firm-level data exist, it is rather rare to observe the entry decision since in most cases, FDI has already begun before the sample starts or never

[2] Other models with imperfect competition and fixed costs include Helpman, Melitz, and Yeaple (2004), Ekholm, Forslid, and Markusen (2003), and Markusen and Venables (2000) to name but a few.
[3] See Blonigen (2005) for a recent review of the empirical FDI literature.

occurs. More importantly, these firm level choices may well differ from the driving forces that the aggregate models study. In this paper, we use a proprietary dataset on country level FDI into Iceland. There are two useful features of these data. First, up until 1989, there was essentially zero FDI in Iceland. This allows us to observe the entry decision for countries as a whole, something other data sets do not permit. This first point makes our Heckman analysis particularly useful. Moreover, a majority of FDI in Iceland is greenfield, rather than mergers or acquisitions. While, as described Milesi-Ferretti (2000) the latter dominates the data for FDI into developed countries, the theory tends to treat fixed costs as a facet of greenfield investment, making our data more suitable to the question at hand . Second, Iceland is a well-developed, highly-skilled nation. While developing countries may also have many zero observations, data shows that the bulk of FDI flows between the developed countries (Markusen, 2002). If, as many studies argue, FDI between developed countries takes place for different reasons than FDI between developed and developing countries, the Icelandic data give us the opportunity to examine fixed costs for FDI in a way that data from developing countries do not.

The rest of the paper is laid out as follows. In Section 2, we present a simple model of the decision to become multinational in order to motivate our analysis and derive predictions for the data. Section 3 describes our data and our empirical approach. Section 4 contains our results. Section 5 concludes.

2. A Model of Fixed Costs and FDI

In this section, we use a basic model in order to describe the factors that influence a firm's decision to become multinational as well as the amount of subsidiary output conditional on the decision to undertake FDI. This model bears similarities to the examples found in Markusen (2002) and elsewhere, although we make a handful of alternative assumptions that are in line with the Icelandic data we use below.

Consider a firm that is based in its home country. This firm produces and sells its output on the world market according to the price $P(Q;\alpha)$ where Q is its total output and α is a shift parameter. We assume that an increase in α increases the price for all positive Q, that is, $P_\alpha > 0$ where the subscript denotes the derivative. We also assume that an increase in α increases marginal revenue for a given Q. This is guaranteed if, where $\varepsilon \equiv P_Q(Q;\alpha) \cdot Q \cdot P(Q;\alpha)^{-1}$ is the elasticity of the price with respect to total quantity, $\varepsilon_\alpha \leq 0$. A sufficient condition for this is that $P_{\alpha q} \geq 0$. We also assume that the price function is such that marginal revenue is strictly decreasing in total output, which is ensure when $\varepsilon_q \geq 0$. A sufficient condition for this is that $P_{qq} \leq 0$.

The firm can potentially produce in two locations, home and foreign. Foreign variables are denoted by *. Home output is q and host output is q^*. Variable costs at home include total production costs $C(q;\beta)$ and trade costs tq. Host variable costs are likewise composed of production costs $C^*(q^*;\beta^*)$ and trade costs t^*q^*. Both cost functions are increasing, convex functions of quantity. β and β^* are shift parameters that increase both total and marginal production costs for all positive quantities, i.e. $C_{q\beta} > 0$, $C^*_{q^*\beta} > 0$. In addition to these variable costs, the firm faces firm level fixed costs F and plant level fixed costs γ and γ^* for its home and foreign plants respectively. We assume that both F and γ are unavoidable and that the marginal revenue exceeds home marginal costs at zero output, ensuring positive production.

This leaves the firm with two choices, whether to open a plant in foreign and how much to produce in each location. If the firm does not open a foreign plant (i.e. $q^* = 0$), it has a national firm structure and its profits are given by:

$$\pi_N = P(q;\alpha)q - C(q;\beta) - tq - \gamma - F \ . \quad (1)$$

In this case, its optimal home production, q_N, is such that:

$$P(q_N;\alpha)(1-\varepsilon) - C_q(q_N;\beta) - t = 0 \quad (2)$$

where subscripts denote derivatives. If the firm is a multinational firm, then profits are given by:

$$\pi_N = P(q+q^*;\alpha)(q+q^*) - C(q;\beta) - tq - C^*(q^*;\beta^*) - t^*q^* - \gamma - \gamma^* - F \quad (3)$$

which yields optimal home and host productions, q_{MNE} and q^*_{MNE}, which are such that:

$$P(q_{MNE} + q^*_{MNE};\alpha)(1-\varepsilon) - C_q(q_{MNE};\beta) - t = 0 \quad (4)$$

and

$$P(q_{MNE} + q^*_{MNE};\alpha)(1-\varepsilon) - C^*_{q^*}(q^*_{MNE};\beta^*) - t^* = 0 \ . \quad (5)$$

Since the marginal cost is increasing in quantity, these optimal choices will be such that:

$$q_{MNE} < q_N < q_{MNE} + q^*_{MNE} \quad (6)$$

i.e. total output is higher by a multinational firm, although its home output declines.

