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**Determinants of Exports and
Foreign Direct Investment in
a Small Open Economy**

Viðskipta- og hagfræðideild **Háskóla Íslands**
Odda við Sturlugötu



To my parents, Olga and Kristján

Helga Kristjánsdóttir

Determinants of Exports and
Foreign Direct Investment in
a Small Open Economy

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Fylgt úr hlaði

Það er viðskipta- og hagfræðideild Háskóla Íslands mikil ánægja að gefa út doktorsritgerð Helgu Kristjánsdóttur *Determinants of Exports and Foreign Direct Investment in a Small Open Economy (Gangráðar útflutnings og beinnar erlendrar fjárfestingar í smáu, opnu hagkerfi)*. Helga er fyrst allra til að ljúka doktorsprófi frá viðskipta- og hagfræðideild en ritgerð hennar er á sviði alþjóðahagfræði.

Helga, sem er frá bænum Kaupangi í Eyjafirði, er glæsilegur fulltrúi nýrra tíma þar sem konur sækja sífellt meira fram í vísindum og háskólakennslu. Það er okkur mikil ánægja að fylgja þessari fyrstu doktorsritgerð í viðskipta- og hagfræðideild úr hlaði.

Helga lauk stúdentsprófi frá Menntaskólanum á Akureyri 1989, BS prófi í hagfræði frá Háskóla Íslands 1992, MBA prófi frá Boston College 1995 og MS prófi í hagfræði frá Katholieke Universiteit í Leuven í Belgíu árið 2000. Þá hafði Helga rannsóknarstöðu við Kaupmannahafnarháskóla meðan á doktorsnámi stóð. Hún hefur verið góður fulltrúi viðskipta- og hagfræðideildar á alþjóðlegum vettvangi.

Helga hefur unnið með hagfræðingunum Þorvaldi Gylfasyni, Ronald Davies og Helga Tómassyni að rannsóknum sínum og er árangurinn þessi ritgerð sem deildin hefur ákveðið að gefa út.

Á undanförmum árum hefur viðskipta- og hagfræðideild lagt áherslu á uppbyggingu á rannsóknartengdu námi. Nú er boðið upp á sex námsbrautir í meistaranámi auk doktorsnáms. Það er von okkar að góð frammistaða Helgu verði öðrum hvatning til náms og rannsókna á sviði viðskiptafræði og hagfræði.

Reykjavík 16. júní 2004

Ágúst Einarsson
deildarforseti

Gylfi Zoega
umsjónarmaður doktorsnáms

Gangráðar útflutnings og beinnar erlendrar fjárfestingar í smáu, opnu hagkerfi

„...Landið er fagurt og frítt og fannhvítir jöklanna tindar, himinninn heiður og blár, hafið er skínandi bjart...“, þannig hljómar hluti kvæðisins „Ísland“ eftir Jónas Hallgrímsson sem birtist í *Fjölni* árið 1835. Það var eins og Jónas sæi Ísland úr sjónauka þegar hann orti þessar línur, þar sem hann bjó í Kaupmannahöfn. Markmið þessarar ritgerðar, sem að mestu er skrifuð við Kaupmannahafnarháskóla nokkrum húsalengjum frá dánarstað Jónasar, er einmitt að horfa til Íslands úr sjónauka sem smáríkis í miðju Atlantshafi, það er sjónauka alþjóðahagfræðinnar.

Ísland er hér sett í alþjóðlegt samhengi með því að beita nýjum kenningum á sviði alþjóðahagfræði, þar sem tekið er tillit til smæðar hagkerfisins og landfræðilegrar afstöðu þess gagnvart viðskiptalöndum beggja vegna Atlantsála. Ljóst er að smá, opin hagkerfi á borð við Ísland eru næm fyrir breytingum í viðskiptaumhverfi sínu og því er greining á stöðu þeirra mikilvæg. Ör þróun hefur átt sér stað innan alþjóðahagfræðinnar á undanförunum árum og kenningar sem tengjast milliríkja-viðskiptum og beinni erlendra fjárfestingu vakið mikla athygli. Hagfræðingar hafa í auknu mæli viljað leita skýringa á gangráðum útflutnings og fjárfestingar.

Í öllum köflum verksins miðast rannsóknin við að greina Ísland sem smátt, opið hagkerfi og tengja gögn og kenningar við alþjóðaviðskipti. Alþjóðaviðskipta-kenningar miða að því að skýra fjárfestingu jafnt sem útflutning. Almennt má segja að tilkoma erlendrar fjárfestingar jafngildi útflutningi fjármagns, í þeim skilningi að verið sé að flytja út hlut í fyrirtækjum í formi hlutabréfa. Á þennan hátt tengjast útflutningur og fjárfesting innan ramma alþjóðaviðskipta. Fyrsti kaflinn lýtur að greiningu útflutnings, en hinir þrír sem á eftir fylgja að greiningu beinnar erlendrar fjárfestingar á Íslandi.

Höfuðframlag þyngdaraflskenningar til alþjóðahagfræði varðar þá fjarlægðar-vernd sem afskekkt lönd njóta, á þann veg að fjarlægð er viðskiptahindrun sem dregur úr milliríkja-viðskiptum.

Niðurstöður verksins eru þær helstar að fjarlægð Íslands frá öðrum löndum hamli

útflutningi vöru, þjónustu og fjármagns frá Íslandi og dragi þannig úr viðskiptum þess við ömur lönd. Athuganir gefa til kynna að útflutningur ráðast af stærð viðskiptalandanna og kaupmætti íbúa þeirra, frekar en markaðsaðstæðum á Íslandi. Einnig kemur fram að útflutningur einstakra sjávarafurða er fremur háður fjarlægðarhindrunum en efnahagsumhverfi.

Þegar litið er til uppsafnaðrar beinnar erlendrar fjárfestingar á Íslandi, virðast fjarlægð, markaðsstærð og kaupmáttur upprunalandsins, veigamestu skýriþættirnir.

Niðurstöður þeirra rannsókna sem hér eru settar fram benda til þess að miðað við hina hefðbundnu framsetningu þekkingarlíkansins, sé samband beinnar erlendrar fjárfestingar og mannauðs hér á landi ólíkt því sem erlendar rannsóknir hafa leitt í ljós. Það er ekki fyrr en metnar hafa verið sértækar útgáfur af þekkingarlíkaninu sem unnt er að segja meira til um samband þessara þátta. Jafnframt gefa niðurstöður til kynna að ólíkir drifkraftar skýri fjárfestingu í einstökum atvinnugreinum á Íslandi. Bein erlend fjárfesting er mest í orkufrekum iðnaði og hann lýtur talsvert öðrum lögmálum en aðrar atvinnugreinar. Að lokum má draga þá ályktun að þegar leiðrétt er fyrir föstum kostnaði, skýri þyngdarafslíkanið fjárfestingarmynstrið betur en þekkingarlíkanið.

Aðkoma viðskipta- og hagfræðideildar Háskóla Íslands hefur verið mér mikils virði við ritgerðarsmíðina og munar þar mestu um framlag Þorvaldar Gylfasonar prófessors sem stutt hefur mig með ráðum og dáð í gegnum allt rannsóknarferlið. Hann hefur alltaf verið jákvæður, og átti meðal annars frumkvæði að námsdvöl minni í Kaupmannahöfn. Einnig hafa hinir tveir leiðbeinendur mínir, Helgi Tómasson dósent við Háskóla Íslands og Ronald Davies dósent við Oregon Háskóla verið mér mjög hjálplegir. Jafnframt er mér mikils virði hve Ágúst Einarsson prófessor og deildarforseti hefur hvatt mig til ritgerðarsmíðarinnar.

Von mín er að ritgerðin varpi bjartara ljósi á Ísland í alþjóðasamhengi „í godtvejr og storm“, eins og Jónas Hallgrímsson hefði kannski orðað það.

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Helga Kristjánsdóttir

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My research was mainly performed at the University of Copenhagen in Denmark over a two year timespan where I was surrounded by lots of wonderful people, one of them being Ronald Davies, later becoming my supervisor. The Danish people were very generous to me and supportive in every way. I was able to attend over twenty conferences and workshops all over Europe. I also took part in the CEPR research network "The Analysis of International Capital Markets: Understanding Europe's Role in the Global Economy", a network funded by the European Commission under the Research Training Network Programme. I especially want to express my gratitude to two professors at the University of Copenhagen for their hospitality, these are Peter Birch Sørensen, the head of the Economic Policy Research Unit (EPRU), and Martin Browning the head of the Centre for Applied Microeconometrics (CAM).

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Introduction

Following World War II, the capacity of the industrialized countries to produce and distribute various manufacturing goods both rebuilt itself and increased substantially. Countries were not only able to fulfill the demand of their own markets, but also saw potential markets for various industrialized goods in other countries as well. As an example of this, during the 1960s large Japanese car manufacturers were expanding their operations and market share. As part of this expansion, companies like Toyota and Mitsubishi had to choose whether to produce cars in Japan for export to the US or whether to simply produce them within the US. A decision to produce in the US would involve investment in manufacturing, i.e. becoming a multinational corporation. A multinational entity (MNE) or, in short, a multinational is a firm that has invested directly in certain activities across borders. Ever since the opening up of countries in the aftermath of the World War II, multinational activities involving exports and investment have become increasingly more important for world trade. Over the last part of the twentieth century, trade grew by twice the rate of world GDP and foreign direct investment (FDI) grew at twice the rate of trade. These patterns highlight the importance of understanding international trade and investment in the modern economy.

Prior to the 1980s, international economics was divided into two primary veins. First there was the general-equilibrium trade theory, based on perfect competition with constant returns to scale. Second, there was the partial equilibrium theory allowing for imperfect competition with increasing returns to scale (Markusen, 2002). These were combined in the so-called New Trade Theory during the 1980s and continuing up to today. An important part of this movement is the study of FDI. When choosing whether to export or invest in countries, critical macroeconomic variables include the cost of endowments such as labor and raw materials, the market size of the host and source countries, as well as the distance between them (Markusen, Konan, Venables, and Zhang, 1996). When firms locate production in foreign countries in order to gain access to abundant factors, the investment is referred to as being vertical (Helpman, 1984). However, if it is primarily due to the

desire to overcome trade costs and gain market access, it is said to be horizontal (Markusen, 1984).

For a long time the general belief was that capital-abundant countries were investing in capital-scare countries, i.e. that capital was flowing from the north to the south and creating vertical FDI. However, as Markusen (2002) describes, recent studies have shown that the majority of FDI has taken place between the wealthy countries, so that flow of capital has been between the east and west rather than from north to south. In other words, the flow of FDI has not been primarily from the developed to the developing countries, but rather among the developed ones. A second important fact is that small economies are more reliant on international markets and, therefore, import and export relatively more than large economies do. For example, in 1999, large economies like Japan and the US (Japan having about 127 million people, and US about 278 million) exported less than 12% of their gross domestic product. In comparison, the exports of the Scandinavian countries (with about 4-9 million people each) ranged from 37-44% of their gross domestic product (World Bank, 2002). Surprisingly, the export ratio of Iceland with a population of 0.3 million was only 34%. This indicates the need for Iceland to seriously consider the role of trade and FDI in developing and maintaining stable growth at a high level.

In order to properly bring Iceland in from the cold and into this discussion, special consideration should be given to its dual natural resources in fish products and hydropower. Development in trans-Atlantic trade is highly important for Iceland. Being a country in the middle of the North-Atlantic Ocean, it is distant from its major trading partners along the Atlantic. Before developing policy, it is necessary to analyze patterns in Icelandic trade and FDI data. Key to this analysis is the role of Iceland's small economy, unique endowments, and geographic remoteness. Whether Iceland is moving down the Milky Way alongside other nations or being sucked into a black hole, can be analyzed using the tools of economic geography, a galaxy of theory and empirics based on gravity.

In recent years, economists have shown increased interest in further developing

the theory of international trade, in order to understand the activities of multinationals, and what makes them engage in activities in various countries. This has led to a lively theoretical and empirical debate over how best to describe trade and investment both in theory and with the data at hand. In this dissertation, I will work through some of this progression of thought using new Icelandic data. In particular, emphasis is put on what criteria might be used for selecting certain theories for application to the Icelandic data, how these approaches predict for Iceland, and what these results say about Iceland in an international perspective. This dissertation also seeks to bring in the factor-proportions hypothesis implying that multinationals seek vertical production integration across countries to take advantage of different factor prices resulting from relative differences in factor supplies across countries.

One of my main findings is that it is often insufficient to take "off the shelf" approaches to the Icelandic data. In particular, I often find estimates that vary not only in magnitude, but also in sign from the findings for other, larger economies. Because of potential difficulties with the data such as non-normality of errors, omitted variable biases, and so forth, it is important to caution the reader not to take all coefficient estimates literally.

Nevertheless, I do find some support for the hypothesis that market size, distance, endowments of skilled labor, and other factors are useful when describing patterns of international trade and investment in Iceland.

However, for small resource-based economies like Iceland, the dependence on skilled and unskilled labor may not be the right endowment approach. Instead, resource-based endowments need to be brought into the picture, in order to reflect on the country's heavy dependence on marine and hydropower resources.

In my first chapter, "A Gravity Model for Exports from Iceland" I address Krugman's (1991a) observation that Iceland has a smaller ratio of export to GDP than could be expected. Gylfason too finds that it is only two thirds of its expected value (Gylfason, 1999). Although Krugman does not test this proposition, he asserts that Iceland's low export ratio is due to its small economy and distant

location. Krugman's assumption is in line with the trade theoretic intuition of gravity models, which implies that the volume of exports can be explained by market size and geographic location. I therefore choose to start analyzing Iceland in an international perspective by applying a gravity model to Icelandic exports. The market size measures of gross domestic product and population are meant to reflect economics of scale and its geographic dimension is also accounted for.

Following the literature on international trade, I consider the standard gravity model and apply it to the exports of Iceland. To do this, I use the common gravity model of international trade which was developed to test the effects of market size and distance on trade flows. The model originated in physics and is derived from the law of gravity, implying that a gravity force between two objects is dependent on their mass, and the distance between them. The gravity model is a macro model by nature, however, Bergstrand (1985) has provided microfoundations of the model. In my application of the gravity model, I start by applying a modified version of the Bergstrand (1985) specification.

It is particularly interesting to apply the gravity model to a country as small and distant as Iceland, with an export commodity composition different from most other countries because of Iceland's heavy dependence on seafood exports.

Here, the objective is firstly to investigate how the gravity model specification does for a small, resource based and isolated country like Iceland, when testing some extensions of the model together with the conventional specification. These modifications include capturing the difference between trade blocs receiving exports, as well as the difference between sectors. Secondly, the objective is to find out whether a correction for small economic size changes the estimates obtained, and thirdly to apply the gravity specification to important marine export products.

I test for this using a unique data set for Iceland. In this research merchandise exports constitute export of goods and services. And the data allow for disaggregation by four main sectors: the fishing industry, manufacturing, power intensive industries and finally other industries. The good export data availability from the Statistical Bureau of Iceland allows for even further disaggregation to analyze how

well the gravity model does for sectors when they are analyzed individually.

One of my modifications of the gravity model includes a first-ever application of the so-called inverse hyperbolic sine function, rather than a logarithmic function. The advantage of applying this function is that it allows for inclusion of zeros and negatives in the sample data, and has analogous shape to a logarithm function for positive values. This is especially convenient when analyzing disaggregated data for Iceland, since lots of zeros appear in the data when thinly spread across sectors and countries.

Consistent with Krugman, I find that distance is a significant barrier to Icelandic exports. Regression results for exports from Iceland indicate that exports are reduced by distance, just as standard results predict. More specifically, results indicate that distance negatively affects exports. However, unlike Krugman, I find that the market size of the trade partner is useful for explaining trade patterns. Moreover, estimates indicate that exports are not correlated with the market size of Iceland, but rather market size and wealth of the recipient country. Thus, although estimates for Iceland differ somewhat from the general case, due to how heavily dependent the economy is on metal and fishing exports, I find it instructive to focus on these industries specifically.

The second chapter is called "Determinants of Foreign Direct Investment in Iceland". One way of looking at trade as presented in the first chapter, is to view it in a broader perspective. Trade literature views foreign direct investment (FDI) as one form of trade, i.e. trade in financial capital. Export of capital from Iceland across borders, corresponding to moving the origin of capital away from Iceland to some other country, which corresponds to exporting the origin of capital.

The World Bank defines foreign direct investment in the following way: "Foreign direct investment is net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows total net, that is, net FDI in the reporting economy

less net FDI by the reporting economy” (World Bank, 2002).

In trade literature FDI is generally either measured as stocks or flows, and I prefer to apply the stock measure rather than the flow measure since FDI stock is believed to better reflect long-term strategies of MNEs (Davies, 2002). More specifically, the FDI stocks are believed to carry information about investment incentives from the past to the present, i.e. accumulated changes in investment up to the current year. Some researchers (CMM, 2001; Brainard, 1997) have used affiliate sales. However, similar to FDI flows, affiliate sales are subject to short-term, rather than long-term objectives of MNEs operations.

In recent years researchers have become increasingly interested in understanding what drives multinationals to undertake a cross border investments, that is foreign direct investment (FDI) in other countries. Gravity models have gained popularity in the trade literature in recent years, in order to estimate determinants of FDI. This form of investment, FDI, is generally considered more stable than foreign bank loans or foreign portfolio investment (Grosse, 1997).

Recent examples of a gravity model application to FDI include Brainard (1997) and Mody, Razin and Sadka (2003). Like in this chapter, the paper by Brainard seeks to explain determinants of unilateral MNE activities specifically, since she separately estimates inward and outward FDI proxies. Again, the gravity model offers ways to estimate how much FDI is driven by market size and distance. Also a gravity model approach is applied to FDI in a paper by Jeon and Stone (1999), where they seek to explain how FDI is attracted to counties in the Asia-Pacific region. Like in this chapter Jeon and Stone provide disaggregation by sectors and countries and estimate fixed country and sector effects. However, they only receive separate estimates for individual years whereas here data run over countries, sectors, and years. Their results indicate that FDI is not much driven by market size in the host countries in the Asia-Pacific region. Moreover, Di Mauro (2000) provides analysis of FDI entering the Central Eastern European Countries (CEEC), the study is comparable to this chapter since FDI data are disaggregated over both countries and sectors over time. The data dimension applied here covers source

countries, sectors, and year of investment. This allows me to analyze fixed source country effects and sector specific effects, as well as simultaneously estimating sector and trade bloc fixed effects. That is, the idea is to capture whether it is possible to determine fixed difference between sectors. I use inbound FDI in Iceland, it is a common practice to study data sets that cover only one country's inbound FDI, and an example of that would be Waldkirch (2003).

Results indicate that consistent with previous literature, distance and source country market size (population and GDP) are useful for predicting FDI levels. However unlike earlier findings, estimates indicate that wealth may be more important than market size, since the effects of the market size variables of GDP and population are often close to being equal and opposite in sign.

In the third chapter, "The Knowledge-Capital Model and Small Countries", I switch from a gravity model of FDI to the currently popular Knowledge-Capital (KK) model of FDI presented by Carr, Markusen and Maskus (2001). The reason for switching to a KK model for further estimation of FDI is that I believe the KK model may perform better for a resource-based country like Iceland, since the model allows for incorporation of factor endowment proxies together with macro measurements.

Some important contributions of the KK model include incorporation of source endowments as part of its components and other factors such as investment cost and trade cost to account for both horizontal and vertical motives for FDI. Just as soon the KK model was put forward it gained a lot of publicity and debate, and has been tested by several economists. Blonigen, Davies and Head (2002) applied the same set of data as CMM to a different specification and found that the CMM specification was not able to account for vertical motives of FDI. They therefore concluded that the CMM is only able to capture incentives for making horizontal FDI, and therefore the previous model by Helpman (1984) could not be rejected in favor of the KK model. Then Davies (2002) went on with a more generalized specification and found support for the CMM model. Davies found that the source country needed to be sufficiently more skilled than the host, before multinational

in the source have an incentive for undertaking vertical investment in the host. Finally, some Swedish economists went with more expanded set of data and found support for the CMM specification. The Stockholm economists Braconier, Norbäck, and Urban (2003) concluded that previous studies had suffered from poor coverage of data.

In this study, the basic KK specification is tested together with several additional variations. These include restricting the number of size variables, omitting outliers, and increasing observations by replacing trade and investment costs with dummies and time trends. Also, the procedures used by Davies (2002) and Blonigen, Davies and Head (2003) are applied to thoroughly analyze knowledge effects on FDI, and to better understand whether FDI tends to be horizontal or vertical. And finally, some new skill measures are included such as education and per capita wealth.

It is interesting to apply the KK model to a small open economy like Iceland because of its small size and location, together with generally being regarded as relatively skilled-labor abundant. The model helps explain how capital in Iceland is linked to knowledge, i.e. how FDI is determined by the amount of skilled labor in Iceland compared to countries investing in Iceland.

Even though the KK model has a more developed theoretical motivation than the gravity model, empirical testing of several KK model specifications provides estimates considerably different from those obtained previously by CMM and other researchers. In particular, my results for the skilled labor measures run contrary to earlier findings. These results may be because the CMM specification encounters data difficulties when GDPs are highly mismatched or due to differences between the large country data used by other researchers. Alternatively, as explored in Chapter four, they may arise from the omission of factor endowments important in the Icelandic economy such as energy or fish stock.

The fourth chapter is called "What Drives Sector Allocation of Foreign Direct Investment in Iceland?" The estimates obtained for various KK model specifications in Chapter three indicated that the dependence on skilled and unskilled labor may not be the right endowment approach for a small resource based country like Iceland.

Therefore, in this fourth chapter, I break FDI down by sectors and add to the endowment measures used in previous chapters.

A recent study of one sector dominance in inward FDI can be found in a paper by Waldkirch (2003). In his paper Waldkirch seeks to explain the dominance of the manufacturing industry of inward FDI into Mexico, where he emphasizes the role of skilled and unskilled labor as factor endowments for FDI. Waldkirch says his additions to previous work on the KK model by CMM and Blonigen et al., is to offer more specific analysis by providing sector decomposition of FDI. This research not only offers sector disaggregation but also a refinement of CMM's KK model by bringing more resource endowments to the story, especially to reflect on how heavily dependent the economy of Iceland is on marine and hydropower resources.

The analyses include investigation of four major sectors: the power intensive sector, commerce and finance, telecom and transport, and other industries. The decomposition of FDI into different sectors allows for discussion of how factor abundance can influence the allocation of FDI across sectors. In particular the relation between FDI and electricity prices may influence the predominance of FDI in the power intensive industry in Iceland. Also, by sector disaggregation, it is possible to determine how the economic size variables in the CMM specification affect individual sectors.

The measures used to capture natural resource endowments include total fish stock caught in Icelandic waters. Also, infrastructure, pollution quotas and government stability are accounted for in this research. Since Iceland has a considerably larger pollution quota than all other countries engaging in the 1997 Kyoto Protocol on climate change, this may well affect the sector allocation of FDI.

The results support the hypothesis that there are more factors at work in a small resource-based country like Iceland, than the two factors of skilled and unskilled labor in the basic CMM specification.

In this Chapter I test FDI sector shares as well as FDI levels in each sector; this is useful analytically because FDI shares reflect the relative size of each sector within a particular year of investment. The share measure allows for analyzing the

relative importance of the power intensive sector in overall FDI.

The share measure for FDI has been applied before in similar research. In a well known paper, Brainard (1997) proxies outward and inward FDI separately as the share of affiliate sales in total exports. Another more recent example of a share measure can be found in a paper by Slaughter (2000), where he constructs an investment share variable as the share which accounts for an FDI proxy (measured as majority owned affiliates) in overall multinational investment.

A notable feature of the data is a large number of zeros, arising from that no investment is made in particular sectors in particular years, and potentially leading to non-normality of errors. Theories on FDI assume that there is a certain threshold cost (Markusen, 2002) i.e. fixed cost, which multinationals need to consider when determining whether to undertake FDI. However, these are generally not dealt with in empirical models of FDI.

In order to account for fixed cost I apply what is called sample selection, which implies a division of the sample based on whether investment takes place by a particular country in a particular year or not. More specifically, the procedure used to control for whether sample selection is driving my results, by using the Heckman's (1979) two-step procedure.

I find that the KK model seems to explain something about fixed costs; however it does not seem to tell much about the level of investment, that is marginal change in investment, after firms have overcome the threshold of fixed cost. The gravity model, however, does provide information about both issues.

The results turn out to be somewhat different from what was anticipated since the KK model still does not perform very well for Iceland. All things considered, it appears that one of the main advantages of applying the Heckman procedure to the gravity model rather than the KK model is the capability of the gravity model gives an indication of how host country characteristics affect FDI, whereas the KK specification does not. However, the procedure to include endowment measures in the gravity model can be credited to the KK literature.

Taken together, the application of a macroeconomic approach by means of a

gravity model implies that consistent with Krugman's earlier conjecture, distance is found to be a significant barrier to Icelandic exports. The results also indicate that exports are not so much driven by market size of the export providing country, Iceland, but rather market size of the country receiving exports, and that wealth effects may be more important than market size effects.

When the gravity model is applied to analyze foreign direct investment, distance and source country market size (population and GDP) are found useful for predicting FDI levels, which is consistent with previous literature. However, unlike earlier findings, estimates indicate that wealth may be more important than market size, since the effect of the market size variables of GDP and population are often close to being equal and opposite in sign.

Moreover, even though the KK model has a more developed theoretical motivation than the gravity model, the several specifications provide considerably different from what obtained in earlier research by CMM and other researchers. This is particularly evident for skilled labor measures that run contrary to earlier findings. Therefore, my conclusion is that this may be because the basic CMM specification does not do so well when source and host differ considerably in their GDPs sizes. Also, a possible reason for the deviation maybe because in previous research, variation was derived from differences between much bigger countries, opposite from the small versus large country case here. Furthermore, an important issue maybe that the KK model specification tested by CMM only incorporates the two endowments of skilled and unskilled labor, which may not be the right endowment comparison for Iceland because how heavily the economy is dependent on the dual natural resources of hydropower energy and fish products.

In the end, when all chapters are considered simultaneously, the end result is that the geographic approach to trade theory, which results in the gravity model, applies well to a small open economy like Iceland. Gravity forces appear to describe Iceland's exports in that distance hampers trade whereas larger trading partners increase it. Moreover, the distance effect is not only apparent in Icelandic exports, but may also be important for foreign direct investment in Iceland. Although

I find some reasons to prefer the gravity model when estimating foreign direct investment, I also find support for the intuition behind the Knowledge-Capital model, i.e. that endowments matter. In particular, I find that, rather than merely using knowledge endowment proxies, employing proxies for endowments crucial to the Iceland economy can be useful both in terms of describing levels of investment and the fixed costs typical in foreign direct investment models.

This dissertation is not put forward in order to invalidate the traditional wisdom on trade and investment behavior, but rather is meant to provide some extensions of existing knowledge in the field.

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1 Chapter I. A Gravity Model for Exports From Iceland

1.1 Introduction

Because of Iceland's small economy and population, the country is highly dependent on international trade. Generally, small economies export a greater proportion of their gross domestic product than larger economies. One could therefore expect Iceland's export ratio to be high relative to other nations. This is however not the case since the export ratio of Iceland did not exceed export ratios of other small nations in Europe from 1988-1997¹, and Gylfason finds that it is only two thirds of its expected value (Gylfason, 1999). When corrected for its small size, Krugman (1991a) observes that Iceland has a smaller ratio of export to GDP than could be expected. Although he does not test this, Krugman explains the low export ratio of Iceland by its geographical isolation, lack of intra-industry trade and resource dependence of the Icelandic economy.

I test these suppositions using the popular gravity model of exports in which trade is dependent on distance and economic size. I find that distance does reduce exports, but that the market size of Iceland is not correlated with exports. Instead, market size and wealth seem to be more important.

In recent years there has been a growing literature on the New Trade Theory, allowing for increasing returns to scale and imperfect competition. Within the New Trade Theory, there is the field of Geography and Trade, in which the gravity model is classified (Markusen, 2002, pp. 3). The model incorporates economics of scale by accounting for market size, proxied by country population size and GDP. A geographic dimension is also included in the model by including distance.

The gravity concept is originated in physics, referring to Newton's law of gravity. Newton discovered the nature of gravity in his mother's garden in England, 1666, (Keesing, 1998) when analyzing the pulling force causing an apple fall to the ground. He named the pulling force gravity. The gravitational force between two objects

¹See Figure 1.1 in Section 1.2.

is dependent on their mass and the distance between them. When the gravity model is applied to economics, exports correspond to the force of gravity, and gross domestic product corresponds to "economic mass". In economics, the model is used to explain the driving forces of exports, i.e. what forces one country to export to another. The gravity model has been applied in economics for a long time. Early versions of the model were presented by Tinbergen (1962) and Pöyhönen (1963). The gravity model is a macro model by its nature, since it is designed for capturing volume, rather than the composition, of bilateral trade (Appleyard & Field 2001, pp. 177-8).

Although the model was widely used in empirical work, it lacked a theoretical basis until Bergstrand (1985) laid out the microfoundations of the model. The model specification applied by Bergstrand has probably been the most commonly used to date. In a later paper, Bergstrand (1990) assumed product differentiation between firms rather than countries. The gravity model has been increasingly popular in the last decade. Helpman (1998) concludes that the gravity model does best for similar countries that have considerable intra-industry trade with each other.

Given Krugman's comments, it appears as if the properties of the gravity model are particularly suitable in the case of Iceland, since the model not only captures effects of distance on trade volume, but also the exporting and recipient countries market size and wealth. However, there are features unique to Iceland. The fact is that Iceland's export commodity composition differs from most other countries, with exports dominated by seafood exports. The main exporting industry is the fishing industry, which is subject to natural fluctuations, as reflected in the business cycle of the economy. However, the share of fishing products in exports has been gradually decreasing, going from 56% of merchandise exports in 1990² down to 41% in 2000. The contribution of the fishing industry to GDP was also much lower since fisheries only accounted for about 6% of GDP in 2000³. Therefore, it is useful

²National Economic Institute of Iceland (2000), Historical Statistics 1945-2000, Table 7.11.

³National Economic Institute of Iceland (2000), Historical Statistics 1945-2000, Table 1.7.

to analyze marine products specifically.

The main results indicate that exports are negatively affected by distance, as standard results predict. Also, I find that the recipient country variables are much more influential in determining exports than the variables accounting for the size and wealth of the exporting country, Iceland. This is potentially due to the small time series variation of the Icelandic variables.

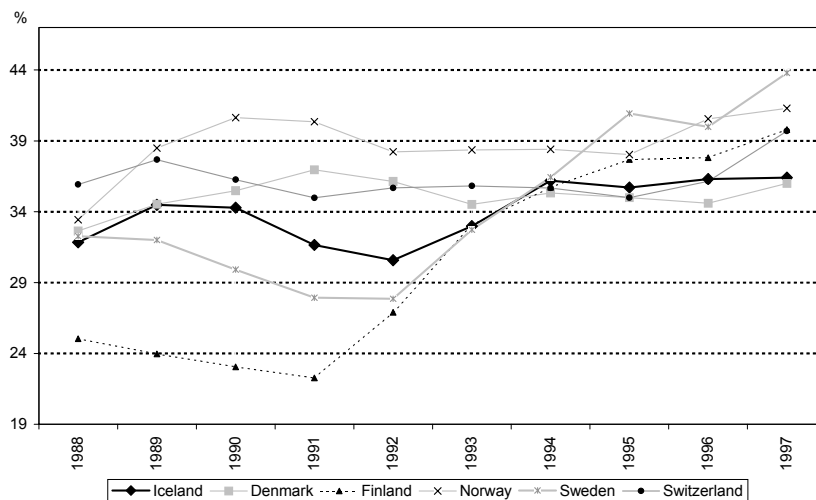
Moreover, when corrected for size, wealth, and distance, the marine sector is estimated to have the highest export share, and there is not a difference between the EU and NAFTA countries in receiving exports. Furthermore, when an international export ratio is inserted into the equation in order to correct for the small size of Iceland, it does not seem to improve estimates of the exporting country variables. Finally, the exporting country's variables continue to be insignificant when the driving factors of individual marine products are analyzed. Thus, while the standard wisdom is somewhat upheld for the case of Iceland, due to the heavy dependance on metal and fishing exports, I find that it is instructive to focus on these industries specifically.

The chapter is organized as follows. Section 2 gives an overview of Iceland's export development. Section 3 reviews previous literature on the matter and sets out details of the data. Section 4 explains the modelling strategy used here and the previous export studies for Iceland. In Section 5 gravity model results are discussed. Section 6 explains how the export ratio is inserted into the gravity model, while Section 7 provides concluding remarks.

1.2 Iceland's Export Development

Greater openness may cause economies to be vulnerable to volatility due to trade shocks, but more openness generally enables specialization and scale economics. The term *export ratio* is commonly used in trade theory to reflect relative the share of exports in overall economic activity. The term is expressed in terms of export share in gross domestic product (GDP). Around the World War I, Iceland's export went up to about 60% of GDP, but declined thereafter. Later in the 1960s, the export ratio rose again to almost 45% of GDP, but has since been around 30% of GDP. Small countries have been estimated to export relatively more of GDP than large economies (Gylfason, 1999). Because the GDP of Iceland is by far the lowest of the Nordic and European Free Trade Association (EFTA) countries, Iceland could be expected to have the highest export ratio of all the countries. This is however not the case, as exhibited in Figure 1.1.

Figure 1.1: Several Countries Export Ratios in 1988-1997 (%).



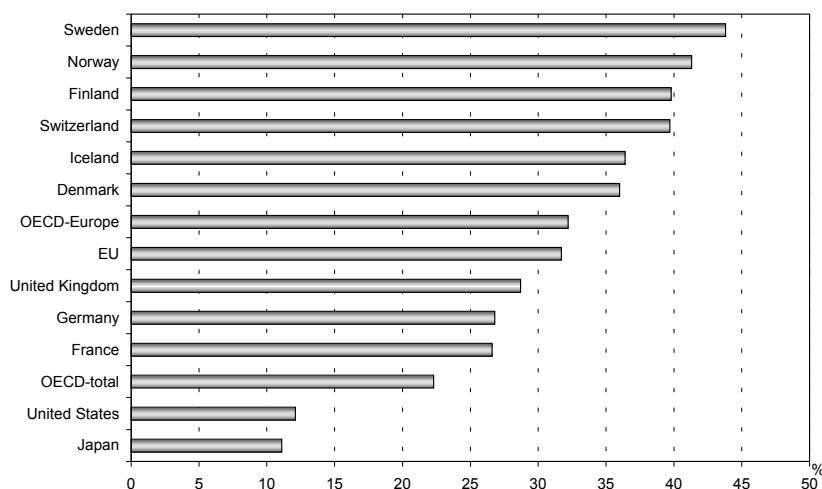
Source: The National Economic Institute of Iceland (2000).

Figure 1.1 gives an overview of several countries export ratios during 1988-1997⁴,

⁴Source: Website, Historical Statistics 1945-2000, Table 10.3.

i.e. merchandise exports⁵ as percentage of GDP. The countries under consideration are the Nordic countries and Switzerland⁶. Switzerland is included since it has membership to EFTA like Norway and Iceland. In 1965-1997 all the Figure 1.1 countries' export ratio ranged from 19-46%, which is high in an international comparison. Large economies like Japan and the US had much lower export ratio (ranging from 5 to 15%). France had an export ratio of 13-27% in the period, OECD Europe about 19-32%, and the EU 18-32%. Moreover, from Figure 1.1 it seems that the export ratio of Iceland is subject to more fluctuations than most of the countries with the exception of Finland and Sweden⁷.

Figure 1.2: Several Countries Export Ratios in 1997 (%).



Source: The National Economic Institute of Iceland (2000).

Figure 1.2 exhibits⁸ export ratios for a number of countries in 1997. Iceland is listed as being fifth from the top. Later in this chapter the relatively low

⁵Merchandise exports are exports of goods and services. However, later the analysis of goods exports will be analyzed, rather than exports of goods and services.

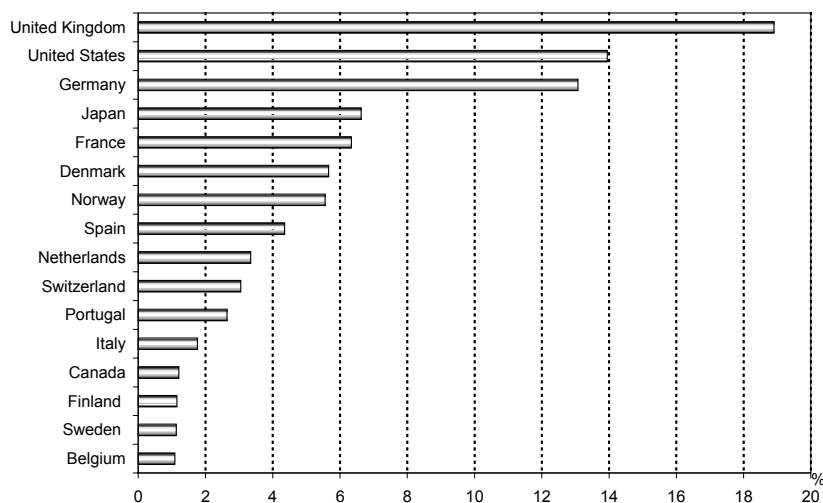
⁶Switzerland is also included since it is one of the EFTA member countries. The EFTA countries are Iceland, Norway, Switzerland and Liechtenstein.

⁷An increase in the export ratios of Finland and Sweden in the period is likely to be explained, to a large extent, by an increase in the export of Nokia and Ericson.

⁸Source: Website, Historical Statistics 1945-2000, Table 10.3.

export ratio of Iceland will be corrected for by an international export ratio. This correction is performed by inserting an international export ratio into the gravity model regression for Iceland. The objective of this is to estimate if and how it improves the outcome of the gravity model that is used for Iceland's exports.

Figure 1.3: Iceland's Main Trading Partners in 1997 (%).



Source: The National Economic Institute of Iceland (2000).

Figure 1.3 shows 1997 exports from Iceland to different countries by percentage decomposition⁹. About two-thirds of Iceland's merchandise exports went to Europe (that is the European Economic Area), 15% to the US and Canada combined, and 9% to Asia (7 of the 9% is accounted for by Japan). The large share of exports going to Europe should not be surprising based on the fact that Iceland belongs to Europe and the European Economic Area (EEA) through its membership in EFTA.

⁹Percentage split up of exports from Iceland to its main trading countries in 1997, accounts for 90% of total exports.

1.3 Literature on the Gravity Model and Exports

1.3.1 Literature on the Gravity Model

A considerable amount of literature has been published on the gravity model. In early versions of the model, Tinbergen (1962) and Pöyhönen (1963)¹⁰ conclude that exports are positively affected by the income of the trading countries and that distance can be expected to negatively affect exports.

In their papers, Pulliainen (1963) and Geraci and Prewo (1977) apply a gravity approach in their research but do not include commodity prices. Anderson (1979) applies product differentiation, assumes Cobb-Douglas preferences, and that products are differentiated by country of origin, which is referred to as the Armington Assumption¹¹. Moreover, Anderson assumes that each country only produces one particular good. Tariffs and transport cost are not taken into account in this model. Anderson concludes that his application of the gravity model is an alternative to cross-sectional budget studies. The model is limited by the fact that it only holds for countries with identical preferences for traded goods, and identical structure in terms of trade tax and transport.