Using these equilibrium conditions, it is possible to derive some predictions regarding output levels.

Proposition 1: *Consider the above firm. Its optimal output levels are such that:*

a) q_N , q_{MNE} *, and* q^*_{MNE} *are increasing in α*

b) q_N *is decreasing in β and t and independent of* β^* *and* t^**,*

c) q_{MNE} *is decreasing in β and t and increasing in* β^* *and* t^**, and* *d)* q^*_{MNE} *is increasing in* β *and t and decreasing in* β^* *and* t^*.

Proof: Equations (2), (4), and (5) yield the following comparative statistics, where subscripts denote the partial derivatives:

$$\frac{dq_N}{d\alpha} = \frac{P_\alpha(1-\varepsilon) - P\varepsilon_\alpha}{C_{qq} + P\varepsilon_Q - P_Q(1-\varepsilon)} > 0, \qquad \frac{dq_N}{d\beta} = \frac{-C_{q\beta}}{C_{qq} + P\varepsilon_Q - P_Q(1-\varepsilon)} < 0,$$

$$\frac{dq_N}{dt} = \frac{-1}{C_{qq} + P\varepsilon_Q - P_Q(1-\varepsilon)} < 0, \qquad \frac{dq_N}{d\beta^*} = \frac{dq_N}{dt^*} = 0$$

$$\frac{dq_{MNE}}{d\alpha} = \frac{C^*_{q^*q^*}\left(P_\alpha(1-\varepsilon) - P\varepsilon_\alpha\right)}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} > 0,$$

$$\frac{dq_{MNE}}{d\beta} = \frac{C_{q\beta}\left(P_Q(1-\varepsilon) - P\varepsilon_Q - C^*_{q^*q^*}\right)}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} < 0,$$

$$\frac{dq_{MNE}}{dt} = \frac{P_Q(1-\varepsilon) - P\varepsilon_Q - C^*_{q^*q^*}}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} < 0,$$

$$\frac{dq_{MNE}}{d\beta^*} = \frac{-C^*_{q^*\beta}\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} > 0,$$

$$\frac{dq_{MNE}}{dt^*} = \frac{-\left(P_Q(1-\varepsilon) - P\varepsilon_Q\right)}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} > 0,$$

$$\frac{dq^*_{MNE}}{d\alpha} = \frac{C_{qq}\left(P_\alpha(1-\varepsilon) - P\varepsilon_\alpha\right)}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} > 0,$$

$$\frac{dq^*_{MNE}}{d\beta} = \frac{-C_{q\beta}\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} > 0,$$

$$\frac{dq^*_{MNE}}{d\beta^*} = \frac{C^*_{q^*\beta}\left(P_Q(1-\varepsilon) - P\varepsilon_Q - C_{qq}\right)}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} < 0,$$

$$\frac{dq^*_{MNE}}{dt} = \frac{-\left(P_Q(1-\varepsilon) - P\varepsilon_Q\right)}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} > 0 \text{, and}$$

$$\frac{dq^*_{MNE}}{dt^*} = \frac{P_Q(1-\varepsilon) - P\varepsilon_Q - C_{qq}}{C_{qq}C^*_{q^*q^*} - \left[C_{qq} + C^*_{q^*q^*}\right]\left[P_Q(1-\varepsilon) - P\varepsilon_Q\right]} < 0 .$$

Q.E.D.

The intuition behind these results is straightforward. An increase in α increases the marginal revenue, leading to an increase in output.[4] When the firm is a multinational, since marginal costs are increasing, it divides this increase across locations. When β rises, marginal costs at home rise, leading the firm to decrease home output. When it is a multinational, it partly offsets this by increasing foreign production. Comparable changes happen when home's trade cost rises. When β^* rises, a multinational firm reduces foreign production and partly replaces it with home production. A national firm, however, is unaffected by this. Comparable changes happen when foreign trade costs rise.