Like Anderson, Bergstrand (1985) assumes CES preferences and applies the Armington assumption. When Bergstrand tests his assumption for product differentiation he concludes that empirically, price¹² and exchange rate variables have plausible and significant effects on aggregate trade flows. His estimates indicate that goods are not perfect substitutes and that imported goods are closer to being substitutes for each other than substitutes for domestic goods. His empirical results indicate that the gravity equation is a reduced form of a partial subsystem of a general equilibrium model with nationally differentiated products. Later, Bergstrand (1990) distances himself from the Heckscher-Ohlin model by assuming,

¹⁰"Linnemann (1966) extended the gravity equation by including a population variable to internalize economies of scale and kept GNP to explain the propensity to import" (Larue and Mutunga (1993, pp. 63).

¹¹Assumption implying that there is imperfect substitutability between imports and domestic goods, based on the country of origin.

¹²Bergstrand adds price indexes to an earlier specification by Linnemann (1966).

within a framework of Dixit-Stiglitz monopolistic competition, product differentiation between firms rather than between countries. Bergstrand assumes a two-sector economy with monopolistically competitive sectors, and different factor proportions within each sector. This yields a comparable gravity equation.

Baldwin (1994a) emphasizes that gravity models are most suitable for industrial goods, since they generally exhibit increasing returns to scale which can result in significant two-way trade of similar products between similar countries. It therefore appears to be useful to apply gravity models to trade between the industrialized countries to obtain reliable results. However, the model coefficients will be subject to issues like income elasticity of the products, the capital-labor ratio, and how integrated the trading countries are.

Deardorff (1995) derives the gravity model in the framework of a Heckscher-Ohlin model¹³. By simplifying an earlier approach made by Anderson (1979), he presumes that the same preferences hold, not only for traded goods like Anderson, but for all goods.

Evenett and Keller (1998) find empirical support for formulations of the gravity model, based on both the Heckscher-Ohlin model and increasing returns to scale. Moreover, Helpman (1998) concludes that the primary advantage of using gravity models is to identify determinants influencing volume of trade, as well as some underlying causes for trade. Helpman believes that volume of trade is not considered by many trade theories, and that the gravity equation works best for similar countries with considerable intra-industry trade between them, rather than for countries with different factor endowments and a predominance of inter-industry trade. Helpman suggests that product differentiation can be considered above and beyond factor endowments.

Several studies have been undertaken to analyze the determinants of exports between different countries with models other than the gravity model. For example,

¹³Deardorff (1995) rejects statements implying that the Heckscher-Ohlin model is incapable of providing sufficient foundation for the gravity equation. He points out that authors, claiming the gravity equation was lacking theoretical basis, had gone on with providing empirical evidence for the equation.

Baldwin, Francois and Portes (1997) perform a study based on a global applied general equilibrium model where the world is divided into nine main regions, each including thirteen sectors. A traditional Cobb-Douglas utility function with CES preferences is used to model demand. The supply side is formulated such that some sectors are characterized by perfect competition and constant returns to scale, while others are subject to scale economics and monopolistic competition. A value added chain links all the sectors together, while firms use a mixture of factors in a CES production function. This approach is quite interesting, however it is difficult to apply, since it requires very detailed data such as input-output tables. An approach of this kind may also be subject to some limitations of the general equilibrium approach.

Finally, Deardorff (1998) shows that the gravity model is consistent with several variants of the Ricardian and Heckscher-Ohlin models.

1.3.2 Earlier Research on Trade in Iceland

In an earlier analysis of the gravity model, Kristjánsdóttir (2000) presents a gravity model for Iceland, based on export to different countries over time. The panel data covers a 27-year period from 1971-1997 for the 16 main Icelandic trade partners. The results obtained indicate that GDP and population variables of the trading countries have significant impact on exports from Iceland. These results are in line with research on other countries, except that neither source country population nor distance were estimated to be significant in determining exports. Kristjánsdóttir also found that in the period from 1971 to 1997 trading country membership to EFTA had positive effects on exports. However, for the subperiod of 1988 to 1997, a membership to EU or NAFTA has positive effects on exports, rather than EFTA membership. Moreover, seasonal analysis covering quarterly data on 1988 to 1997 reveal that when quarters 1, 2 and 3 are compared to the fourth quarter, only the first quarter has significantly lower exports.

Byers, Iscan and Lesser (2000) present a study for potential trade flows of the

Baltic countries, if the Baltics had a trading environment similar to the Nordics¹⁴. The study is based on panel data covering two years, 1993 and 1994. The analysis indicate that the Baltic countries would have exported significantly more had their trade pattern developed analogous to the Nordic countries. Kristjánsdóttir (2000) applies the Byers, Iscan and Lesser estimates to Iceland. Kristjánsdóttir's results indicate that potential trade flow from Iceland would be substantially higher to almost all of its trading partners if Iceland had a trading environment identical to the other Nordic countries.

Herbertsson, Skuladottir and Zoega (1999) find symptoms of the Dutch disease in Iceland when analyzing the primary and secondary sector after splitting production up to tradable and non-tradeable sectors, as done by Gylfason et al. (1997). They determine that Iceland is subject to one of three symptoms of the Dutch disease, that is, the symptoms of a booming primary sector which is likely to pay high real wages, which again may affect wages positively in other sectors as to decrease their potentials.

Although the above analyses have all explained exports in different ways, the approach tried in this chapter adds to the previous ones in that it takes new and different aspects into account. One of the main advantages of the current analysis is that there the data cover not only the export dimensions of time and countries (like Kristjánsdóttir, 2000) but also export split up by sectors. This allows for various additional applications for Iceland of the gravity model. For example, it allows for estimation of fixed effects between exporting sectors, and simultaneous estimates of sector and trade bloc fixed effects. Also, a valuable contribution of this chapter is that the procedure attempts to correct for the smallness of the country.

¹⁴In the study made by Byers, Iscan and Lesser (2000) all the Nordic countries are included, except for Iceland.

1.3.3 Variables and Data Used in This Research

The export data are based on data from the Statistical Bureau of Iceland (2000). The data covers exports of goods from Iceland to its main trading countries. The data are annual over the eleven year period 1989-1999, running over countries and sectors. Included are the 17 main recipient countries of exports from Iceland. These are Australia, Austria, Belgium, Canada Denmark, Finland, France, Germany, Japan, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States. Data for Germany refer to the years after unification, and therefore run from 1991, rather than 1989. The overall export volume used in this research accounts for 89.84% of Iceland's total merchandise exports in 1997¹⁵. An export index from the National Economics Institute of Iceland¹⁶ is used to put all export data on 1995 level¹⁷. As noted by Baldwin (1994b), "Trade is not a nominal phenomenon, so the gravity model should be regressed on real values of the data". Data on exports decomposed by sectors are from the Statistical Bureau of Iceland (2000), where the sectors are split up by a domestic classification system. A definition of the variables used in this research is given in Table 1.1.

The gross domestic product data are obtained from the World Bank. More specifically, the gross domestic product (GDP) used is "GDP at market prices" (current US\$)¹⁸. The GDP data covers data on Iceland and the countries Iceland exports to. These data are divided by the GDP price deflator¹⁹ also obtained from the World Bank.

¹⁵During the time period 1971 to 1997, more than 74.46% of Iceland's annual total merchandise exports were exported to these 17 countries. Merchandise exports cover exports of both goods and services.

¹⁶Source: Website, Historical Statistics 1945-2000, Table 7.12: Export prices, import prices, and terms of trade of goods and services in ISK 1945-1999, indices.

¹⁷The index was originally on a 1990 base, then converted to a 1995 base.

¹⁸Could have used "GDP at market prices (constant 1995 US\$)" instead, but chose not to do so, since prices are put fixed at a certain level by the GDP deflator.

¹⁹The GDP deflator obtained from the World Bank was noted as "base year varies by country".

Table 1.1. Variable Definition

Variable		Predicted signs
$\sinh^{-1}(EXP_{j,s,t})$	Exports transformed by the Inverse Hyperbolic Sine Function, running over source countries (i) and sectors (s), over time (t).	
$\ln(Y_t)$ <i>Export Cnt GDP</i>	Logarithm (ln) of Host country Gross Domestic Product (GDP), over time (t).	+
$\ln(Y_{j,t})$ <i>Recipient Cnt GDP</i>	Logarithm (ln) of Source country (i) Gross Domestic Product (GDP), over time (t).	+
$\ln(N_t)$ <i>Export Cnt Pop</i>	Logarithm (ln) of Host country population (Pop), over time (t).	+
$\ln(N_{j,t})$ <i>Recipient Cnt Pop</i>	Logarithm (ln) of Source country population (Pop), over time (t).	+
$\ln(D_j)$ <i>Distance</i>	Logarithm (ln) of distance between the source and the host country.	–
$Sector_1$ <i>Fishing Industry</i>	Dummy variable accounting for the Fishing Industries.	+ / –
$Sector_2$ <i>Manufact. Ind.</i>	Dummy variable accounting for the Manufacturing Industries.	+ / –
$Sector_3$ <i>Power Inten. Ind.</i>	Dummy variable accounting for the Power Intensive Industries.	+ / –
$Sector_4$ <i>Other Industries</i>	Dummy variable accounting for all remaining Industries.	+ / –
$Bloc_1$ <i>EFTA</i>	Dummy variable accounting for country membership to the EFTA trade bloc.	+ / –
$Bloc_2$ <i>EU</i>	Dummy variable accounting for country membership to the EU trade bloc.	+ / –
$Bloc_3$ <i>NAFTA</i>	Dummy variable accounting for country membership to the NAFTA trade bloc.	+ / –
$Bloc_4$ <i>NON Bloc</i>	Dummy variable accounting for country non-membership to any trade bloc.	+ / –

Data on distance between Iceland’s capital (Reykjavik) and the capital of the exporting country are used in order to capture the distance²⁰ from Iceland to different countries. An exception of the data measure is the case of Canada, where the midpoint between Quebec and Montreal is used, since it is believed to better

²⁰ Although Iceland enjoys recent advances in communications leading to increasingly less transaction cost and cost of trade, transportation costs are believed to increase as distance increases. And transport costs are a large share of the overall transaction costs in trading. Since information is generally lacking on transaction costs, these are not included in the model. Instead, distance is inserted as a proxy for transaction costs.

represent the economic center of Canada than the capital city Ottawa. Also, in the case of the United States, New York is chosen rather than Washington. All distances are presented in kilometers and in a logarithm format. Data on distances are collected from the Distance Calculator (2000). Data on population are from the World Bank database. Data on countries' various trade bloc membership are from a brochure by de la Torre and Kelly (1993).

Finally, data used in calculating the export ratio in Section 6 are obtained from the IMF. These are 10 year panel data from 1988 to 1997, for 119 export countries²¹.

Table 1.2. Summary Statistics for the Basic Sample

Variable	Units	Obs	Mean	Std. Dev.	Min	Max
$EXP_{j,s,t}$	Million USD	748	2.21e+07	5.02e+07	0	4.27e+08
Y_t	Trillion USD	748	0.007	0.0006	0.006	0.008
$Y_{j,t}$	Trillion USD	740	1.22	1.96	0.01	8.58
N_t	Individuals	748	265263.60	7641.54	252700	277500
$N_{j,t}$	Individuals	748	4.32e+07	6.38e+07	377600	2.78e+08
D_j	Kilometers	748	3711.88	3602.57	1747	16609
$\ln(EXP_{j,s,t})$	Nat. Logarithm	660	15.21	2.29	2.99	19.87
$\sinh^{-1}(EXP_{j,s,t})$	Inv. Hyp. Since	748	14.03	5.56	0	20.56
$\ln(Y_t)$	Nat. Logarithm	748	-4.93	0.08	-5.02	-4.77
$\ln(Y_{j,t})$	Nat. Logarithm	740	-0.79	1.42	-4.29	2.15
$\ln(N_t)$	Nat. Logarithm	748	12.49	0.03	12.44	12.53
$\ln(N_{j,t})$	Nat. Logarithm	748	16.63	1.51	12.84	19.44
$\ln(D_j)$	Nat. Logarithm	748	7.99	0.57	7.47	9.72

Sources: World Bank, Statistical Bureau of Iceland, National Economics Institute of Iceland, Distance Calculator.

Table 1.2 shows an overview of the sample used in this research. Table 1.2 shows statistics for the variables both before and after they have been treated with the logarithm and inverse hyperbolic sine functions.

²¹See country list in Appendix C.

1.4 A Gravity Model Applied to Iceland's Exports

1.4.1 General Model Specification

The gravity model has proven to be an effective tool in explaining bilateral trade flows as a function of the exporter's and the importer's characteristics together with factors that aid or restrict trade. Isard and Peck (1954) as well as Beckerman (1956) find trade flows to be higher between geographically close areas (Oguledo and Macphee, 1994).

Tinbergen (1962) and Pöynönen (1963) developed the gravity equation with exports being a function of country gross national product and distance between economic centers (Larue and Mutunga, 1993).

Deardorff derives the gravity model in his 1998 paper. In his case of impeded trade, he assumes that there exist barriers to trade for every single good, so that they are strictly positive on all international transactions. The trade barriers are thought of being incidental and in the form of transport costs. Deardorff applies the HO model with perfect competition²². Factor prices are assumed to be unequal for each pair of countries to allow for non-FPE between countries²³. If it is further assumed that there are many more goods than there are factors, then under the conditions of frictionless trade, unequal factor prices would imply that any pair of countries would only have few goods in common. However under the condition of impeded trade, goods can become nontraded, and they can compete in the same market if the difference in production cost equals the transport cost between the two countries.

In the case to be considered it is assumed that for every single good there is

²²Under the conditions of perfect competition, producers in the local market cannot compete with producers in the foreign market, since exporters are faced with positive transport costs for every good.

²³The FPE theorem (factor price equalization theorem) is one of the major theoretical results of the HO model, showing that free and frictionless trade will cause FPE between two countries (Deardorff, 2003).

only one single country exporting that good²⁴. Furthermore in the following setup it is assumed that each good is produced only by the country exporting it, and that consumers distinguish differences between the goods²⁵. Therefore, under the condition of an international trading equilibrium every single good (i) produced by a single different country (i), can be presented by x_i . Because of identifiable difference between the goods, they can be viewed as imperfect substitutes and enter into utility function as such. Suppose we have identical Cobb-Douglas preferences, where consumers spend a fixed share of their income, β_i on a good coming from country i, so that $\beta_i = Y_i/Y^w$. Then the income of country i can be presented as the following:

$$Y_i = p_i x_i = \sum_j \beta_i Y_j = \beta_i Y^w \quad (1.1)$$

Now trade including transport cost, referred to as c.i.f. (cost, insurance, freight)²⁶, can be presented as shown below.

$$T_{ij}^{cif} = \beta_i Y_j = \frac{Y_i Y_j}{Y^w} \quad (1.2)$$

The expression put forward in Equation (1.2) corresponds to the gravity model expression in Feenstra (2003)²⁷. And it follows that trade excluding transport costs, that is f.o.b. (free on board), can be put forward as shown in Equation (1.3). Another way of presenting the above equations (1.1) and (1.2), is to say

²⁴In his set-up, Deardorff assumes that if goods' transport costs are not decreasing in the amount exported, but constant, then it will be extremely rare to find two countries selling the same good in the same market. And by simplifying further, he assumes that there is a single exporter of each good.

²⁵This is without relying on the Armington assumption, which implies that the difference between goods is due to the difference in their national origin.

²⁶**CIF:** The price of a traded good including transport cost. It stands for "cost, insurance, and freight," but is used only as these initials (usually lower case: c.i.f.). It means that a price includes the various costs, such as transportation and insurance, needed to get a good from one country to another. Contrasts with FOB.

FOB: The price of a traded good excluding transport cost. It stands for "free on board," but is used only as these initials (usually lower case: f.o.b.). It means the price after loading onto a ship but before shipping, thus not including transportation, insurance, and other costs needed to get a good from one country to another. Contrasts with CIF and FAS.

FAS: Same as FOB but without the cost of loading onto a ship. Stands for "free alongside ship" (Deardorff, 2003).

²⁷For more discussion, see Feenstra Chapter 5, Equation (5.14).

that since there is no transport factor, nor distance included in the c.i.f. version of the equation, those would be an example of a gravity model with frictionless trade. However, the f.o.b. case would apply under the conditions of impeded trade, since the relative trade flow constraint corresponds to the transport costs imposed.

$$T_{ij}^{fob} = \frac{Y_i Y_j}{t_{ij} Y^w} \quad (1.3)$$

Under the assumption that we have CES preferences rather than Cobb-Douglas preferences, it is possible to allow for an decrease in trade as distance increases. Under these conditions, consumers in country j maximize a CES utility function. The below CES utility function definition is based on the good products of all countries i (including their own).

$$U^j = \left(\sum_i \beta_i c_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} \quad (1.4)$$

In Equation (1.4) the elasticity of substitution σ is strictly positive between any pair of countries' products. Buyers in market j need to pay transport cost and are faced with c.i.f. prices $t_{ij} p_i$. Under these conditions, consumers need to maximize the above utility function subject to the income $Y_i = p_i x_i$ obtained from production of good x_i . Their consumption can be presented as shown in Equation (1.5):

$$c_{ij} = \frac{1}{t_{ij} p_i} Y_j \beta_i \left(\frac{t_{ij} p_i}{p_j^I} \right)^{1-\sigma} \quad (1.5)$$

In Equation (1.5) the term p_j^I presents a price index in accordance to the CES preferences for the range of products landed in country j , and can be presented more specifically as shown in Equation (1.6):

$$p_j^I = \left(\sum_i \beta_i t_{ij}^{1-\sigma} p_i^{1-\sigma} \right)^{1/(1-\sigma)} \quad (1.6)$$

Under the f.o.b. conditions, the export value of goods going from country i to country j , can then be presented in Equation (1.7):

$$T_{ij}^{fob} = \frac{1}{t_{ij}} Y_j \beta_i \left(\frac{t_{ij} p_i}{p_j^I} \right)^{1-\sigma} \quad (1.7)$$

Likewise the c.i.f. version would be analogous, but multiplied by t_{ij} . Trade would be decreasing in t under the conditions where sigma is greater than one. Under the Cobb-Douglas preferences, β_i represented the share of income spent on consumption, however under the CES preferences the consumption share is represented by θ_i . It is possible to present the relationship between beta and theta and then solve for β_i :

$$\begin{aligned}
\theta_i &= \frac{Y_i}{Y^w} = \frac{p_i x_i}{Y^w} \\
&= \frac{1}{Y^w} \sum_j \beta_i p_j x_j \left(\frac{t_{ij} p_i}{p_j^I} \right)^{1-\sigma} \\
&= \beta_i \sum_j \theta_j \left(\frac{t_{ij} p_i}{p_j^I} \right)^{1-\sigma}
\end{aligned} \tag{1.8}$$

from which

$$\beta_i = \frac{Y_i}{Y^w} \frac{1}{\sum_j \theta_j \left(\frac{t_{ij} p_i}{p_j^I} \right)^{1-\sigma}} \tag{1.9}$$

Applying this to Equation (1.7) we get

$$T_{ij}^{fob} = \frac{Y_i Y_j}{Y^w} \frac{1}{t_{ij}} \left[\frac{\left(\frac{t_{ij}}{p_j^I} \right)^{1-\sigma}}{\sum_h \theta_h \left(\frac{t_{ih}}{p_h^I} \right)^{1-\sigma}} \right] \tag{1.10}$$

A normalization of each country's product price at unity allows for simplification of the above equation. By doing so the CES price index p_j^I becomes an index, accounting for transport factors for country j as an importing country, and its average distance from suppliers can be presented as δ^s :

$$\delta_j^s = \left(\sum_i \beta_i t_{ij}^{1-\sigma} \right)^{1/(1-\sigma)} \tag{1.11}$$

Then the relative distance from suppliers can be presented as the transport factor t_{ij} , divided by the relative distance from suppliers, and denoted with ρ_{ij} :

$$\rho_{ij} = \frac{t_{ij}}{\delta_j^s} \quad (1.12)$$

By inserting the equation above into Equation (1.7), it simplifies to the following:

$$T_{ij}^{fob} = \frac{Y_i Y_j}{Y^w} \frac{1}{t_{ij}} \left[\frac{\rho_{ij}^{1-\sigma}}{\sum_h \theta_h \rho_{ih}^{1-\sigma}} \right] \quad (1.13)$$

The results in Equation (1.13) show that exports from i to j will be analogous under the conditions of the CES and Cobb-Douglas preferences if the importing country j 's relative distance from exporting country i equals the average of all demanders' relative distance from i . Under these circumstances, the c.i.f. specification can be presented by the simple gravity equation derived before, and the f.o.b. specification as a reduced version of that when corrected for the transport factor.