In addition, we can ask how changes in these parameters affect whether a firm chooses to become a multinational. A firm will choose the multinational structure if:

$$\gamma^* \leq \left(P(q_{MNE} + q^*_{MNE}) - \frac{C(q_{MNE})}{q_{MNE}} - t\right)q_{MNE} - \left(P(q_N) - \frac{C(q_N)}{q_N} - t\right)q_N + \left(P(q_{MNE} + q^*_{MNE}) - \frac{C^*(q^*_{MNE})}{q^*_{MNE}} - t^*\right)q^*_{MNE} \tag{7}$$

i.e. if the variable cost savings from foreign production exceed the increase in fixed costs. Using equation (7), we derive predictions for when FDI of any level is likely to occur:

Proposition 2: *The firm is more likely to become a multinational as:*

a) β rises,

b) t rises,

[4] Our model can be generalized such that, as long as marginal revenue is non-decreasing in α and decreasing in quantity, we obtain identical comparative statics.

c) β^* falls,
e) t^* falls, and
f) γ^* falls.

Proof: Rewriting equation (7), define $\triangle\pi \equiv \pi_{MNE} - \pi_N$ which are calculated at their optimum values. Thus, (7) holds if and only if $\triangle\pi \geq 0$. Taking the derivatives of (7), applying the envelope theorem, and using (6), we find that:

$$\frac{d\triangle\pi}{d\beta} = C_\beta(q_N;\beta) - C_\beta(q_{MNE};\beta) > 0,\ \frac{d\triangle\pi}{dt} = q_N - q_{MNE} > 0,\ \frac{d\triangle\pi}{d\beta^*} = -C^*_{\beta^*} < 0$$

$$\frac{d\triangle\pi}{dt^*} = -q^*_{MNE} < 0, \text{ and } \frac{d\triangle\pi}{d\gamma^*} = -1 < 0.$$

When $\triangle\pi$ rises, this implies that (7) is more likely to hold, implying that the firm is more likely to choose the multinational structure. ***Q.E.D.***

The interpretation of these is straightforward. As the costs of home production rise, this gives greater incentive to shift some home output overseas. As the costs of foreign production, including fixed costs rise, this reduces the usefulness of foreign production, reducing the need to become multinational. With respect to α, we find that:

$$\frac{d\triangle\pi}{d\alpha} = P_\alpha(q_{MNE} + q^*_{MNE};\alpha)\left(q_{MNE} + q^*_{MNE}\right) - P_\alpha(q_N;\alpha)q_N \tag{8}$$

which is ambiguous in sign. If $P_{\alpha q} \geq 0$, which is a sufficient condition for $\varepsilon_\alpha \leq 0$, then $\frac{d\triangle\pi}{d\alpha} > 0$, implying that a rise in demand increases the likelihood of the firm choosing the multinational structure.

Using these results, we derive the following set of predictions for FDI. First, when demand is high FDI is more likely to occur and, assuming it does occur, there will be more of it. Second, as home costs rise, either due to rising production or trade costs, both the likelihood of FDI and its magnitude will rise. Third, as foreign costs rise, either due to rising production or trade costs, both the likelihood of FDI and its magnitude will fall. Fourth, as the fixed cost of the foreign plant rises, the likelihood of FDI falls but nothing happens to the size of any FDI that occurs.

3. Empirical Methodology and Data

Turning to the data, our goals are twofold. First, we desire to test the above theoretical predictions, in particular what factors determine whether any FDI takes place at all (i.e. whether profits from FDI exceed those of exporting). Second, we wish to see to what extent estimates from a typical FDI regression may be affected by ignoring the two-stage decision process of whether to undertake FDI (the selection stage) and then, conditional on this, how much FDI to do (the treatment stage). Thus, we will compare the results from a Heckman (1979) two-stage estimation process with those from simple OLS.

Since fixed costs govern the initial entry of FDI, a shortcoming of most country- or industry-level FDI datasets is that investment began long before the start of the sample. One possible way around this is to consider a positive flow of FDI as a signal that a new MNE is entering the market. This is the technique used by Razin, Rubenstein, and Sadka (2004) and Razin, Sadka, and Tong (2005). The downside of this approach is that once some FDI has occurred, a positive flow of could be because of a new entrant or an expansion of an existing project. Thus it is unclear how to interpret such results. While firm-level data would allow the researcher to observe entry, these datasets suffer from their own difficulties. First, most firms undertake only one or two investment projects across the world, implying a predominance of “no activity” observations. Second, for firms to enter into such datasets, they either undertake some level of FDI or are notable along some other dimension (such as size). This therefore introduces sample selection issues that cast doubt on the estimates obtained from them.

An exception to these rules is the data of Iceland. The Icelandic data is especially well suited to the current problem for several reasons. First, Iceland is a stable, highly skilled economy with high per-capita income. These are traits that mirror those of the other developed countries, countries that are the major recipients of FDI.[5] Second, until fairly recently, Iceland received little inbound FDI. Thus, our dataset, which begins in 1989 and runs through 2001, allows us to observe the initial entry of firms from a particular parent country into the host. This avoids some of the problems found in using data from long-established hosts such as the U.S. or the European Union countries. Third, a great deal of Icelandic FDI is concentrated in power-intensive industries such as aluminum smelting. Using data on FDI in these industries is to our advantage since these are also high fixed cost industries. Furthermore, since these investments are all greenfield FDI, the issue of fixed costs directly applies. This is not true for mergers and acquisitions, investment methods that form the bulk of FDI in other datasets.

We use two different dependent variables in our regressions, the flow and the stock of FDI from a parent country j into Iceland's power-intensive industry in a year t.[6] These data are measured in millions of real 1995 U.S. dollars and come from the Central Bank of Iceland. We use the flow variable in order to make our results comparable to those of Razin, Rubenstein, and Sadka (2004) and Razin, Sadka, and Tong (2005). As suggested by Blonigen and Davies (2004), we use a log-linear specification to aid with

[5] See Markusen (2002) for a discussion of the distribution of FDI across country categories.
[6] Kristjánsdóttir (2005) uses the stock data for the power-intensive industry as well as three other industry categories. In that earlier work, roughly similar results were found.

the skewness typical in FDI data. This implies that our regression specification is similar to the gravity specification used by Eaton and Tamura (1994), Brainard (1997), Blonigen et. al. (2005), and others.[7] Nevertheless, in unreported results we used levels instead of logs and found comparable results. These alternative regressions are available upon request. Note that when using logs in a dataset such as ours with a large number of zeros that using the standard estimation procedures will drop these "no FDI" observations from the dataset, potentially biasing the estimates. One of our chief objectives is to explore the extent of this bias by comparing such results to those from a Heckman two-step procedure. Under this technique, we first use Probit to regress a dummy variable equal to one if there is positive FDI from country j in year t on a set of controls. Then, conditional on being selected, we regress the (log) size of this FDI on additional control variables.

Our set of potential parent countries are the 23 countries that were OECD members during the entire sample period.[8] This set of countries provided all of Iceland's inbound FDI across all industries, however not all of them invested in Iceland and only some invested in Iceland's power-intensive industry.[9] Furthermore, these countries provide the large majority of worldwide FDI outflows. They therefore provide a reasonable group of countries to use as potential sources for Icelandic FDI. An additional reason to utilize this sample is that it brings us closer to that of Razin, Rubenstein, and

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[7] In addition to the gravity approach, there is the "knowledge-capital" model used by Carr, Markusen, and Maskus (2001). This model uses FDI in levels and interaction terms to deal with non-linearities in the data. Due to our small number of observations and the issues raised by Blonigen and Davies (2004), we have opted for this log-linear approach in order to preserve our degrees of freedom.

[8] In their paper by Razin, Rubinstein, and Sadka (2004) use data on 24 of the 30 member countries of OECD. Our data include more countries than used in the Razin et al. paper, and our additions to research in the field include usage of several natural resource variables.

[9] The 24th OECD country was Iceland itself. Only 17 of the 23 invested at all in Iceland during the sample and only 4 of these actually invested in the power-intensive industry.

Sadka (2004) and Razin, Sadka, and Tong (2005) who use data on FDI stocks from OECD countries.

In line with the above theory and other work, our control variables include several specific to the parent country j. The first group of these are standard ones in FDI regressions: parent country GDP ($GDP_{j,t}$), parent country GDP per capita ($GDPcap_{j,t}$), parent country skill ($Skill_{j,t}$), parent country trade openness ($Open_{j,t}$), and the distance between the parent country and Iceland ($Distance_j$). Typical results find positive effects from the first four of these variables and a negative effect for the last. All of these are defined in Table 1. Their sources are also given there.

Using the theory from Section 2, however, we do not necessarily expect this. For example, suppose a larger parent economy has both lower domestic costs due to economies of scale associated with firm fixed costs (a lower β) and more consumers (a higher α). Therefore we might expect this country's firms to be less like to undertake FDI yet if they do, they might produce more output. Alternatively, a higher parent per-capita GDP would be associated with a higher β, making FDI more likely, and a higher α, meaning more FDI if any is undertaken. A high skill might imply higher parent labor costs (high β), but may not have any impact on demand conditions after controlling for income. A high openness may reduce the need for outbound FDI since parent exports are relatively easy, however if FDI occurs access to inputs imported into the parent might then increase the amount of FDI. Distance, on the other hand, could be positively correlated with β^*, suggesting that countries distant from Iceland are both less likely to enter Iceland at all and that those that do will produce less.