1.4.2 The Gravity Model Specification for Exports

The gravity model specification presented by Bergstrand (1985) is shown in Equation (1.14)²⁸. The equation captures the volume of exports²⁹ between the two trading partners as a function of their GDPs and the distance between them.

$$PX_{ij,t} = \alpha_0 (Y_{j,t})^{\beta_1} (Y_{i,t})^{\beta_2} (D_{ij})^{\beta_3} (A_{ij})^{\beta_4} \zeta_{ij} \quad (1.14)$$

In Equation (1.14), the explanatory variable $PX_{ij,t}$ represents export from country i to country j , at time t . The variable $Y_{j,t}$ denotes the GDP of country j at time t , $Y_{i,t}$ is the GDP of country i at time t , and D_{ij} is the geographic distance³⁰ between the economical centers of country i and country j . The letter A_{ij} denotes factors that affect trade between country i and j , and ζ_{ij} is a log-normally distributed error term, with $E(\ln \zeta_{ij})=0$.

²⁸Refers to "The Gravity Equation in International Trade: Some microeconomic Foundations and Empirical Evidence" *The Review of Economics and Statistics*, 67: 474-481, by Bergstrand (1985).

²⁹ α_0 can also be presented as e^{β_0} , as shown in Equation (1.15).

³⁰Distance is estimated in kilometres.

Often times, dummies are also included in the model, like a dummy for "common border" determining whether countries have common borders, and a dummy for identical languages in the trading countries. However, these dummies are not applied here, since Iceland does not share a common border with other countries, nor does it share a language with any country. The size of the exporting and importing countries are basic determinants in explaining exports. Generally countries are expected to trade more as they increase in size. The size of the economy can either be measured by the two variables of population or the GDPs. The GDP of the domestic country is believed to reflect the capacity to supply exporting goods. Likewise, the GDP of the country importing from Iceland ($Y_{j,t}$) is believed to represent its demand for exports. That is, country's j demand is believed to increase as ($Y_{j,t}$) increases.

Recipient and Export country population is often inserted for variable A in Equation (1.14) as an additional determinant of trade. Generally the coefficient for recipient country population is expected to be positive, since a bigger market in the recipient country is expected to demand more goods. Population in the export country is also expected to have positive effects on exports, since the export country is expected to be able to supply more as the population grows in size.

Distance D_{ij} is also important in explaining trade between economies. An increase in distance between economies is expected to increase transportation costs and thus reduce trade. The sign of the distance coefficient cannot be predicted in advance. If the sign is estimated to be positive, it indicates that the market can be expected to be dominated by a home market effect, as explained by Helpman and Krugman (1989), and in numbers of other models such as the geographical model of Krugman (1991a). However, it is typically negative.

1.4.3 The Model Specification Applied

When choosing a gravity model specification for Iceland, Equation (1.14) is used as a base case. The model specification in Equation (1.15) is an extension of Equation (1.14), where population has been inserted as an additional factor in the model:

$$EXP_{ij,t} = e^{\beta_0}(Y_t)^{\beta_1}(Y_{j,t})^{\beta_2}(N_{j,t})^{\beta_3}(N_{j,t})^{\beta_4}(D)_{ij}^{\beta_5}e^{u_{ij,s,t}} \quad (1.15)$$

Like in the Bergstrand 1985 paper³¹, the source country of exports, export country is denoted with (i) , while the recipient country is denoted with (j) . However, since it is clear that this research applies to one export country only, there is no need to identify the export country specifically, the subscript (i) is therefore left out. Export therefore only varies by recipient countries (j) .

$$\begin{aligned} \ln(EXP_{j,s,t}) &= \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + u_{j,s,t} \end{aligned} \quad (1.16)$$

In Equation (1.16) export from country (i) to country (j) is denoted by $(EXP_{j,s,t})$, here a regression is run on exports to different sectors (s) over time (t) . Exports are a function of export country GDP (Y_t) , recipient country GDP $(Y_{j,t})$, export country population (N_t) , recipient country population $(N_{j,t})$, and the distance (D_j) between the exporting and the recipient (j) country. Sector specific effects on exports are determined by (s) where s runs from 1 to 5, depending on the number of the sector. Later in this research, a number of modifications are then made to improve the model specification above.

³¹Bergstrand (1985), pp. 474.

1.5 Empirical Results of the Gravity Model

1.5.1 The Basic Regression Results

The regression results for Equation (1.16) in Section 4.3, are shown in Table 1.3. The first column in Table 1.3 represents estimates for the natural logarithm of exports. Results obtained from running the inverse hyperbolic sine (IHS) function are reported in columns two and three.

Table 1.3. The Basic Model Specification

	LN ROBUST	IHS ROBUST	IHS ROBUST
Regressors	Only EXP>0	Only EXP>0	All EXP obs
$\ln(Y_t)$ <i>Export Country GDP</i>	-0.715 (-0.45)	-0.716 (-0.45)	-0.361 (-0.09)
$\ln(Y_{j,t})$ <i>Recipient Country GDP</i>	1.552*** (5.18)	1.552*** (5.18)	3.568*** (5.17)
$\ln(N_t)$ <i>Export Country Pop</i>	1.250 (0.27)	1.250 (0.27)	-7.712 (-0.62)
$\ln(N_{j,t})$ <i>Recipient Country Pop</i>	-0.559** (-2.02)	-0.559** (-2.02)	-1.910*** (-2.91)
$\ln(D_j)$ <i>Distance</i>	-2.065*** (-11.05)	-2.065*** (-11.05)	-2.993*** (-8.29)
<i>Constant</i>	22.934 (0.35)	23.626 (0.36)	166.981 (0.96)
OBSERVATIONS	652	652	740
LOG-LIKELIHOOD	-1292.6301	-1292.6284	-2246.1319
DEGREES OF FREEDOM	5	5	5
R-SQUARED	0.4076	0.4076	0.1825

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

Table 1.3 presents results for the basic gravity model specification for different functional forms³². The advantage of using the IHS function rather than the logarithm function is that the IHS function can be applied to zeros³³. The gravity

³²All robust t-statistics are calculated using White's (1980) heteroskedasticity correction.

³³More specifically, the IHS function can be applied to zeros and negatives but it is only needed for dealing with zeros.

model specification is generally presented in a natural logarithm format, but in this research the IHS function is believed to be more appropriate. The reason why is that when disaggregated over countries and sectors, exports from small countries become very thinly spread, resulting in lots of zeros in the data. Since the logarithm function can only be applied to non-negatives, it can only be applied to 652 observations out of 740, whereas the IHS function can be applied to the full data set of 740 observations. The column in the middle shows the case when the IHS function is applied to positive observations only. A comparison between the first and second column shows that when the IHS function is applied to positive observations only, it yields similar results as the logarithm function in the first column. The fact that similar coefficients are received in the first columns indicate that, a considerable number of export observations is high enough for the two functions to yield similar coefficients, see more detailed discussion on that in Appendix A, Section 9.

Other approaches, including adding 1 to all exports could also have been used. However, since my goal is to look for patterns in the data rather than obtain precise estimates for policy, I use the approach.

The IHS results in Table 1.3 indicate that a one percent increase in recipient country GDP can be expected to raise exports by about 3.56%, given everything else equal. When translated to actual numbers, we can first consider the mean GDP in Iceland over the export period (as listed in Table 1.2) being about \$7 billion (1995 base), but the GDP average of the recipient countries to be about \$1200 billion. Therefore, if the Icelandic GDP goes up from \$7 to \$10 billion, then the model predicts that the mean export would go up from around \$22 billion to about \$78.5 billion on average.

An increase of 1% in the population of the recipient country is estimated to negatively effect exports by about -1.91%. Let us take a nice example on what this coefficient indicates about export to different countries. Consider two countries about equally as distant from the exporting country (Iceland), but one about twice the size of the other. These could be Norway and Sweden. In the export

period examined, Sweden had average population of 8.7 million people, whereas Norway had population average of 4.3 million. Given everything else equal the model predicts that, based on negative population coefficient, Sweden should only be receiving about 30% of the export volume going to Norway. More specifically the difference between the countries is found to be 26%, indicating that Sweden should be receiving about 26% of what Norway receives. This is based on the fact that average export to Norway over the period was about \$14 million, which would result in Sweden receiving exports of $14 \times 0.26 = \$3.64$ million. The true average exports for Sweden in the period amounted to \$5.68 million, or $5.68/14 = 0.4$, or 40% of exports to Norway. The estimates therefore give a fair indication of the relationship of exports to some economic factors.

The distance variable is estimated to negatively affect goods exports by a coefficient of -2.993 . Distance is of particular interest in the case of Iceland because of how distant the country is from all its trading countries, but distance is a proxy for transport costs that have a high weight in overall transaction costs. The outcome obtained here is typical of trade regressions, since export is estimated to affect distance negatively³⁴. More specifically, the coefficient can be interpreted such that by doubling distance between Iceland and the trading country, exports becomes 13% of what it was before³⁵.

When the export and recipient country variable coefficients are considered specifically, what is noteworthy is that only the recipient country coefficients are estimated to be significant whereas the export country coefficients are not. The positive significant coefficient of the recipient country GDP implies increased demand for exports as the trading country's economic size increases. However, recipient country population is estimated to negatively affect exports, implying negative interaction between demand and population, and resulting in more exports to countries as they are less populated. Another way of interpreting the coefficient estimates for the

³⁴The intuition behind the sign of the distance coefficient is explained in earlier sections.

³⁵Since $[2 \times \text{Distance}]^{(-2.993)} = \text{Distance}^{2 \times (-2.993)} = \text{Distance}^{-5.986}$. That is, a twofold increase in distance leads to a decrease of about 13% of the previous value.

recipient country would be to say that, combined, exports increase as the recipient country's income per capita goes up. So overall it seems as exports are affected by both recipient country *per capita* wealth effects and market size effects. Also, it should be noted that the significance of recipient variables is calculated assuming normality of error terms. With small samples this may not be valid, however, since this is the standard approach in trade regressions, I use it and simply caution the reader.

The estimates obtained for the export country coefficients in Table 1.3 indicate that neither the export country GDP or population are estimated to be significant. The results therefore indicate that market size (estimated by population) and economies of scale (accounted for by GDP size) in the export country do not seem to be very influential for overall exports going from Iceland to the recipient countries. This may be because the goods exports are driven mainly by seafood exports, so the supply potential is based primarily on natural resources (i.e. the size of the fishing stock).

1.5.2 Fixed Sector Effects Estimated

In this section I continue by adding fixed sector estimates to the basic regression as presented in Equation (1.17). The fixed effects technique³⁶ is used to estimate Equation (1.17), where the γ'_s are constants (s=1,2,...4) accounting for sector specific effects.

$$\begin{aligned} \sinh^{-1}(EXP_{j,s,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ & + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + \gamma_s Sector_s + \varepsilon_{j,s,t} \end{aligned} \quad (1.17)$$

Table 1.4 shows the results from estimating fixed sector effects together with the basic gravity specification. Regression results obtained for the basic gravity model variables are analogous in Table 1.4 to those in Table 1.3. The sector specific effects are obtained by setting one of the sectors equal to zero, and estimating the fixed deviation of other sectors. In this research I choose to fix sector three. The third

³⁶Greene (1997). *Econometric Analysis*. Prentice Hall, New Jersey.

sector accounts for *power intensive industries* (Ferro-silicon and Aluminium), and as a base sector is not presented³⁷ in Table 1.4.

Table 1.4. Fixed Sector Effects

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Export Country GDP</i>	-0.361 (-0.11)
$\ln(Y_{j,t})$ <i>Recipient Country GDP</i>	3.568*** (6.43)
$\ln(N_t)$ <i>Export Country Population</i>	-7.712 (-0.81)
$\ln(N_{j,t})$ <i>Recipient Country Population</i>	-1.910*** (-3.64)
$\ln(D_j)$ <i>Distance</i>	-2.993*** (-13.02)
<i>Sector</i> ₁ <i>Fishing Industries</i>	8.714*** (16.08)
<i>Sector</i> ₂ <i>Manufacturing Industries</i>	6.917*** (12.75)
<i>Sector</i> ₄ <i>Other Industries</i>	5.987*** (11.13)
<i>Constant</i>	161.576 (1.21)
OBSERVATIONS	740
LOG-LIKELIHOOD	-2043.3047
DEGREES OF FREEDOM	8
R-SQUARED	0.5275

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

The t-statistics in Table 1.4 clearly indicate that all other sectors vary positively from the *power intensive sector*. The positive effects estimated indicate that the other sectors have significantly more weight in goods exports than the *power intensive sector*. The coefficient estimates obtained range from 5.99 to 8.72. Moreover, the coefficient estimates indicate that sector 4, *other industries*, deviates least from the *power intensive sector*, the *manufacturing sector* comes second, and the *fishing*

³⁷To avoid the dummy variable trap of perfect collinearity.

sector third with the biggest deviation. Another way of interpreting the sector specific results would be to say that, when corrected for market size, economic wealth, as well as distance (trade cost), the *fishing sector* has the highest share in exports, whereas the *manufacturing sector* comes second, *other industries* third, and the *power intensive sector* fourth. However, the estimated coefficients are only expected to give an indication of sector weights. There are two reasons for why the estimates can only be considered to give an indication of export volume: First the average presented here is a geometric average which is not comparable to the "common average" generally used³⁸, and secondly the data source does not include all the countries receiving exports from Iceland.

All the coefficient estimates indicate that the share of all sectors is low when compared to the *marine industry*. But although the *marine industry* strongly dominates exports of goods, its relevance in overall merchandise exports³⁹ is much lower. In 2000 the *marine industry* accounted for 41% of overall merchandise exports, compared to 64% share of goods exports⁴⁰.

In order to get an indication of whether the regression results presented in Table 1.4 are more reliable than those in Table 1.3, the log-likelihood values obtained for regressions are used for comparison. The procedure is to calculate the logarithm value for the ratio of these two, and multiply it by negative two. If this value is observed to be less than the critical value (based on certain degrees of freedom)⁴¹, then the null hypothesis is rejected. The log-likelihood value of -2043.30 obtained for the sector regression indicates that the sector specification predicts better than the basic regression (third column in Table 1.3) and should therefore be somewhat preferred.⁴²

³⁸The common average is calculated as $(X_1 + X_2 + \dots + X_m)/m$. However geometric average is calculated as $(X_1 * X_2 * X_3 * \dots * X_m)^{(1/m)}$.

³⁹Merchandise exports refers to the exports of goods and services.

⁴⁰The National Economic Institute of Iceland (2000).

⁴¹See Greene (1997) pages 159-162 on this.

⁴²The difference between the log-likelihood values is about 202, and double that number is much higher than the critical value for a chi-squared distribution with 3 degrees of freedom. The hypothesis implies that the restricted version is therefore strongly rejected.

1.5.3 Fixed Trade Bloc Effects

The next step in this research is to determine whether there is fixed difference between the trade blocs receiving exports from Iceland. The bloc specific effects are presented in Equation (1.18) as $Bloc_n$, where n runs from 1 to 4. The model specification can then be expressed as the following:

$$\begin{aligned} \sinh^{-1}(EXP_{j,s,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ & + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + \pi_n Bloc_n + \varepsilon_{j,s,t} \end{aligned} \quad (1.18)$$

When the omitted category is set equal to zero, it holds that $\pi_2=0$ where π_2 is the constant for the EU trade bloc. Other trade blocs (categories) can be represented in comparison to the EU bloc.

The results obtained for the trade bloc specification indicate that the main variation in the basic specification variable estimates is that recipient country population now loses its significance (although continuing to have a negative sign). This indicates that when corrected for trade bloc membership, neither market size of the export or recipient country matters. These results make sense in that they imply that countries identify themselves with bigger markets as they become trade bloc members. Another change from the basic regression results is that in Table 1.5 export country GDP becomes positive (previously negative), indicating positive wealth effects of the export country on exports, although the coefficient is far from being significant. Other estimates are analogous to those of the basic regression. After correcting for GDP and population size as well as distance, the EFTA and non-bloc countries are estimated to have positive effects on exports when compared to EU. What might support these results is the fact that Iceland is a member country of EFTA. The trade bloc dummy effects indicate a significantly higher share of exports going to EFTA countries, and countries outside of trade blocs, rather than EU countries. However, NAFTA countries are not estimated to receive a higher share of exports than EU countries.

Table 1.5. Fixed Trade Bloc Effects

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Export Country GDP</i>	0.188 (0.04)
$\ln(Y_{j,t})$ <i>Recipient Country GDP</i>	2.466*** (3.40)
$\ln(N_t)$ <i>Export Country Population</i>	-5.085 (-0.41)
$\ln(N_{j,t})$ <i>Recipient Country Population</i>	-0.827 (-1.17)
$\ln(D_j)$ <i>Distance</i>	-5.567*** (-5.55)
$Bloc_1$ <i>EFTA</i>	0.982* (1.82)
$Bloc_3$ <i>NAFTA</i>	0.813 (0.83)
$Bloc_4$ <i>NON Bloc Members</i>	5.122*** (2.87)
<i>Constant</i>	137.699 (0.80)
OBSERVATIONS	740
LOG-LIKELIHOOD	-2240.507
DEGREES OF FREEDOM	8
R-SQUARED	0.1948

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

What shed light on these results is the fact that EFTA bloc membership not only accounts for current member countries of EFTA, but also those of the 17 recipient countries that had EFTA membership sometime in the period estimated (1989-1999). The fact that the NAFTA coefficient is not significantly different from EU indicates that the export volume to the NAFTA countries is not so different from that going to the EU countries, when corrected for sizes and distances. Finally, a comparison of the log-likelihood value in Table 1.5 is compared to those obtained previously. This indicates that the trade bloc regression is roughly the same as the basic one in Table 1.3, which is again less preferable to the sector-specific results.

1.5.4 Fixed Sector and Trade Bloc Effects

The final step in estimating the gravity model specification for overall volume of goods exports is to run a regression including both sector and bloc specific effects simultaneously. Estimates for a specification including sector and bloc specific effects are presented in Table 1.6.