In many FDI regressions, these parent country variables are matched with comparable host country variables. In our case, however, the host country does not vary. It is therefore not surprising that when variables such as Icelandic GDP, per-capita income, skill, openness, and investment costs were included, they were never significant. Because of this insignificance, they were excluded from the presented estimates. It is worth noting that when they were included, they impacted our reported estimates in only minor ways although due to the large decline in the degrees of freedom (our sample size is fairly small), many of our other coefficients became insignificant. These alternative results are available upon request.

Although we did not include the Icelandic variables, we did include several variables that attempt to control for the costs in the power-intensive industry. One of the primary attractions of Iceland for this industry is its abundant and inexpensive hydroelectric power. As the name implies, one of the power-intensive industry's primary inputs is electricity. As a result, when the price of electricity increases in the parent country or the rest of the world, this makes FDI in Iceland more attractive. Specifically, we utilize two such measures: the worldwide price of oil and the greenhouse gas emissions allowance of the host country. For the oil price, given the time it takes to get investment underway, we use the lagged price of oil (Oil_{t-1}) when estimating whether any FDI occurs and the current price of oil (Oil_t) in estimating the amount of FDI given that there is some amount. This is to account for the fact that oil prices at the time the entry decision is made are more likely to affect that decision. A rise in either of these is equivalent to a rise in β, making FDI more attractive. What can be predicted, however, is the permissible greenhouse emissions. The Kyoto Protocol established time tables for each country, outlining the level of carbon dioxide it can emit. With a higher home allowance ($CO2_{j,t}$), this is might be equivalent to lower pollution standards and lower compliance costs, i.e. a lower β and less likely FDI. On the other hand, a high allowance in the parent country might be indicative of high pollution levels and high damages associated with pollution. Therefore, in such a country, the government might actually set more stringent standards making FDI more likely. Similarly, when firms have more exposure to hydro power in their home country, we predict that they will find it easier to use this technology in Iceland. Therefore parent countries with more past hydro power production ($Hydro_{j,t-1}$) at home are more likely to undertake FDI. At the same time, greater current hydro power ($Hydro_{j,t}$) would imply less need to shift energy-intensive production to Iceland meaning that, given a positive amount of FDI, the level of activity should be lower. Despite the importance of these industry-specific cost variables, such items are typically not considered in FDI studies.

Finally, in some specifications, we include information on whether firms from a parent country j have previously invested in Iceland outside of the power-intensive sector. We do this to investigate the possibility that when one firm invests in Iceland that this provides information to other firms from the same parent country or that this reduces uncertainty about Iceland's economic environment. One method of doing this is to include Other FDI $Dummy_{j,t-1}$ which is a dummy variable equal to one if there was positive FDI from country j in year t-1 in some other industry. The other is to include Other $FDI_{j,t-1}$ where we use the magnitude of this other industry FDI (which is measured in the same way as our dependent variable).

Table 1 reviews our variables, their sources, and our a priori expectations regarding the signs of the control variables in each of the two stages (selection and treatment). Table 2 provides summary statistics for all variables and a list of countries in the data.

4. Results

Table 3 presents our results when FDI is measured in log flows. Column 1 contains the results from a typical OLS gravity regression.[10] Column 2 reports the results from the selection stage of the Heckman two-step (whether FDI occurs) and Column 3 presents those for the treatment stage (the magnitude of FDI given that it occurs). In the OLS regression, only three control variables are significant, $GDP_{j,t}$, $Distance_{j}$, and $Hydro_{j,t}$. Both $GDP_{j,t}$ and $Distance_{j}$ have estimated coefficients typical of FDI regressions. Specifically, a 1% rise in parent country GDP is linked to 2.4% increase in FDI to Iceland. A 1% rise in distance from Iceland, however, leads to a 9% fall in FDI. However, as the Heckman results indicate, such inferences need to be tempered by potentially misleading effects from OLS estimation that ignores the “no FDI” observations.