Table 1.6. Fixed Sector and Trade Bloc Effects

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Export Country GDP</i>	0.188 (0.06)
$\ln(Y_{j,t})$ <i>Recipient Country GDP</i>	2.466*** (4.05)
$\ln(N_t)$ <i>Export Country Population</i>	-5.085 (-0.54)
$\ln(N_{j,t})$ <i>Recipient Country Population</i>	-0.827 (-1.46)
$\ln(D_j)$ <i>Distance</i>	-5.567*** (-6.21)
<i>Sector</i> ₁ <i>Fishing Industries</i>	8.714*** (16.29)
<i>Sector</i> ₂ <i>Manufacturing Industries</i>	6.917*** (12.84)
<i>Sector</i> ₄ <i>Other Industries</i>	5.987*** (11.25)
<i>Bloc</i> ₁ <i>EFTA</i>	0.982** (2.33)
<i>Bloc</i> ₃ <i>NAFTA</i>	0.812 (1.14)
<i>Bloc</i> ₄ <i>NON Bloc Members</i>	5.122*** (3.07)
<i>Constant</i>	132.295 (1.00)
OBSERVATIONS	740
LOG-LIKELIHOOD	-2033.5182
DEGREES OF FREEDOM	11
R-SQUARED	0.5398

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

In Table 1.6, Sector 3 (power intensive industries) and Bloc 2 (EU) are kept fixed simultaneously. The estimates in Table 1.6 imply that the coefficient estimates obtained for the first five variables and the last three variables are analogous to estimates obtained in Table 1.5. Moreover, the estimates obtained for fixed sector differences are very similar to those obtained in the sector specific regression presented in Table 1.4.

Taken together, the fixed effects estimates obtained can be interpreted such that the coefficients indicate how much exports of the third sector (power intensive) to the second bloc (EU) vary from other sectors and blocs. So for example, the coefficient obtained for fishing industries exports to EFTA would be $8.714 + 0.982 = 9.696$, and so forth for other blocs and sectors. However, the estimates can also be interpreted individually for sectors and blocs like in previous subsections.

Thus after controlling for unobserved sector-specific effects and trade blocs, my results indicate that Icelandic exports exhibit patterns similar to those of other countries with regards to recipient market size and distance. It should be noted that this refers to the sign of the coefficients. Given the difficulty of comparing data across sources and countries, magnitudes are generally not compared across trade regressions.

1.6 Correcting for a Small Country Size

1.6.1 Export Ratio Modification

The regressions in the previous sections imply that Icelandic exports are not highly affected by export country factors such as GDP and population. In this section I will analyze whether it is possible to correct for the smallness of the export country and find significant effects. The idea is to determine whether correcting for the smallness of Iceland, by inserting a new population coefficient, improves the estimate for the remaining variable measuring the size of Iceland, GDP. The procedure is to insert an export ratio into the conventional gravity specification to see whether it increases the fit of the model.

The term "trade openness" is believed to show the extent to which countries are open to international trade. The export ratio⁴³ is calculated as export divided by GDP⁴⁴. The use of an export ratio has primarily been connected to economic growth studies, where openness is generally found to increase growth.

Iceland is included as one of 159 countries in an extensive cross-sectional study by Gylfason (1999), connecting an export ratio with various factors. In the Gylfason study the objective is to find the determinants of export and economic growth using a sample of 1995-1994 cross section data. He finds low exports and slow growth to be associated with inflation and abundance of natural resources. The export ratio coefficient is obtained by running a regression on IMF data for the 159 countries in 1994. The equation he estimated is presented as Equation (1.19):

$$\frac{EXP_{i,t}}{Y_{i,t}} = \tau_0 + \tau_1 \ln(N_{i,t}) + \varphi_{i,t} \quad (1.19)$$

For his sample Gylfason receives a constant estimate of 86.33%, and the slope coefficient to be -5.66%. These estimates imply that the export ratio decreases with a population increase, and that small nations export a higher percent of their

⁴³Recent literature on the export ratio includes Lee, Roehl and Soonkyoo (2000), Okuda (1997) and He and Ng (1998).

⁴⁴However, an openness ratio is calculated as the sum of export and import divided by GDP (World Bank, 2002).

GDP than larger nations. When population for Iceland is inserted into the model, an export ratio of 55% is obtained, indicating that Iceland could be expected to export 55% percent of GDP. However, in 1994 the export ratio was about 33%.

1.6.2 The Export Ratio Applied in This Research

The Equation (1.19) applied in the previous section is the same as estimated by Gylfason (1999). Gylfason used cross-sectional data for 1994, but here panel data are estimated for a 10 year period from 1988 to 1997 for 119 countries⁴⁵. The data used here are obtained from an IMF database. The regression results for Equation (1.19) are shown in Table 1.7.

Table 1.7. Export Ratio, Level Estimates for Eq. (1.19)

Regressors	ROBUST
$\ln(N_{i,t})$ <i>Export Country Population</i>	-0.049*** (-19.22)
<i>Constant</i>	1.137*** (26.53)
OBSERVATIONS	1809
LOG-LIKELIHOOD	61.2280
DEGREES OF FREEDOM	1
R-SQUARED	0.1446

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

When the results in Table 1.7 are compared⁴⁶ to the results obtained by Gylfason, they appear to be analogous. The model estimates are all significant. An estimated coefficient for population is -0.049, about -5%, which is close to the estimate of -5.7% obtained by Gylfason (1999). Also, the constant estimate of 86% is not so far from the constant estimate of 114% in Table 1.7. The differences from the research performed by Gylfason earlier is likely to be due to differences in data.

⁴⁵Iceland included; see other countries listed in Appendix C.

⁴⁶The log-likelihood value calculated is not used to calculate likelihood ratio since this model is not comparable to equations in previous tables. This is due to the logarithm format and different data sample.

The next step is then to rewrite Equation (1.19) so the left hand variable is presented in logarithms. The model can therefore be rewritten, as presented in Equation (1.20).

$$\ln\left(\frac{EXP_{i,t}}{Y_{i,t}}\right) = \tau_0 + \tau_1 \ln(N_{i,t}) + \varpi_{i,t} \quad (1.20)$$

The regression results for Equation (1.20) are then presented in Table 1.8. The coefficient estimates obtained for the logarithm estimates are slightly lower than those obtained for level estimates earlier.

Table 1.8. Export Ratio, Logarithm Estimates for Eq. (1.20)

Regressors	LN ROBUST
$\ln(N_{i,t})$ <i>Export Country Population</i>	-0.137*** (-16.10)
<i>Constant</i>	0.899*** (6.65)
OBSERVATIONS	1809
LOG-LIKELIHOOD	-1823.1716
DEGREES OF FREEDOM	1
R-SQUARED	0.1382

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

The new logarithm equation yields a coefficient estimate of -13.7% for population and a constant estimate of 89.9%.

1.6.3 Export Ratio Inserted into a Gravity Model

The objective of this section is to estimate a model like the gravity model when the coefficient for the export country population is restricted to be equal to the population coefficient in the export ratio Equation (1.20). In order to do so the gravity model first needs to be rewritten. Therefore it is logical to start rewriting Equation (1.16) estimated before. The gravity equation is rewritten here by subtracting the logarithm value of the exporting country GDP $\ln(Y_t)$ from both sides as shown in Equation (1.21). The gravity equation can therefore be rewritten as:

$$\begin{aligned} \ln(EXP_{j,s,t}) - \ln(Y_t) &= \beta_0 + (\beta_1 - 1) \ln(Y_t) + \beta_2 \ln(Y_{j,t}) \\ &\quad + \beta_3 \ln(N_t) + \beta_4 \ln(N_{j,t}) \\ &\quad + \beta_5 \ln(DIS_j) + \varepsilon_{j,s,t} \end{aligned} \quad (1.21)$$

The expression shown in Equation (1.21) above can be expressed as the logarithm of export divided by GDP. This is done as the next step in the estimation procedure. Then the coefficient for export country population is set the same as the one estimated earlier for Equation (1.20). Equation (1.21) is rewritten into an export ratio form and becomes Equation (1.22):

$$\begin{aligned} \ln\left(\frac{EXP_{j,s,t}}{Y_t}\right) &= \beta_0 + (\beta_1 - 1) \ln(Y_t) + \beta_2 \ln(Y_{j,t}) - 0.13 \ln(N_t) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(DIS_j) + \varepsilon_{j,s,t} \end{aligned} \quad (1.22)$$

Since the export ratio in a logarithm format is identical to subtracting one from the coefficient of the export country GDP variable, the new estimates for other variables are not expected to be much different from Equation (1.16) before. Then Equation (1.22) is rewritten and the regression Equation (1.23) is obtained:

$$\begin{aligned} \ln\left(\frac{EXP_{j,s,t}}{Y_t}\right) &= \phi_0 + \phi_1 \ln(Y_t) + \phi_2 \ln(Y_{j,t}) - 0.13 \ln(N_t) \\ &\quad + \phi_4 \ln(N_{j,t}) + \phi_5 \ln(DIS_j) + \varepsilon_{j,s,t} \end{aligned} \quad (1.23)$$

As the estimates for Equation (1.23) in Table 1.9 reveal, the export country population coefficient has been restricted to be -0.137 (which corresponds to the export ratio coefficient obtained for Equation (1.20) in Table 1.8). All the variables in Equation (1.23) are estimated to be significant except export country GDP. This indicates that inserting an export ratio does not really seem to solve the small country case problem. The estimated results for Equation (1.23) are shown in Table 1.9.

Table 1.9. Gravity Model Corrected for Small Pop. Size, Eq. (1.23)

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Export Country GDP</i>	-2.567 (-1.12)
$\ln(Y_{j,t})$ <i>Recipient Country GDP</i>	3.542*** (5.08)
$\ln(N_t)$ <i>Export Country Population</i>	-0.137
$\ln(N_{j,t})$ <i>Recipient Country Population</i>	-1.888*** (-2.87)
$\ln(D_j)$ <i>Distance</i>	-2.988*** (-8.65)
<i>Constant</i>	61.081*** (4.20)
OBSERVATIONS	740
LOG-LIKELIHOOD	-2246.3182
DEGREES OF FREEDOM	n. a.
R-SQUARED	

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

It can thus be concluded that an export ratio insertion into the traditional gravity model specification does not seem to give more significance to the export country (Iceland) variables. In other words, the results indicate that even if Iceland was more similar to the general case, population wise, the estimates for the gravity model cannot necessarily be expected to fit the data better. This could be because of limited variation in the Icelandic data.

1.7 Exports of Marine Products

In the above results, the marine sector (fishing industries) was estimated to have the highest export share of overall exports. However, the marine sector represents a wide range of different products, which may vary considerable in their sensitivity to market size, economic wealth, and distance, depending on the nature of the product. Some of the marine products are exported by air cargo from Iceland, which is extremely expensive. The option of choosing to export by air cargo can be preferred however, if the product has a high value and a short life time.

$$\begin{aligned} \sinh^{-1}(EXP_{j,f,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ & + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + \varepsilon_{j,f,t} \end{aligned} \quad (1.24)$$

Based on the above discussion, Equation (1.24) represents exports of various fish products f , from Iceland to a recipient country j , over time t , as a function of the variables of the basic gravity model specification.

The HNR number listed at the top of each column in Table 1.10 refers to the product classification number, as listed in Table 1.11 in Appendix B⁴⁷. What is first noteworthy in Table 1.10 is that neither variables representing the export country Iceland (population and GDP) are estimated to be significant for any of the marine products. This is in line with my earlier results. When the first two columns accounting for salted fish are considered more carefully, estimates indicate that exports are negatively affected by the wealth of the recipient country. Another way of interpreting this is to say that the less wealthy countries are more interested in buying dried or uncured salted fish. These results might reflect the demand for salted fish by relatively poor European countries (like Portugal and Spain). Also, interestingly enough, distance (transport cost) is not estimated to have significant impacts on the exports of uncured salted fish. A possible explanation is that uncured salted fish is expensive to export to all possible destinations. More specifically, if it is expensive to export uncured salted fish to all possible destinations, the

⁴⁷Since only certain fishing products are selected to be estimated in Table 10, the sum of the products estimated needs not to equal the overall marine exports.

threshold cost is so high that it overcomes the marginal effects of distance increase.

Table 1.10. Marine Product Estimates

Regressors		IHS ROBUST ESTIMATES				
HNR nr	10	30	110	175	350 & 355	380 & 385
	Dried salted fish	Uncured salted fish	Whole fish, fresh, chilled or on ice	Other frozed cod fillets	Capelin and herring oil, Other fish oil	Capelin, herring and cod meal, Other fish meal
$\ln(Y_t)$	3.252 (1.01)	-2.737 (-0.62)	0.154 (0.03)	2.099 (0.45)	0.218 (0.05)	-1.277 (-0.28)
$\ln(Y_{j,t})$	-1.197** (-2.28)	-2.771*** (-3.82)	0.763 (1.25)	-0.111 (-0.16)	-1.482*** (-2.59)	-0.102 (-0.16)
$\ln(N_t)$	-3.949 (-0.43)	15.128 (1.22)	-2.229 (-0.17)	-7.174 (-0.53)	9.633 (0.83)	8.456 (0.65)
$\ln(N_{j,t})$	1.561*** (3.14)	2.978*** (4.31)	-0.391 (-0.65)	0.905 (1.35)	1.752*** (3.17)	0.546 (0.89)
$\ln(D_j)$	-0.724*** (-3.64)	-0.391 (-1.07)	-2.048*** (-7.92)	-1.846*** (-7.46)	-1.381*** (-4.79)	-1.970*** (-8.20)
<i>Const</i>	45.713 (0.35)	-248.837 (-1.42)	54.667 (0.29)	102.068 (0.54)	-136.525 (-0.84)	-103.055 (-0.57)
OBS	740	740	740	740	740	740
LL	-2048.79	-2259.75	-2296.15	-2297.84	-2219.70	-2300.26
DoFR	5	5	5	5	5	5
R-SQ	0.0372	0.0344	0.0411	0.0554	0.0357	0.0408

Note: Robust t-statistics are in parentheses below the coefficients. ***,
** and * denote significance levels of 1%, 5% and 10%, respectively.

Columns three and four account largely for cod exports, chilled and frozen. Estimates for these product exports indicate that neither GDP or population of Iceland and the recipient country significantly affect exports. These results may indicate that exports of cod products can be sold to various potential recipient markets, and the export country chooses the destination country based on transport cost rather than anything else.

Finally, the last two columns show estimates for exports of products derived

from marine goods, that is, fish oil and fish meal exports. The results for the fish oil in the fifth column indicate negative wealth effects, but positive population effects. Estimates for the last two columns indicate that for exports of fish meal, only distance is estimated to matter. However, for the export of fish oil, the recipient country's wealth, population and distance are estimated to matter.

Overall, the results for Table 1.10 indicate that export country factors do not seem to matter much for exports, nor do recipient country factors matter in the case of cod exports. This is potentially due to the small intertemporal variation in the Icelandic variables.

1.8 Conclusion

The objective of this research on exports is to examine how the gravity model specification does for small countries like Iceland, find out whether correcting the model for small country case improved the model estimates, and finally to analyze gravity estimates for important marine export products.

The main results indicate that most of the determining factors for a small country like Iceland are the same as in the general case, i.e. exports can be determined by distance together with GDP and population of the recipient country. However, the variables accounting for exporting country (Iceland) market size, do not seem to drive exports.

Regression estimates indicate that the marine sector strongly dominates all other export sectors. Estimates also indicate that when corrected for country distance, country size, and population size, the EFTA trade bloc and countries outside of blocs attract more exports than the EU trade bloc. This is taking into account that some countries started out with EFTA membership in the beginning of the period, and then changed to EU later on. However, NAFTA is not estimated to be different from EU in terms of export attractiveness.

When an international export ratio is inserted into the gravity equation as to correct for small country size, it is not estimated to improve the overall estimation results.

That is, inserting an export ratio does not bring estimates closer to what obtained for other countries in previous research.

Finally, estimates for various marine products indicate that there is variation in relevance of wealth and market size effects on these products.

1.9 Appendix A. Various Functional Forms

The natural logarithmic function is used to convert the gravity model into a linear regression of the form

$\ln(Y) = \alpha_0 + \alpha_1 \ln(x_1) + \dots + \alpha_m \ln(x_m)$. To be able to use the logarithm, the variables need to have positive values. In my case this always holds for the explanatory variable x_i but not the dependent variable y , which sometimes is zero. To also include these zero values I deviate from the geometric model by replacing the logarithm on the left hand side with the inverse hyperbolic sine function: $\sinh^{-1}(Y) = \alpha_0 + \alpha_1 \ln(x_1) + \dots + \alpha_m \ln(x_m)$.

The advantage is that $\sinh^{-1}(Y) = \alpha_0 + \alpha_1 \ln(x_1) + \dots + \alpha_m \ln(x_m)$ is defined for all values of Y . The shape of the Natural Logarithm Function $\ln(x)$ is shown in Sketch 1.1 below (dotted line) and the Inverse Hyperbolic Sine Function $\sinh^{-1}(x) = \ln(x + (1 + x^2)^{0.5})$ (thin line).

Sketch 1.1

Sketch 1.1 exhibits that the two functions are similar for large values of Y .

Sketch 1.2 exhibits the difference between the two functions. In fact, for $y > 2$ the difference is approximately constant as seen in Sketch 1.2.

Sketch 1.2

This means that for large values of y , the modified model behaves analogous to the original model. What effect does this have on the interpretation of the coefficients α_i ? In the case of the logarithm, the effect is quite clear. Suppose x_i increases s fold, then

$$\begin{aligned}\ln(y_{new}/y_{old}) &= \ln(y_{new}) - \ln(y_{old}) \\ &= \alpha_i \ln(sx_i) - \alpha_i \ln(x_i) \\ &= \alpha_i \ln(s) \\ &= \ln(s^{\alpha_i})\end{aligned}$$

so $y_{new} = s^{\alpha_i} y_{old}$, that is, y increases by the factor s^{α_i} . For example, if $\alpha_i = 3$ and x_i increases by 1%, then the model predicts 3.03% increase in the dependent variable y .

On the other hand, this is not as simple when the inverse hyperbolic sine is used. If the z is presented as $z = \sinh^{-1}(y_{old})$ then $y_{new}/y_{old} = \sinh(z + \alpha_i \ln(s)) / \sinh(z)$.

Sketch 1.3

Sketch 1.3 shows this ratio as function of z when $\alpha_i = 3$ and $s = 1.01$. The Sketch indicates that if $z > 1.5$, then a 1% increase in a variable with coefficient equal to 3 results in a 3% increase in y , just as when a logarithm was used. Note that $z > 1.5$ roughly corresponds to $y_{old} > 2$, which corresponds to when the functions differ by constant. So in this case, the effect of the coefficients depends on the size of the dependent variable y , except when y is large, then the behavior is as for the logarithm.

There is another drawback in using the Inverse Hyperbolic Sine function. When using a logarithm, the scaling of an variable does not affect the result. Suppose a variable is changed from being measured in millions of dollars to billions of dollars, then all the values of the variable decrease by a factor of 1000. But $\ln(x_in_million) = \ln(x_in_billion) - \ln(1000)$, so this will only change the constant coefficient α_0 in the regression. However, when using the inverse hyperbolic sine function, the scaling of the dependent variable clearly matters, especially if it goes below 2.

1.10 Appendix B. Merchandise Classification

Table 1.11. Merchandise Classification by Statistics Iceland

HNR	HNR1	ITEXTI	ETEXTI
010	1	Þurrkaður saltfiskur	Dried salted fish
030	1	Blautverkaður saltfiskur	Uncured salted fish
060	1	Saltfiskflök, bitar, o.fl.	Salted fish fillets, bits etc.
080	1	Skreið	Stockfish
090	1	Hertir þorskhausar	Dried fish heads
100	1	Ný, kæld eða ísvarin fiskflök	Fish fillets, fresh, chilled or on ice
110	1	Nýr, kældur eða ísvarinn heill fiskur	Whole fish, fresh, chilled or on ice
120	1	Fiskur til bræðslu	Fish for reduction
130	1	Fryst síld, heil og flök	Frozen herring, whole or in fillets
140	1	Fryst loðna, heil og flök	Frozen capelin, whole or in fillets
150	1	Heilfrystur þorskur	Whole-frozen cod
155	1	Heilfrystur karfi	Whole-frozen redfish
160	1	Heilfrystur flatfiskur	Whole-frozen flatfish
165	1	Annar heilfrystur fiskur	Other whole-frozen fish
170	1	Blokkfryst þorsklök	Block-frozen cod fillets
175	1	Önnur fryst þorsklök	Other frozen cod fillets
180	1	Blokkfryst ýsuflök	Block-frozen haddock fillets
185	1	Önnur fryst ýsuflök	Other frozen haddock fillets
190	1	Blokkfryst ufsaflök	Block-frozen saithe fillets
195	1	Önnur fryst ufsaflök	Other frozen saithe fillets
200	1	Blokkfryst karfaflök	Block-frozen redfish fillets
205	1	Önnur fryst karfaflök	Other frozen redfish fillets
210	1	Blokkfryst flatfiskflök	Block-frozen flatfish fillets
215	1	Önnur fryst flatfiskflök	Other frozen flatfish fillets
220	1	Önnur blokkfryst fiskflök	Other block-frozen fish fillets
225	1	Önnur fryst fiskflök	Other frozen fish fillets
230	1	Frystur fiskmarningur	Minced or strained fish, frozen
240	1	Fryst rækja	Frozen shrimp
250	1	Frystur humar	Frozen lobster
260	1	Frystur hörpudiskur	Frozen scallop
270	1	Fryst loðnuhrogn	Frozen capelin roe
275	1	Önnur fryst hrogn	Other frozen fish roe
280	1	Þorskalýsi til manneldis	Cod liver oil for human consumption
285	1	Þorskalýsi, fóðurlýsi	Cod liver oil for animal feeds
290	1	Söltuð grásleppuhrogn	Salted lumpfish roe
300	1	Önnur sykursöltuð hrogn	Other sugar-salted roe
310	1	Grófsöltuð hrogn	Other salted roe
330	1	Saltsíld	Salted herring
350	1	Loðnu- og síldarlýsi	Capelin and herring oil
355	1	Annað lýsi	Other fish oil
380	1	Loðnu-, síldar- og þorskmjöl	Capelin, herring and cod meal
385	1	Annað mjöl	Other fish meal
399	1	Aðrar sjávarafurðir	Other marine products

Table 1.11. Cont.

HNR	HNR1	ITEXTI	ETEXTI
510	2	Kindakjöt	Lamb and mutton
520	2	Mjólkur- og undanrennuduft	Milk and skim milk powder
530	2	Kaseín (ostaefni)	Casein
540	2	Ostur	Cheese
550	2	Ull	Wool
560	2	Saltaðar gærur	Salted sheepskins
570	2	Saltaðar nautgripa- og hrosshúðir	Salted cattle and horse hides
580	2	Þurrkuð refaskinn	Dried fox skins
590	2	Þurrkuð minkaskinn	Dried mink skins
600	2	Lifandi hross	Live horses
620	2	Lax og silungur, kældur eða frystur	Salmon and trout, chilled or frozen
650	2	Dúnn	Eiderdown
690	2	Aðrar landbúnaðarafurðir	Other agricultural products
800	3	Fiskmeti í loftþéttum umbúðum	Preserved marine products
805	3	Óáfengir drykkir	Non-alcoholic beverages
808	3	Áfengir drykkir	Alcoholic beverages
809	3	Lyf og lækningatæki	Medicine and medical prod.
810	3	Þang- og þamnjöl	Seaweed meal
813	3	Fiskafóður	Fish feeds
815	3	Kísilgúr	Diatomite
825	3	Fiskkassar, trollkúlur og netahringir	Fish tubs, trawl floats, net rings etc.
830	3	Loðsútuð skinn	Tanned or dressed skins
840	3	Pappaumbúðir	Paperboard containers
845	3	Ullarlopi og ullarband	Wool tops and wool yarn
850	3	Ofin ullarefni	Woollen fabrics
855	3	Fiskinet og -línur, kaðlar o.p.h.	Fishing lines, cable, nets etc.
860	3	Þrjónavörur, aðallega úr ull	Knitted clothing, mainly of wool
865	3	Annar fatnaður	Other garments
870	3	Ullarteppi	Woollen blankets
880	3	Kísiljárn	Ferro-silicon
885	3	Ál	Aluminium
887	3	Álpönnur	Aluminium pans
888	3	Steinull	Rock wool
890	3	Rafeindavogir	Electronic weighing machinery
893	3	Ýmis búnaður til fiskveiða	Fishing equipment
895	3	Vélar til matvælavinnslu	Food processing machinery
899	3	Aðrar iðnaðarvörur	Other manufacturing products
910	4	Brotajárn	Metal scrap
920	4	Frímerki	Postage stamps
930	4	Notuð skip	Used ships
935	4	Endurbætur fiskiskipa	Reconstruction of fishing vessels
940	4	Vikur	Pumice stone
945	4	Þvottavikur	Pumice for stonewash
950	4	Flugvélar og flugvélahlutar	Aircraft and aircraft components
990	4	Aðrar vörur	Miscellaneous

1.11 Appendix C. Export Ratio Sample

The regression estimates obtained for the export ratios in Equations (1.19) and (1.20) in sections 1.6.1 and 1.6.2 are based on a the following sample of 119 countries obtained from the IMF database.

Table 1.12. Countries in the Export Ratio Sample

12299Z..ZF...AUSTRIA
12499Z..ZF...BELGIUM
12899Z..ZF...DENMARK
13799Z..ZF...LUXEMBOURG
14299Z..ZF...NORWAY
14499Z..ZF...SWEDEN
17299Z..ZF...FINLAND
17499Z..ZF...GREECE
17699Z..ZF...ICELAND
17899Z..ZF...IRELAND
18199Z..ZF...MALTA
18299Z..ZF...PORTUGAL
18699Z..ZF...TURKEY
21399Z..ZF...ARGENTINA
21899Z..ZF...BOLIVIA
22899Z..ZF...CHILE
23399Z..ZF...COLOMBIA
23899Z..ZF...COSTARICA
24399Z..ZF...DOMINICANREPUBLIC
24899Z..ZF...ECUADOR
25399Z..ZF...ELSALVADOR
25899Z..ZF...GUATEMALA
26399Z..ZF...HAITI
26899Z..ZF...HONDURAS
27899Z..ZF...NICARAGUA
28399Z..ZF...PANAMA
28899Z..ZF...PARAGUAY
29399Z..ZF...PERU
29899Z..ZF...URUGUAY
29999Z..ZF...VENEZUELA,REP.BOL.
31199Z..ZF...ANTIGUAANDBARBUDA
31399Z..ZF...BAHAMAS,THE
31699Z..ZF...BARBADOS
32899Z..ZF...GRENADA
33699Z..ZF...GUYANA
33999Z..ZF...BELIZE

Table 1.12. Cont.

34399Z..ZF...JAMAICA
36199Z..ZF...ST.KITTSANDNEVIS
36499Z..ZF...ST.VINCENT&GREN.
36699Z..ZF...SURINAME
36999Z..ZF...TRINIDADANDTOBAGO
41999Z..ZF...BAHRAIN
42399Z..ZF...CYPRUS
42999Z..ZF...IRAN,I.R.OF
43699Z..ZF...ISRAEL
43999Z..ZF...JORDAN
44399Z..ZF...KUWAIT
44999Z..ZF...OMAN
45399Z..ZF...QATAR
45699Z..ZF...SAUDIARABIA
46399Z..ZF...SYRIANARABREPUBLIC
46699Z..ZF...UNITEDARABEMIRATES
46999Z..ZF...EGYPT
47499Z..ZF...YEMEN,REPUBLICOF
51399Z..ZF...BANGLADESH
51499Z..ZF...BHUTAN
51899Z..ZF...MYANMAR
52499Z..ZF...SRILANKA
53299Z..ZF...CHINA,P.R.:HONGKONG
53499Z..ZF...INDIA
53699Z..ZF...INDONESIA
54299Z..ZF...KOREA
54899Z..ZF...MALAYSIA
55899Z..ZF...NEPAL
56499Z..ZF...PAKISTAN
56699Z..ZF...PHILIPPINES
57899Z..ZF...THAILAND
61299Z..ZF...ALGERIA
61699Z..ZF...BOTSWANA
61899Z..ZF...BURUNDI
62299Z..ZF...CAMEROON
63499Z..ZF...CONGO,REPUBLICOF
63699Z..ZF...CONGO,DEM.REP.OF
63899Z..ZF...BENIN
64499Z..ZF...ETHIOPIA
65299Z..ZF...GHANA
65499Z..ZF...GUINEA-BISSAU
66299Z..ZF...COTEDIVOIRE
66499Z..ZF...KENYA

Table 1.12. Cont.

66699Z..ZF...LESOTHO
67299Z..ZF...LIBYA
67499Z..ZF...MADAGASCAR
67699Z..ZF...MALAWI
67899Z..ZF...MALI
68299Z..ZF...MAURITANIA
68499Z..ZF...MAURITIUS
68699Z..ZF...MOROCCO
68899Z..ZF...MOZAMBIQUE
69299Z..ZF...NIGER
69499Z..ZF...NIGERIA
69899Z..ZF...ZIMBABWE
71499Z..ZF...RWANDA
71899Z..ZF...SEYCHELLES
72299Z..ZF...SENEGAL
72499Z..ZF...SIERRALEONE
72899Z..ZF...NAMIBIA
73499Z..ZF...SWAZILAND
74299Z..ZF...TOGO
74499Z..ZF...TUNISIA
74699Z..ZF...UGANDA
74899Z..ZF...BURKINAFASO
75499Z..ZF...ZAMBIA
81999Z..ZF...FIJI
84699Z..ZF...VANUATU
85399Z..ZF...PAPUANEGUINEA
91199Z..ZF...ARMENIA
91399Z..ZF...BELARUS
91799Z..ZF...KYRGYZREPUBLIC
91899Z..ZF...BULGARIA
92699Z..ZF...UKRAINE
93599Z..ZF...CZECHREPUBLIC
93699Z..ZF...SLOVAKREPUBLIC
93999Z..ZF...ESTONIA
94199Z..ZF...LATVIA
94499Z..ZF...HUNGARY
94699Z..ZF...LITHUANIA
96199Z..ZF...SLOVENIA
96499Z..ZF...POLAND
96899Z..ZF...ROMANIA

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2 Chapter II. Determinants of Foreign Direct Investment in Iceland

2.1 Introduction

Foreign direct investment (FDI) has received increased attention in recent years. In some recent literature, economists have been analyzing the driving forces of FDI, and why FDI tends to take place between wealthy countries rather than flowing from the rich to the poor countries (Markusen, 2002).

One of the interesting features of inbound Icelandic FDI is that until fairly recently, there was none. As with the small level of exports, this might be due to the small market size of Iceland as well as its location. Gravity models of trade leads us to believe that this is the result of market size and distance. Therefore, in this chapter I choose to test this by using the gravity model of FDI which specifically accounts for these effects.

Gravity models have been increasingly popular in trade literature for analyzing the driving forces of foreign direct investment. In an interesting chapter, Brainard (1997) applies a gravity model to multinational activities. Brainard investigates multinational enterprises (MNEs) and seeks to capture the trade-off between MNE affiliate sales and trade. She applies data on MNEs in the U.S. and its trading countries. In her paper, Brainard uses affiliate sales to proxy FDI rather than applying actual FDI, which is a reasonable way to capture actual MNE activity because it measures the value of this activity.

Brainard estimates the incentive multinationals have for exporting rather than undertaking FDI, when corrected for several factors such as trade, investment costs, and economies of scale. Brainard uses the share of exports in total sales as her dependent variable, which is meant to be an inverse indicator for foreign affiliate sales in total sales (FDI).

She finds that MNEs have more incentive to undertake overseas production (FDI) rather than exporting to the foreign market when transport costs and trade barriers increase, and with a decrease in investment barriers as well as relative

weight of plant to firm scale economics.

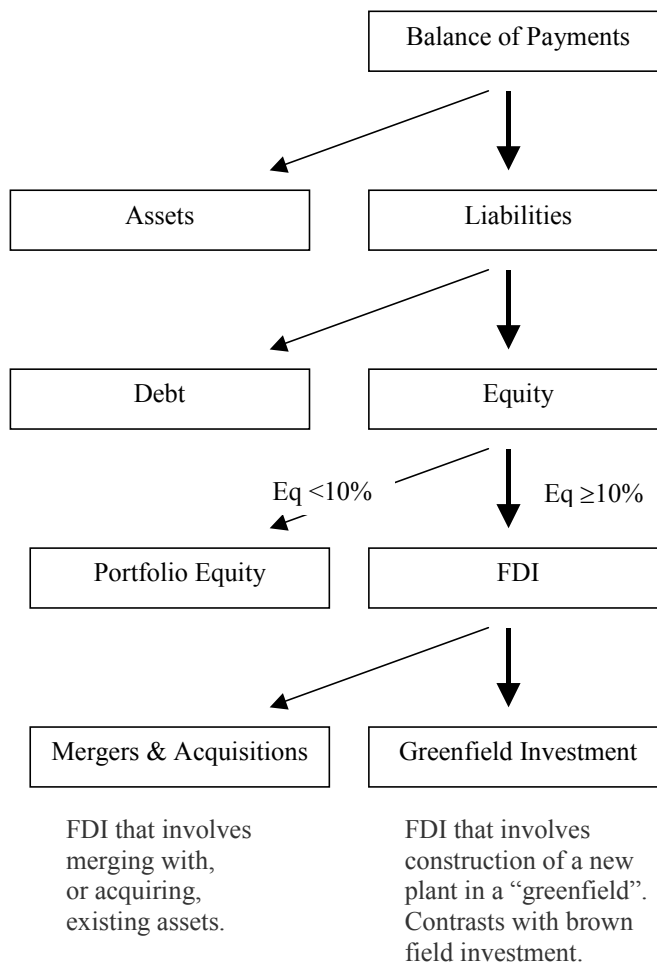
Several other papers apply gravity models to FDI flows and FDI stock data. Jeon and Stone (1999) study FDI flows with an emphasis on the Asia-Pacific region. They estimate sector and country fixed effects, and run separate regressions for individual years in 1987-93. Jeon and Stone found that in most cases FDI is positively affected by home country Gross Domestic Product (GDP) and negatively affected by home country population. However, their estimates indicate that for most years FDI is not impacted by host country population, GDP, or distance. Jeon and Stone also use dummies to account for the difference in investment made by various trade blocs. Di Mauro (2000) provides an interesting study where she analyzes two issues: Whether FDI in the Central and Eastern European Countries (CEEC) region can be regarded as a substitute for exports from the European Union (EU), which would have a negative impact on employment in the EU, and secondly whether FDI in the CEEC region can be considered as replacing investment in regions such as Portugal and Spain. Econometrically, the research by Di Mauro is interesting, since she disaggregates FDI by both countries and sectors over time. The data dimensions are therefore comparable to the ones used in this research, although different questions are asked here, and different regressions are used.

An additional study on CEEC's is the gravity model approach by Bevan and Estrin (2000), where they evaluate the determinants of foreign direct investment flows in transition economies.

In de Mello Sampayo (2000), a gravity model is applied to evaluate determinants of US originated FDI. Finally, an even more recent paper by Mody, Razin and Sadka (2003), extends the gravity model to an information-based model of FDI flows.

More related to my data are the studies that have been carried out in order to analyze the determinants of FDI in Iceland (e.g. Thorsteinsson, 1995; Sighvatsson, 1996; Gylfason, 2000; and Sigurdsson, 2001). However, none of these use the gravity model approach.

Figure 2.1. Balance of Payments and FDI.



Sources: Deardorff (2003), Calderon, Norman and Servén (2002), Lane and Milesi-Ferretti (2003).

Figure 2.1 shows an overview of the balance of payments on the macro economic level. Foreign direct investment falls within the category of liabilities, since it represents the foreign ownership of controlling firm stock in a particular country. When compared to foreign bank loans or foreign portfolio investment, FDI is gener-

ally considered more stable, which is particularly important in a volatile economic environment (Grosse, 1997).

The analysis provided in the following sections seeks to investigate whether FDI is driven by gravity model features such as market size and distance. This chapter also investigates fixed source country effects and sector specific effects. The research is based on unique data on FDI in Iceland which covers both source countries and sectors of allocation over time. The data dimensions also allow for simultaneous estimates for sectors and trade blocs.

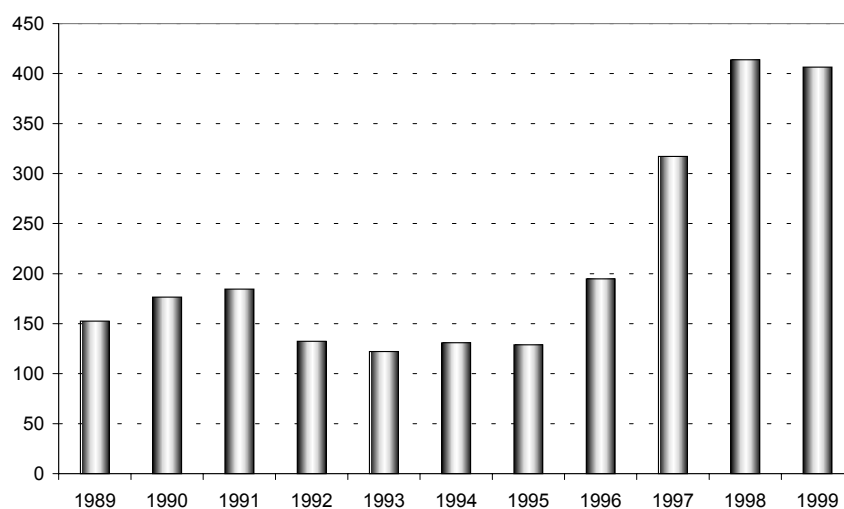
I test the gravity model and find that consistent with previous literature, distance seems to matter for FDI. However unlike earlier findings, wealth may be more important than market size. Here population size and GDP size are believed to give an indication of market size. If FDI is increasing in market size, then both population and GDP could be expected to have positive signs. Both source and host country GDP are always estimated to be positive. However, source and host country population is almost always estimated to be negative. If the signs of the market size variables (GDP and population) are close to being equal and opposite (GDP per capita), then it is possible to say that FDI is affected by wealth effects, rather than market size effects.

The chapter is organized as follows. Section 2.2 gives an overview of how FDI has developed in Iceland. In Section 2.3 the foundations of the gravity model are laid out. Section 2.4 lists the data used in this research, and Section 2.5 exhibits regression results for the basic gravity model specification. Section 2.6 provides results for simultaneous analysis of sources and allocation of FDI, while Section 2.7 considers FDI allocation specifically. Section 2.8 provides results from running the gravity model for FDI stock, and finally Section 2.9 includes summary and conclusions.

2.2 Development of Foreign Direct Investment in Iceland

Foreign direct investment (FDI) is often formed when multinationals expand their operations from one country to another. Although foreign investors have been increasingly interested in investing in Iceland, the inward FDI stock in Iceland has been low compared to the other Nordic countries. As can be seen in Figure 2.2, in Iceland, FDI inflows were marginal until 1996 when a Swiss multinational started investing in the aluminum sector.

Figure 2.2: Foreign Direct Investment Stock in Iceland, Million \$ (1995).



Source: The Central Bank of Iceland (2001).

Figure 2.2 shows the development of foreign direct investment (FDI) stock in Iceland, with Iceland being the host country of investment. In Figure 2.2, FDI is presented as the FDI stock at the end of period.⁴⁸ The stock of FDI equals accumulated FDI inflows. As Figure 2.2 exhibits, total FDI stock has grown substantially from 1995 to 2000, or about four-fold.

⁴⁸All stock values in the figures are the end of period values.