Turning to the Heckman results, we find far more significance in our coefficients. In the selection stage, five of our eight explanatory variables are significant. As expected, higher parent country per capita GDP, higher parent skill, smaller parent openness, and smaller distance make FDI into Iceland more likely. The parent CO_2 allowance is also

[10] In unreported results, we used levels instead of the gravity model’s log specification. In this case, we also applied the Tobit procedure since we were able to keep zero observations in the sample. Tobit and OLS yielded qualitatively similar estimates for our significant variables. Nevertheless, when applying a Heckman two-step to the level data, we found that most of the explanatory power lay in the selection stage. Thus, the level results pointed to the same sensitivity we found here. These alternative estimates are available upon request.

positive, consistent with the increased damage and compliance cost story discussed above. In the treatment stage, however, we only find two significant coefficients: $GDP_{j,t}$ and $Hydro_{j,t}$. Both of these coefficients are comparable to their OLS predictions.

The difference between the OLS and Heckman regressions are important when considering how one ought to interpret regression coefficients, especially for small economies and disaggregated datasets where there are a large number of “no FDI” observations. Most strikingly, the results for distance suggest that it may be an important determinant on whether FDI takes place, not on its magnitude. As such, it may be more closely related to variation in the fixed cost of FDI, not marginal costs. Furthermore, by ignoring the “no FDI” observations, important information provided by other variables such as $GDPcap_{j,t}$ and $Skill_{j,t}$ are lost.

In particular, it is worth noting that the predicted signs of such variables differ between the OLS and Heckman results. In our data, the selection and treatment stages obtain different signs for all six variables included in both. More importantly, comparing the results from OLS to the treatment stage (both of which consider the magnitude of FDI), we find different signs on three of these variables. As such, when comparing the estimates across data sets, some with many zero observations and some with few, this can cause misleading differences when only using OLS. For example, Blonigen and Davies (2004) use data on US FDI and find that parental $Openness_{j,t}$ is positively correlated with FDI, a result they interpret as an FDI deterrent effect from trade costs. In contrast, our OLS results would tend to suggest that $Openness_{j,t}$ either has no effect of a slight negative effect on FDI. However, after dealing with the sample selection created by zeros, the positive coefficient in the treatment stage is consistent with their result. Thus when comparing results from large countries with few zeros in the data to those from small countries, it is necessary to deal with the potentially greater sample selection in these latter data.

Table 4 repeats the above exercise using the logged FDI stock as the dependent variable. Overall, the results are similar to the flow results in Table 3 with the exception that more variables are significant in the OLS regression. More importantly, however, is that the Heckman results indicate that most of this significance drives whether or not FDI happens, not the magnitude of FDI given that it occurs. Furthermore, we again find important sign differences between the OLS estimates and the Heckman estimates. In particular, $Openness_{j,t}$ is positive and significant in the OLS results, but negative and significant in the Heckman selection stage. Thus, these results also indicate the potential dangers of using the standard gravity model approach when fixed costs and "no FDI" observations are important features of the economic environment.

Table 5 repeats the Heckman estimation of FDI flows but includes either the Other FDI $Dummy_{j,t-1}$ or the Other $FDI_{j,t-1}$ variables. Table 6 does the same for FDI flows. In no case is the other FDI variable significant. This suggests that other firms entering Iceland in other industries does not transmit information to power-intensive firms considering entering Iceland. Thus, in this case, we find no evidence for the agglomerative type effects found by Head, Ries, and Swenson (1995) or Blonigen, et. al. (2005). Our other control variables, however, are similar in sign and significance as the earlier Heckman results.

5. Conclusions

The goal of this paper has been to investigate the role of fixed costs in FDI data. Since the decision of whether or not to undertake FDI at all is central to the theoretic literature on multinational firms, it is important to ask to what degree failure to empirically model the two-stage decision process affects the inferences drawn from standard gravity-type regression analysis. To explore this, we use a unique data set on Iceland, a developed, skilled country that in many ways mirrors the primary recipients of FDI. It is differentiated, however, by the large number of "no FDI" observations, a facet which makes it an ideal candidate for exploring these issues with real world data.

We find that the standard OLS regression approach does indeed lose information by failing to consider the selection stage of the FDI process. In particular, it can lead to misleading estimates on the role of items such as distance between the parent and host countries and parent country openness.

While it is always difficult to take estimates from one country's data and apply them to others, a potentially serious problem for an unusual economy such as Iceland, there are nevertheless lessons to be gained from our exercise. First, our results indicate that the fixed costs in the theory do indeed play a significant role in the data. Second, when there are a large number of zeros in the data, failing to account for this can bias the estimates. As more researchers begin to use data on developing countries, industries, or individual firms, this indicates that there is a particular need to be cognizant of these "no FDI" observations and to model them appropriately. It is our hope that apart from the information drawn from this particular dataset that this lesson is a useful one for future research.