2.3 The Gravity Model

2.3.1 Theoretical Foundations of the Model

Several authors have made a contributions to the foundations of the gravity model. Valuable contributions to literature have been made by Anderson, Bergstrand and Deardorff. Anderson (1979) assumes product differentiation and Cobb-Douglas preferences. Anderson puts forward the so-called Armington Assumption on the basis that products are differentiated by the country of origin. However, tariffs and transport costs are not accounted for in this gravity model specification.

Later, Bergstrand (1985) presumes that the Armington assumption holds as well as CES preferences. Bergstrand's conclusion is that price and exchange rate variation have significant effects on aggregate trade flows. He also finds that the gravity equation is a reduced form of a partial subsystem of a general equilibrium model with nationally differential products.

Deardorff (1995) derives a gravity model in the framework of a Heckscher-Ohlin model. Bergstrand presumes that the same preferences hold for all goods and thus simplifies the setup of Anderson (1979), who assumed this only for traded goods. Deardorff rejects the hypothesis that the Heckscher-Ohlin model is not a sufficient framework for the gravity equation, and points out that empirical evidence for the equation has been provided by those who complained about lack of theoretical basis for the equation. Later, Deardorff (1998) finds the gravity model to be consistent with several variants of the Ricardian and Heckscher-Ohlin models.

2.3.2 The Model Specification

The most commonly used version of the gravity model specified by Bergstrand (1985) is presented in Equation (2.1).

$$X_{ij,t} = \alpha_0 (Y_{i,t})^{\alpha_1} (Y_{j,t})^{\alpha_2} (D_{ij})^{\alpha_3} (A_{ij})^{\alpha_4} \zeta_{ij,t} \quad (2.1)$$

In the Bergstrand (1985) gravity model paper, Equation (2.1) explains the volume of trade between countries i and j by their GDPs, distance, and factors that either aid or restrict trade. The variable $X_{ij,t}$ accounts for export from country i to

country j , at time t . The variable $Y_{i,t}$ is the GDP of country i at time t , $Y_{j,t}$ is the GDP of country j at time t and D_{ij} is the distance between the economic centers of country i and country j . The variable A_{ij} accounts for factors that either stimulate or reduce trade between country i and j , and finally $\zeta_{ij,t}$ is a log-normally distributed error term, with $E(\ln(\zeta_{ij,t}))=0$ (Greene, 1997).

Similar to the paper by Di Mauro (2000a, 2000b), the gravity model in this chapter predicts the volume of FDI stock. FDI is expected to increase with an increase in the GDPs of the host and source economies, but also expected to decrease as distance increases. The gravity model specification used in this research can be presented as shown in Equation (2.2). The dependent variable is now specified as inward FDI in Iceland, and varies over source countries, sectors, and time. However, the variables representing the host country on the right hand side do not vary by country. Therefore the host country notation is simplified as to only vary by time, not various host countries. The j notation is therefore not needed; only the i notation for source countries is used, as exhibited in Equation (2.2):

$$FDI_{i,s,t} = e^{\beta_0} (Y_{i,t})^{\beta_1} (Y_t)^{\beta_2} (N_{i,t})^{\beta_3} (N_t)^{\beta_4} (D_i)^{\beta_5} \zeta_{i,t} \quad (2.2)$$

This basic equation specification is presented in a logarithm format, and all are natural logarithms. Therefore, the interaction between the variables in the equation and the dependent variable is presented in percentages, i.e. how much a percentage change in one of the variables affects the dependent variable. The explanatory variables in Equation (2.2) are somewhat identical to Equation (2.1), but now $N_{i,t}$ and N_t have been added to the basic equation in order to account for the size of the economies. GDP accounts for the economies' total wealth. In model specifications introduced later in this chapter, dummies are added to account for the source countries membership to trade blocs and the allocation of FDI to several investment sectors. In similar papers for other countries, people have tended to add dummies for common borders between trading partner countries or countries that share a language. However, Iceland is unique in that it does not share a border or language with any other country, rendering this technique unnecessary.

Table 2.1. Variable Definition

Variable		Predicted signs
$\ln(FDI_{i,s,t})$	Foreign Direct Investment transformed by the Natural Logarithm Function, running over source countries (i) and sectors (s), over time (t).	
$\sinh^{-1}(FDI_{i,s,t})$	Foreign Direct Investment transformed by the Inverse Hyperbolic Sine Function, running over source countries (i) and sectors (s), over time (t).	
$\ln(Y_t)$ <i>Host Country GDP</i>	Logarithm (ln) of Host country Gross Domestic Product (GDP), over time (t).	+
$\ln(Y_{i,t})$ <i>Source Country GDP</i>	Logarithm (ln) of Source country (i) Gross Domestic Product (GDP), over time (t).	+
$\ln(N_t)$ <i>Host Country Pop</i>	Logarithm (ln) of Host country population (Pop), over time (t).	+
$\ln(N_{i,t})$ <i>Source Country Pop</i>	Logarithm (ln) of Source country population (Pop), over time (t).	+
$\ln(D_i)$ <i>Distance</i>	Logarithm (ln) of distance between the source and the host country.	-
$Sector_1$ <i>Power Intensive Ind</i>	Dummy variable accounting for the Power Intensive Industries.	+ / -
$Sector_2$ <i>Comm. and Fin. Ind</i>	Dummy variable accounting for the Commerce and Finance Industries.	+ / -
$Sector_3$ <i>Telecom & Transp. Ind</i>	Dummy variable accounting for the Telecom and Transport Industries.	+ / -
$Sector_4$ <i>Other Industries</i>	Dummy variable accounting for the Agriculture, Fishing and remaining Industries.	+ / -
$Bloc_1$ <i>EFTA</i>	Dummy variable accounting for country membership to the EFTA trade bloc.	+ / -
$Bloc_2$ <i>EU</i>	Dummy variable accounting for country membership to the EU trade bloc.	+ / -
$Bloc_3$ <i>NAFTA</i>	Dummy variable accounting for country membership to the NAFTA trade bloc.	+ / -
$Bloc_4$ <i>NON Bloc Members</i>	Dummy variable accounting for country non-membership to any trade bloc.	+ / -

All regressions presented here are obtained using STATA version 7.0.

2.4 Data Sources and Statistics

Data on Foreign Direct Investment (FDI) applied in this research were kindly provided by the Central Bank of Iceland. These data run over 4 investment sectors and an 11 year period, from 1989 to 1999. The data account for annual data on FDI undertaken in Iceland in the estimated period.

Table 2.2. Summary Statistics

VARIABLE	UNITS	OBS	MEAN	STD.	MIN	MAX
$FDI_{i,s,t}$	Million USD (1995 base)	748	3.155	13.887	-0.953	157.934
$\ln(FDI_{i,s,t})$	Natural Logarithm	240	0.366	2.514	-6.830	5.062
$\sinh^{-1}(FDI_{i,s,t})$		748	0.559	1.165	-0.847	5.755
Y_t	Trillion USD (1995 base)	748	0.007	0.001	0.007	0.009
$\ln(Y_t)$	Natural Logarithm	748	-4.934	0.083	-5.016	-4.765
$Y_{i,t}$	Trillion USD (1995 base)	740	1.219	1.957	0.014	8.582
$\ln(Y_{i,t})$	Natural Logarithm	740	-0.788	1.425	-4.289	2.149
N_t	Million	748	0.265	0.008	0.253	0.278
$\ln(N_t)$	Natural Logarithm	748	-1.327	0.029	-1.376	-1.282
$N_{i,t}$	Million	748	43.179	63.843	0.378	278.230
$\ln(N_{i,t})$	Natural Logarithm	748	2.817	1.509	-0.974	5.628
D_i	Million	748	0.004	0.004	0.002	0.0167
$\ln(D_i)$	Natural Logarithm	748	-5.827	0.571	-6.349	-4.098
$Sector_k$	$Sector_k \in \{1, 2, 3, 4\}$	748			0	1
$Bloc_n$	$Bloc_n \in \{1, 2, 3, 4\}$	748			0	1

Sources: Central Bank of Iceland, Bali-Online Webside, Economic Institute of Iceland, International Labor Organization, World Bank, World Competitiveness Report, Kyoto Protocol.

The data cover the inward FDI stock in Iceland, obtained from 17 different source countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Japan, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States. One could therefore expect the number of observations to be $17 * 4 * 11$, which equals 748. However, the number of

observations is 740 since data for Germany in 1989 and 1990 is not included in the data, because these are the years before the unification of Germany.

The countries' trade bloc membership is also included in the research. The trade blocs included are Bloc 1 for the European Free Trade Association (EFTA), Bloc 2 for the European Union, Bloc 3 is the North American Free Trade Agreement (NAFTA), and finally Bloc 4 includes NON Bloc countries (non member countries).

Data on FDI are divided into four main investment sectors: Sector 1 represents the Power Intensive Industries, Sector 2 Finance & Commerce Industries, and Sector 3 Telecom & Transport. Finally Sector 4 represents the Fishing Industry, the Agricultural Industry, and remaining industries.

The original FDI data were obtained in Icelandic Krona, and then converted to US dollar values using World Bank dollar exchange rates, and finally put on a base of 1995 using the World Bank GDP deflator. By doing so, the FDI values become comparable to the values of the variables on the right hand side of the equation, since values for foreign GDP are obtained in 1995 US dollar values. The GDP values used are defined by the World Bank (2001) CD-Rom as "constant 1995 US\$" (real values of GDP on a 1995 year base)⁴⁹. These are presented as trillion dollar values on a 1995 base, here trillion is equals million million, that is 1×10^{12} ⁵⁰. Finally, the FDI data used in the last column in Table 2.8 are added up across sectors. Therefore, in those regressions the number of observations is 185.

⁴⁹The GDP World Bank deflator used is on a 1995 year base.

⁵⁰The definition of trillion varies between countries. In US and Canada it is defined as 10^{12} , however in Britain, France and Germany it is defined as cubed million or 10^{18} (Hyper Dictionary, 2004).

2.5 The Basic Gravity Model Specification

The error term relationship previously described in Equations (2.1) and (2.2), in Section 2.3.2, can be presented in Equation (2.3) as follows, where the (ζ) is replaced by (ε) , so that: $E(\ln \zeta_{i,s,t}) = E(\varepsilon_{i,s,t}) = 0$.

$$\begin{aligned} \ln(FDI_{i,s,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{i,t}) + \beta_3 \ln(N_t) \\ & + \beta_4 \ln(N_{i,t}) + \beta_5 \ln(D_i) + \varepsilon_{i,s,t} \end{aligned} \quad (2.3)$$

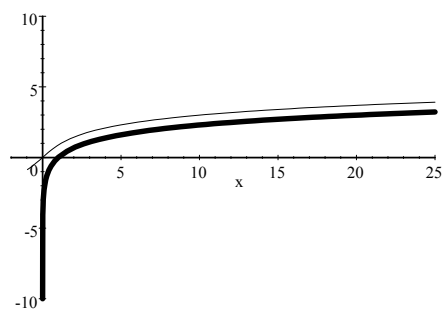
A different functional form of the gravity equation is shown in Equation (2.4) after applying the so-called "Inverse Hyperbolic Sine Function" to the dependent variable, rather than applying the natural logarithm function⁵¹. The procedure is preferred because of the need for transformation that does not truncate or eliminate low values of the dependent variable. This way of imposing the Inverse Hyperbolic Sine Function (IHS) to the dependent variable while imposing natural logarithm on the independent variables has been used in studies on household wealth. The procedure was proposed by Johnston (1949) and suggested as a suitable transformation for household wealth data by Burbidge, Magee and Robb (1988), since some households hold zero or negative net worth (Carroll, Dynan and Krane⁵², 1999). Figure 2.3 provides a graphical description of the natural logarithm function $\ln(x)$ (thick line) and the inverse hyperbolic sine function⁵³ $\sinh^{-1}(x)$ (thin line).

⁵¹A gravity equation in a natural logarithm format cannot operate on zero or negative values.

⁵²In their 1999 paper, Carroll Dynan and Spencer make special thanks to Martin Browning at the University of Copenhagen for suggesting this transformation, see page 4.

⁵³More specifically, the Inverse Hyperbolic Sine Function can be presented as $\sinh^{-1}(x) = \ln(x + (1 + x^2)^{0.5})$

Figure 2.3: Inverse Hyperbolic Sine and Natural Logarithm Functions



While other methods for dealing with zeros exist, they are all ad hoc in some fashion, rendering this approach as reasonable as any.

The variable notation has been simplified as to better reflect the nature of the data, since the data only covers one way investment⁵⁴, not bilateral investment.

$$\begin{aligned} \sinh^{-1}(FDI_{i,s,t}) = & \beta_0 + \beta_1 \ln(Y_i) + \beta_2 \ln(Y_{i,t}) + \beta_3 \ln(N_i) \\ & + \beta_4 \ln(N_{i,t}) + \beta_5 \ln(D_i) + \varepsilon_{i,s,t} \end{aligned} \quad (2.4)$$

The regression results for Equation (2.4) are presented in Table 2.3. All the variables in Table 2.3 are estimated to be significant except for the domestic population variable.

⁵⁴By this notation, i refers to the source countries of investment, running from 1 to 17. By doing so, the chapter follows the notation applied in other thesis chapters. This notation is well presented in the CMM (2001) paper.

Table 2.3. The Basic Model Specification

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Host Country GDP</i>	2.085** (2.23)
$\ln(Y_{i,t})$ <i>Source Country GDP</i>	1.143*** (7.00)
$\ln(N_t)$ <i>Host Country Population</i>	-2.975 (-1.14)
$\ln(N_{i,t})$ <i>Source Country Population</i>	-0.976*** (-6.29)
$\ln(D_i)$ <i>Distance</i>	-0.235*** (-4.67)
<i>Constant</i>	9.166*** (3.32)
OBSERVATIONS	740
LOG-LIKELIHOOD	-1125.1015
DEGREES OF FREEDOM	5
R-SQUARED	0.1028

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

One of the major questions asked at the beginning of this chapter is whether it is possible to explain FDI in Iceland by distance, together with some other economic variables represented in the gravity model.

Table 2.3 shows robust⁵⁵ regression estimates for the gravity model based on Equation (2.4). The results indicate that the host and source countries' GDP are estimated to be positively significant.

Therefore, a 1% increase in source GDP (equivalent to \$12.19 billion⁵⁶ at the sample mean) implies an 1.143% increase in FDI, equivalent to \$36,062 at the sample means⁵⁷. The fact that the GDPs are estimated to have positive significant effects

⁵⁵All robust t-statistics are calculated using White's (1980) heteroskedasticity correction. Note that all of these t-statistics assume normality which need not be true in the data. Since the trade literature typically ignores this difficulty, I do as well, but note this potential problem.

⁵⁶In this case, a billion dollars is in American terms, so that \$1 billion is equivalent to \$1,000,000,000.

⁵⁷Sample means are listed in Table 2.2. Note that the means are very low, because of all the zeros in the data.

on FDI can be interpreted such that FDI increases with an increase in the economic size of the host and source country, which is as theory would predict. Similarly, theory would predict the population variables of both the host and source countries to have positive effects on FDI. This is however not the case, since both of these variables are estimated to be negative, although only the source country population coefficient is significant.

The significant negative estimate for the source country population indicates that FDI is negatively driven by this measure of market size. This signifies that economies are expected to invest more as their market size becomes smaller. Together it seems that FDI is positively affected by countries' total wealth but negatively by their market size. This is somewhat expected based on the knowledge that a considerable investment is made by small economies like Switzerland, and the EFTA member countries are generally small in population⁵⁸.

Another way of interpreting the results for the host and source country sizes is to consider their combination as per capita wealth effects on investment. Thus the hypothesis would be that GDP and population are equal and opposite in sign. When considering the confidence intervals for the two variables, both intervals overlap one indicating an elasticity of one. This is because when the standard deviations are considered, the source country GDP is found to overlap 1, whereas source population is found to overlap -1⁵⁹. Therefore, the coefficient ratio is estimated to overlap one⁶⁰. This exercise gives a reason to believe that GDP per capita drives FDI rather than the total wealth of the country. More specifically, it indicates that average wealth of the country matters, rather than total wealth.

Finally, the negative distance coefficient obtained indicates that FDI decreases as distance increases. In Table 2.3, I choose to report both R squared and the log-likelihood values as an indication of the regression fit. Since Table 2.3 includes

⁵⁸In the power intensive industry.

⁵⁹The standard deviation for source country GDP is 0.1633 and the coefficient is estimated to be 1.143, so the confidence interval runs from 0.98 to 1.31. However, the standard deviation for source country population is 0.1552, and coefficient -0.976, resulting in a confidence interval between -1.13 and -0.82.

⁶⁰It would provide the same results if the coefficients would overlap 4 and -4, etc.

the first regression obtained in this research, these measures on the R squared and the log-likelihood are for comparison with latter tables, rather than telling a story on their own.

2.6 Allocation of Foreign Direct Investment

2.6.1 Decomposition by Sectors of Allocation

Next I want to look more closely at FDI allocation, and therefore disaggregate FDI by sectors. This will be done now since it allows analysis of whether FDI is driven into individual sectors of allocation by the gravity model variables. I seek to gain some information on sector allocation by measuring whether there is fixed difference between individual sectors. Equation (2.5) offers a sectorial decomposition of FDI by incorporating dummies for sectors.

$$\begin{aligned} \sinh^{-1}(FDI_{i,s,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{i,t}) + \beta_3 \ln(N_t) \\ & + \beta_4 \ln(N_{i,t}) + \beta_5 \ln(D_i) + \gamma_k Sector_k + \varepsilon_{i,s,t} \end{aligned} \quad (2.5)$$

The regression results for Equation (2.5) are presented in Table 2.4, where the variable coefficient γ_k reflects the sector specific effects⁶¹. Here the 3rd sector, Telecom & Transport (T&T), is held fixed. When the estimates presented in Table 2.4 are considered, distance is estimated to be equally as restrictive as in the non-sector specific case in Table 2.3. This indicates that it is not capturing sector specific constants. As before, both domestic and foreign GDPs are estimated to have significant positive effects on FDI, but source and host countries' population to negatively affect FDI. Taken together, these estimates indicate that investment incentives are positively affected by total wealth in both host and source countries. More specifically, higher per capita GDP increases FDI, which is negatively affected by market size (population). The estimates obtained for the source country have higher significance than those of the host country, indicating that FDI is more impacted by source country market size measures than those of the host country.

In Table 2.4, the third sector "Telecom and Transport" (T&T) is held fixed to avoid the dummy variable trap. Estimates for sector one, two and four indicate that these are all estimated to be significantly positive from the T&T sector. Interestingly enough, the commerce and finance (C&F) sector is estimated to account

⁶¹This is done to avoid omitted variable bias.

for even more FDI than the power intensive industries. However, these sector specific estimates are obtained after correcting for economic sizes of the host and source countries as well as distance. This may explain why C&F is higher than the power intensive industry when compared to Telecom and Transport. Also, it could potentially be due to the small time series variation of the Icelandic variables, which impact the research as a whole.

Table 2.4. Fixed Sector Effects

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Host Country GDP</i>	2.085** (2.29)
$\ln(Y_{i,t})$ <i>Source Country GDP</i>	1.143*** (7.22)
$\ln(N_t)$ <i>Host Country Population</i>	-2.975 (-1.17)
$\ln(N_{i,t})$ <i>Source Country Population</i>	-0.976*** (-6.50)
$\ln(D_i)$ <i>Distance</i>	-0.235*** (-4.62)
<i>Sector₁ Power Intensive Ind.</i>	0.575*** (5.07)
<i>Sector₂ Comm. and Fin. Ind.</i>	0.649*** (6.79)
<i>Sector₄ Other Industries</i>	0.435*** (5.43)
<i>Constant</i>	8.751*** (3.26)
OBSERVATIONS	740
LOG-LIKELIHOOD	-1105.4495
DEGREES OF FREEDOM	8
R-SQUARED	0.1492

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

The regression results are based on a sample of data with 740 observations. The log-likelihood values are presented here, since they can be used to compare

different specifications. By following the standard procedure for log-likelihoods⁶², the difference between the two log-likelihood values is multiplied by 2, yielding a value of 4.6. And since the value 4.6 is higher than the critical value 3.841 (based on of one degree of freedom), the restricted model version in Table 2.3 is not preferred⁶³ to the unrestricted version in Table 2.4.