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Table 1: Variable Descriptions

Variable	Description	Unit of Measurement	Source	Expected Sign	
				Selection Stage	*Treatment Stage*
$FDI_{j,t}$	FDI from j in t	Millions of 1995 US dollars	Central Bank of Iceland		
$GDP_{j,t}$	GDP of j in t	Trillions of 1995 US dollars	Penn-World Tables	-	+
$GDPcap_{j,t}$	GDP per capita of j in t	1995 US dollars	Penn-World Tables	+	+
$Skill_{j,t}$	Percentage of workers in 0/1 and 2 job classification	Fraction between 0 and 1.	International Labor Organization	+	+
$Openness_{j,t}$	Imports+Exports/GDP for j in t	Percentage	Penn-World Tables	-	+
$Distance_{j}$	Distance between capital cities	Kilometers	Indo.com	-	-
$Hydro_{j,t}$	Hydropower output of j in t	Billions of kilowatt-hours	International Energy Annual (2002).	+	-
Oil_{t}	World price of a barrel of crude oil in t	1995 US dollars	Energy Information Administration - EIA - Official Energy Statistics from the US Government.	+	+
$CO2_{j,t+1}$	Greenhouse gas emission allowance in manufacturing for j in t+1, CO2 equivalence.	Thousands of tons.	The Environment and Food Agency of Iceland.	+	+
Other FDI $Dummy_{j,t-1}$	Dummy = 1 if j had FDI in another industry in t-1	Dummy Variable	Central Bank of Iceland	+	0
Other $FDI_{j,t-1}$	Amount of FDI j had in another industry in t-1	Millions of 1985 US dollars	Central Bank of Iceland	+	0

Table 2: Descriptive Statistics and Sample Countries (in logs)

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
FDI Flows	28	1.178792	1.769981	-3.18389	4.299045
FDI Stocks	44	3.085803	1.358933	.450276	5.065949
$GDP_{j,t}$	299	-1.042364	1.416335	-4.257324	2.194755
$GDPcap_{j,t}$	299	10.01785	.5923157	7.787382	10.98385
$Skill_{j,t}$	264	-1.547889	.3486501	-2.659199	-.6489697
$Distance_{j}$	299	-5.742244	.6350922	-6.509651	-4.060523
$Hydro_{j,t}$	299	2.297954	2.56579	-3.963316	5.871174
Oil_{t}	299	.0822692	.1998094	-.403399	.3950699
$CO2_{j,t+1}$	299	6.431794	.1789369	6.200509	6.76273
$Open_{j,t}$	299	4.120162	.5563562	2.767778	5.654116

Australia	Austria	Belgium	Canada	Denmark
Finland	France	Germany	Greece	Ireland
Italy	Japan	Luxembourg	Netherlands	New Zealand
Norway	Portugal	Spain	Sweden	Switzerland
Turkey	UK	United States		

Table 3: FDI Flows into Iceland

	OLS	Heckman Two-Step	
		Selection	**Treatment**
	(1)	**(2)**	**(3)**
$GDP_{j,t}$	2.410*** (3.54)	-.304 (-0.81)	2.457* (1.74)
$GDPcap_{j,t}$	-5.625 (-0.80)	16.365*** (3.85)	-36.327 (-0.92)
$Skill_{j,t}$	-1.858 (-0.88)	2.396* (1.95)	-5.658 (-0.87)
$Openness_{j,t}$	-2.882 (-0.54)	-9.226*** (-3.32)	14.027 (0.62)
$Distance_{j}$	-9.302** (-2.05)	-8.775*** (-3.52)	7.917 (0.36)
$Hydro_{j,t}$	-3.920*** (-3.72)		-3.774* (-1.83)
Oil_{t}	-.939 (-0.68)		-.796 (-0.28)
$CO2_{j,t+1}$	.788 (0.36)	3.470*** (2.79)	-3.829 (-0.54)
$Hydro_{j,t-1}$		.094 (1.03)	
Oil_{t-1}		.999 (0.96)	
Constant	28.404 (0.34)	-206.797*** (-3.98)	412.251 (0.84)
Observations	28	263	
Uncensored Observations		28	
Adjusted R^2	0.5127		
Mills Ratio		-3.279 (-0.84)	

Table 4: FDI Stock into Iceland

	OLS	Heckman Two-Step	
		Selection	Treatment
	(1)	(2)	(3)
$GDP_{j,t}$	2.462*** (12.15)	-.304 (-0.81)	2.360*** (3.60)
$GDPcap_{j,t}$	-4.788** (-2.47)	16.365*** (3.85)	9.976 (0.54)
$Skill_{j,t}$	-1.750*** (-2.62)	2.396* (1.95)	.352 (0.12)
$Openness_{j,t}$	5.068*** (4.11)	-9.226*** (-3.32)	-2.328 (-0.22)
$Distance_{j}$	-1.917* (-1.87)	-8.775*** (-3.52)	-9.206 (-0.89)
$Hydro_{j,t}$	-1.342*** (-4.69)		-1.230 (-1.29)
Oil_{t}	-.392 (-1.00)		-.425 (-0.33)
$CO2_{j,t+1}$	.358 (0.68)	3.470*** (2.79)	1.949 (0.59)
$Hydro_{j,t-1}$		.094 (1.03)	
Oil_{t-1}		.999 (0.96)	
Constant	25.101 (1.12)	-206.797*** (-3.98)	-152.871 (-0.67)
Observations	44	263	
Uncensored Observations		44	
Adjusted R^2	0.8969		
Mills Ratio		1.519 (0.84)	

Table 5: The Effect of Other FDI on FDI Flows

	Other FDI Dummy		Other FDI	
	Selection	**Treatment**	**Selection**	**Treatment**
	(1)	**(2)**	**(3)**	**(4)**
$GDP_{j,t}$	-.191 (-0.49)	2.509** (2.30)	-.335 (-0.87)	2.369*** (3.88)
$GDPcap_{j,t}$	16.547*** (4.05)	-29.763 (-1.03)	15.041*** (3.26)	-15.871 (-0.85)
$Skill_{j,t}$	2.441*** (2.12)	-5.121 (-1.03)	2.249* (1.77)	-3.083 (-1.07)
$Openness_{j,t}$	-9.082*** (-3.39)	10.209 (0.62)	-9.090*** (-3.20)	2.687 (0.25)
$Distance_{j}$	-8.963*** (-3.62)	3.826 (0.24)	-8.438*** (-3.31)	-3.472 (-0.32)
$Hydro_{j,t}$		-3.810** (-2.40)		-3.875*** (-4.31)
Oil_{t}		-.659 (-0.30)		-.852 (-0.70)
$CO2_{j,t+1}$	3.611*** (2.84)	-2.564 (-0.50)	3.765*** (2.80)	-.645 (-0.21)
$Hydro_{j,t-1}$	.080 (0.85)		.066 (0.65)	
Oil_{t-1}	.854 (0.80)		1.090 (1.02)	
Other FDI $Dummy_{j,t-1}$	-.354 (-0.74)			
Other $FDI_{j,t}$			.072 (0.75)	
Constant	-210.823*** (-4.13)	326.338 (0.92)	-193.869*** (-3.52)	156.657 (0.67)
Observations	263		263	
Uncensored Observations	28		28	
Mills Ratio	-2.501 (-0.90)		-1.148 (-0.58)	

Table 6: The Effect of Other FDI on FDI Stock

	Other FDI Dummy		Other FDI	
	Selection	**Treatment**	**Selection**	**Treatment**
	(1)	**(2)**	**(3)**	**(4)**
$GDP_{j,t}$	-.191 (-0.49)	2.322*** (3.47)	-.335 (-0.87)	2.447*** (3.10)
$GDPcap_{j,t}$	16.547*** (4.05)	10.561 (0.60)	15.041*** (3.26)	11.862 (0.49)
$Skill_{j,t}$	2.441*** (2.12)	.593 (0.19)	2.249* (1.77)	.518 (0.14)
$Openness_{j,t}$	-9.082*** (-3.39)	-2.527 (-0.25)	-9.090*** (-3.20)	-3.250836 (-0.24)
$Distance_{j}$	-8.963*** (-3.62)	-9.283 (-0.95)	-8.438*** (-3.31)	-10.394 (-0.76)
$Hydro_{j,t}$		-1.229 (-1.26)		-1.235 (-1.09)
Oil_{t}		-.530 (-0.39)		-.496 (-0.32)
$CO2_{j,t+1}$	3.611*** (2.84)	1.867 (0.60)	3.765*** (2.80)	2.064 (0.51)
$Hydro_{j,t-1}$	.080 (0.85)		.066 (0.65)	
Oil_{t-1}	.854 (0.80)		1.090 (1.02)	
Other FDI $Dummy_{j,t-1}$	-.354 (-0.74)			
Other $FDI_{j,t}$			.072 (0.75)	
Constant	-210.823*** (-4.13)	-157.836 (-0.72)	-193.869*** (-3.52)	-176.687 (-0.59)
Observations	263		263	
Uncensored Observations	44		44	
Mills Ratio	1.534 (0.90)		1.805 (0.72)	