⁶²"Let θ be a vector of parameters to be estimated, and let H_0 specify some sort of restriction on these parameters. Let $\hat{\theta}_U$ be the maximum likelihood estimate of θ obtained without regard to constraints, and let $\hat{\theta}_R$ be the constrained maximum likelihood estimator." Greene (1997, pp. 161).

"If the restriction $c(\theta) = 0$ is valid, imposing it should not lead to a large reduction in the log-likelihood function. Therefore, we base the test on the difference, $\ln L - \ln L_R$, where L is the value of the likelihood function at the unconstrained value of θ and L_R is the value of the likelihood value function at the restricted estimate" Greene (1997, pp. 160).

⁶³The objective is to determine whether the restricted version can be rejected when compared to the non-restricted version. This is possible if the difference is high enough.

2.7 Sources of FDI

In order to investigate the country and trade bloc effects on FDI, I next estimate country and bloc specific fixed effects.

2.7.1 Decomposition by Trade Bloc Membership

This subsection deals with the decomposition of FDI by trade blocs. The disaggregation by trade bloc membership is reflected in the variable in Equation (2.6). The coefficient π_n accounts for specific trade bloc effects, running from one to four, bloc=1,2,...4. More specifically bloc 1 represents the European Free Trade Association (EFTA), bloc 2 the European Union (EU), bloc 3 the North American Free Trade Association (NAFTA) and finally bloc 4 non bloc member countries.

$$\begin{aligned} \sinh^{-1}(FDI_{i,s,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{i,t}) + \beta_3 \ln(N_t) \\ & + \beta_4 \ln(N_{i,t}) + \beta_5 \ln(D_i) + \pi_n \text{Bloc}_n + \varepsilon_{i,s,t} \end{aligned} \quad (2.6)$$

As can be seen in Table 2.5, estimates for variables of the basic regression are analogous to the ones obtained in Table 2.3, except that here distance is insignificant. These results for distance may indicate that countries grouped in various trade blocs tend to be geographically close to one another, the geographical fixed difference is captured primarily by these trade blocs so the distance variable is left insignificant. Along these lines, the insignificance of the non-bloc countries may be due to the fact that they are more geographically spread than the others. Therefore, they are not estimated to be significantly different from the EU bloc.

Moreover, the fixed effects estimates indicate that EFTA and NAFTA⁶⁴ are estimated to have significantly higher investment in host than EU, but not the fourth trade bloc (non-bloc members). In general the fixed bloc effects may be related to predictions on investment costs or openness of trade blocs. This is the

⁶⁴The member countries of NAFTA are the US and Canada and they are presumed to be in NAFTA from 1989, although NAFTA was not formed until in 1992. However, it is taken into account whether other countries move between EFTA and the EU, etc.

reason why EFTA countries are estimated to invest more in Iceland when compared to the EU; there could be less trade costs involved for them. However, based on the EEA (European Economic Area) agreement, EU countries have full permission to invest in EFTA countries like Iceland. This freedom to invest must overcome some threshold investment cost and increase dual openness, but apparently there is some fixed difference left. Another possibility is that Switzerland, which is in the EFTA group, has substantial investment in the power intensive industry.

Table 2.5. Fixed Trade Bloc Effects

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Host Country GDP</i>	2.189** (2.37)
$\ln(Y_{i,t})$ <i>Source Country GDP</i>	1.053*** (5.36)
$\ln(N_t)$ <i>Host Country Population</i>	-2.127 (-0.82)
$\ln(N_{i,t})$ <i>Source Country Population</i>	-0.892*** (-4.96)
$\ln(D_i)$ <i>Distance</i>	-0.068 (-0.23)
$Bloc_1$ <i>EFTA</i>	0.484*** (3.41)
$Bloc_3$ <i>NAFTA</i>	0.357** (1.97)
$Bloc_4$ <i>NON Bloc Members</i>	-0.236 (-0.43)
<i>Constant</i>	11.364*** (3.35)
OBSERVATIONS	740
LOG-LIKELIHOOD	-1111.6027
DEGREES OF FREEDOM	8
R-SQUARED	0.1349

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

The log-likelihood measure presented in Table 2.5 has a value of -1111.6027

which is not significantly better than that found in Table 2.3⁶⁵.

2.7.2 FDI Decomposition by Countries of Origin

In order to continue along the same lines, my next regression focuses more specifically on the sources of FDI by analyzing country decomposition. Thus, the next step is to estimate whether a fixed difference is identifiable between source countries of investment. While Equation (2.6) focused on trade bloc membership, Equation (2.7) includes countries of origin.

$$\begin{aligned} \sinh^{-1}(FDI_{i,s,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{i,t}) + \beta_3 \ln(N_t) \\ & + \beta_4 \ln(N_{i,t}) + \theta_i Country_i + \varepsilon_{i,s,t} \end{aligned} \quad (2.7)$$

The fixed country is now Denmark, and the dummy variable is presented as θ_i , and i corresponds to the source countries of investment, from θ_1 to θ_{17} . The regression results are presented in Table 2.6. Estimates for distance cannot be included in the equation, because it is fixed over time.

Overall the estimates for market size and wealth are different and not fully comparable with the basic gravity model specification presented in Table 2.3, since Table 2.6 does not include distance as one of its variables. For the same reason Table 2.3 cannot be regarded as a constrained version of the specification in Table 2.6, since Table 2.6 does not include distance.

As before, the wealth and market size effects obtained for GDPs and population in Table 2.6 indicate that wealth tends to have positive effects on FDI. However, the estimates indicate that FDI is more driven by the wealth of the host country than the wealth of the source country, since only the host is estimated to be significant, even though both are estimated to be positive. Source country population is now estimated to have positive effects on FDI, implying that when correcting for individual countries, FDI is positively impacted by their market size, however not significantly.

⁶⁵Like before, the log-likelihood difference doubled is compared to a critical value from the chi-squared distribution. And if the critical value is lower than the double difference, then the hypothesis imposing restriction is rejected as being more favourable than the unrestricted one.

As can be seen in Table 2.6, investment made by most of the 17 countries in the Table is estimated to have a non-different investment amount from the fixed country, Denmark. Three countries are estimated to invest significantly less than Denmark. They are as follows: Austria, Belgium, and Finland.

The log-likelihood value obtained for Table 2.6 has a value of -1050.27 which is considerable less negative than the log-likelihood value obtained for the restricted specification presented in Table 2.3. However, Table 2.6 regression results cannot be compared to other tables in the remaining part of the chapter, and hardly to Table 2.3, since distance is not included in Table 2.6. Overall, the results seem to vary somewhat depending on whether it is corrected for country or trade bloc effects.

Table 2.6. Fixed Country Effects

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Host Country GDP</i>	2.416** (2.16)
$\ln(Y_{i,t})$ <i>Source Country GDP</i>	0.210 (0.13)
$\ln(N_t)$ <i>Host Country Population</i>	-5.581* (-1.68)
$\ln(N_{i,t})$ <i>Source Country Population</i>	5.381 (1.08)
<i>Country</i> ₁ <i>Austria</i>	-3.763** (-2.08)
<i>Country</i> ₂ <i>Australia</i>	-8.154 (-1.53)
<i>Country</i> ₃ <i>United States</i>	-21.527 (-1.38)
<i>Country</i> ₄ <i>Belgium</i>	-4.914* (-1.75)
<i>Country</i> ₅ <i>United Kingdom</i>	-13.851 (-1.38)
<i>Country</i> ₇ <i>Finland</i>	-1.012** (-2.33)
<i>Country</i> ₈ <i>France</i>	-14.829 (-1.54)
<i>Country</i> ₉ <i>Netherlands</i>	-7.316 (-1.64)
<i>Country</i> ₁₀ <i>Japan</i>	-18.625 (-1.51)
<i>Country</i> ₁₁ <i>Canada</i>	-10.921 (-1.50)
<i>Country</i> ₁₂ <i>Luxembourg</i>	13.122 (1.27)
<i>Country</i> ₁₃ <i>Norway</i>	0.654 (0.84)
<i>Country</i> ₁₄ <i>Spain</i>	-12.531 (-1.44)
<i>Country</i> ₁₅ <i>Switzerland</i>	-1.601 (-1.53)
<i>Country</i> ₁₆ <i>Sweden</i>	-3.606 (-1.61)
<i>Country</i> ₁₇ <i>Germany</i>	-16.071 (-1.47)
<i>Constant</i>	-2.571 (-0.26)
OBSERVATIONS	740
LOG-LIKELIHOOD	-1050.27
DEGREES OF FREEDOM	20
R-SQUARED	0.2671

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

2.8 Sources and Allocation of FDI

2.8.1 Fixed Sector and Trade Bloc Effects Determined

I now proceed by simultaneously taking into account sources and allocation of FDI. The analysis will start by providing a decomposition of investment into the main investment sectors and country membership into the various trade blocs. This is done because it is necessary to determine if there is a fixed difference between individual sectors on one hand, and individual trade blocs on the other hand. These effects will be estimated simultaneously. I start by looking at the least restricted version of the equation, after looking at the basic specification including the variables most commonly used in the gravity model. The results for estimating Equation (2.8) are presented in Table 2.7.

$$\begin{aligned} \sinh^{-1}(FDI_{i,s,t}) = & \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{i,t}) + \beta_3 \ln(N_t) + \beta_4 \ln(N_{i,t}) \quad (2.8) \\ & + \beta_5 \ln(D_i) + \gamma_k Sector_k + \pi_n Bloc_n + \varepsilon_{i,s,t} \end{aligned}$$

In Equation (2.8) the fixed effects technique is applied once more. The sector dummy $Sector_k$ corresponds to sectors where $k = 1, 2, \dots, 4$; and the bloc dummy $Bloc_n$, refers to trade blocs where $n=1, 2, \dots, 4$. The fixed term can therefore be presented as $\beta_0 + \gamma_k + \pi_n$ and the error term as being $\varepsilon_{i,s,t}$. Here π_n is a constant which accounts for trade bloc specific effects as before, and $Sector_k$ is a constant accounting for sector specific effects, while $\varepsilon_{i,s,t}$ is randomly distributed. There are three possibilities available when the results for Equation (2.8) are analyzed. First, it is possible to set $\beta_0 = 0$ and $\pi_n = 0$. Second, it is possible to set $\beta_0 = 0$ and $\gamma_k = 0$. Finally, it is also possible to set $\pi_n = 0$ and $\gamma_k = 0$. Here it is presumed that $\gamma_3 = 0$ (coefficient for T&T sector) and $\pi_2 = 0$ (EU bloc). Therefore, the regression results obtained for the dummy variables combined can be interpreted as the "deviation" from the T&T sector and the EU bloc.

Table 2.7. Fixed Sector and Trade Bloc Effects

Regressors	IHS ROBUST
$\ln(Y_t)$ <i>Host Country GDP</i>	2.189** (2.44)
$\ln(Y_{i,t})$ <i>Source Country GDP</i>	1.053*** (5.54)
$\ln(N_t)$ <i>Host Country Population</i>	-2.127 (-0.84)
$\ln(N_{i,t})$ <i>Source Country Population</i>	-0.892*** (-5.13)
$\ln(D_i)$ <i>Distance</i>	-0.068 (-0.24)
<i>Sector₁ Power Intensive Ind.</i>	0.575*** (5.29)
<i>Sector₂ Comm. and Fin. Ind.</i>	0.649*** (6.58)
<i>Sector₄ Other Industries</i>	0.435*** (5.32)
<i>Bloc₁ EFTA</i>	0.484*** (3.57)
<i>Bloc₃ NAFTA</i>	0.357** (1.99)
<i>Bloc₄ NON Bloc Members</i>	-0.236 (-0.45)
<i>Constant</i>	10.949*** (3.34)
OBSERVATIONS	740
LOG-LIKELIHOOD	-1091.20
DEGREES OF FREEDOM	11
R-SQUARED	0.1814

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

Taken together, the results in Table 2.7 indicate that both the host and source countries' total wealth (measured in GDP) are estimated to have significant and positive effects on FDI. However, the population variables continue to have signs different from what is typically found, with the source country population having a significant value.

When both sector and bloc fixed effects are included simultaneously, the sector

dummy captures the difference between that sector and T&T regardless of bloc. Similarly, the bloc coefficient indicates the average of FDI from a bloc across all sectors. The sector effects estimates indicate that all the sectors are estimated to have a significantly higher share of FDI than the Telecom & Transport sector. Moreover, when keeping the EU trade bloc fixed, the EFTA and NAFTA blocs are estimated to be positively and significantly different from the EU.

One of the interesting things about the results in Table 2.7 is that the distance variable is estimated to be insignificant, although negative as in all previous regressions except for the Table 2.5 estimates. What is common with the regression in Tables 5 and 7 is that both incorporate sector specific effects. Taken together, the results for Tables 5 and 7 indicate that the distance to member countries of individual trade blocs are similar within each bloc and therefore accounted largely for by fixed trade bloc effects.

A comparison of the R-squared value in Table 2.7 to that in Table 2.3 indicates that the regression applied in Table 2.3 does a marginally better job explaining the data. Comparisons of log-likelihoods yield a similar story. However, as before, the log-likelihood ratio tests finds that this difference is not statistically significant.

2.9 Conclusion

The main objective of this chapter is to analyze whether the low Foreign Direct Investment (FDI) can be explained by the gravity model by means of market sizes and distance. The results indicate that FDI is negatively affected by distance, and generally negatively affected by the population of the host and source country, but positively affected by their Gross Domestic Products (GDPs). Taken together, these opposite signs estimates for GDP and population indicate that FDI is possibly affected by distance and wealth, rather than market size.

Estimation of sector specific effects indicates that when corrected for distance, as well as wealth and market size, multinationals have a higher incentive to invest in the "power intensive" sector, the "commerce and finance" sector, and the "other industries" sector relative to the "telecom and transport" sector. Furthermore, when compared to the EU trade bloc member countries, member countries of EFTA and NAFTA are estimated to be more interested in investing in Iceland. However, countries outside of trade blocs (non member countries) are estimated to have less incentive for investing in Iceland than the EU member countries. Finally, overall country effects estimates indicate that in most cases countries do not invest significantly less or more than the fixed country Denmark. However, out of the 17 source countries, 3 countries (Austria, Belgium and Finland) are estimated to invest significantly less than Denmark when corrected for market sizes.

An interesting topic for future research would be to analyze how foreign direct investment in Iceland is affected by factor endowments such as knowledge capital. This could better explain the driving forces of FDI, and more closely determine whether FDI tends to be vertical rather than horizontal in nature.

2.10 Appendix A. Various Regression Modifications

This appendix exhibits several variants of the gravity model specification, based on whether the dependent variable is presented in natural logarithms, or as subject to the hyperbolic sine function. Moreover, the results from taking clustering observations are also taken into account. The clusters are formed based on sectors.

The regression results in the fifth column in Table 2.8 are derived from (time series) data running over countries and years, unlike before, when sectors were used. When these are estimated, they provide results analogous with the IHS results in column three. Therefore, these results back up results for the basic IHS regression.

Table 2.8. Various Regressions of the Basic Specification

	(1)	(2)	(3)	(4)	(5)
Regressors	Cluster ihs ro- bust	ihs ro- bust	ihs	ln	New Data ihs
$\ln(Y_t)$	2.085*** (3.20)	2.085** (2.23)	2.085** (2.21)	5.375 (1.47)	3.579 (1.51)
$\ln(Y_{i,t})$	1.143** (2.25)	1.143*** (7.00)	1.143*** (7.44)	4.561*** (6.27)	3.581*** (10.69)
$\ln(N_t)$	-2.975* (-1.84)	-2.975 (-1.14)	-2.975 (-1.09)	-28.821** (-2.41)	-7.579 (-1.13)
$\ln(N_{i,t})$	-0.976** (-2.00)	-0.976*** (-6.29)	-0.976*** (-6.74)	-4.060*** (-6.14)	-3.171*** (-9.72)
$\ln(D_i)$	-0.235 (-1.55)	-0.235*** (-4.67)	-0.235*** (-3.09)	-1.273*** (-2.74)	-0.609*** (-4.08)
<i>Const.</i>	9.166*** (3.20)	9.166*** (3.32)	9.166*** (3.67)	-4.309 (-0.50)	17.471*** (2.61)
OBS	740	740	740	239	185
R-SQ	0.1028	0.1028	0.1028	0.1373	0.3710
CLUST	68				
LL		-1125.1015	-1125.1015	-539.22888	-320.5548
DoF		5	5	5	5

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

2.11 Appendix B. Investment Definitions

Here are some investment definitions by the World Bank, IMF and the OECD.

”**Foreign direct investment (FDI)** is net direct investment that is made to acquire a lasting management interest (usually 10 percent of voting stock) in an enterprise operating in a country other than that of the investor (defined according to residency). The investor’s purpose is to be an effective voice in the management of the enterprise. FDI is the sum of net equity capital, net reinvestment of earnings, net other long-term capital, and net short-term capital as shown in the balance of payments” (World Bank, 2001, CD-ROM).

”**Direct investment** is the category of international investment that reflects the objective of a resident entity in one economy (direct investor) of establishing a lasting interest in an enterprise (the direct investment enterprise) resident in another economy. ”Lasting interest” implies the existence of a long-term relationship and a significant degree of influence by the direct investor on the management of the direct investment enterprise. Direct investment involves both the initial transaction between the two entities and all subsequent capital transactions between them and among affiliated enterprises, both incorporated and unincorporated” (Falizoni, 2000, pp. 4).

”**A direct investor** is defined as an individual, an incorporated or unincorporated public or private enterprise, a government, a group of related individuals, or a group of related incorporated and/or incorporated enterprises which have a direct investment enterprise that is, a subsidiary, associate or a branch, operating in a country other than the country or countries of residence of the direct investor(s)” (Falizoni, 2000, pp. 4).

”**A direct investment enterprise** is defined as an incorporated or unincorporated enterprise in which a foreign investor owns 10% or more of the ordinary shares or voting power of an incorporated enterprise or the equivalent of an unincorporated enterprise. Ownership of 10 percent or more of the ordinary shares or

voting stock is the guideline for determining the existence of a direct investment relationship. An "effective voice in the management", as evidenced by at least 10 percent ownership, implies that a direct investor is able to influence, or participate in, the management of an enterprise; absolute control by a foreign investor is not required. Direct investment enterprises may be subsidiaries, associates and branches" (Falizoni, 2000, pp. 4).

"Foreign direct investment flows are made of three basic components:

- equity capital: comprising equity in branches, all shares in subsidiaries and associates (except non-participating, preferred shares that are treated as debt securities and are included under other direct investment capital) and other capital contributions such as provisions of machinery etc...

- reinvested earnings: consisting of the direct investors's share (in proportion to direct equity participation) of earnings not distributed, as dividends by subsidiaries or associates and earnings of branches not remitted to the direct investor.

- other direct investment capital (or inter company debt transactions): covering the borrowing and lending of funds, including debt securities and trade credits, between direct investors and direct investment enterprises and between two direct investment enterprises that share the same direct investor" (Falizoni, 2000, pp. 4-5).

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3 Chapter III. The Knowledge-Capital Model and Small Countries

3.1 Introduction

With increased data availability, empirical research on foreign direct investment (FDI) has grown as well. Among the approaches used by researches, the knowledge capital model presented by Carr, Markusen and Maskus (CMM, 2001) has moved to the forefront. The main advantage of this framework is that it is based on the theory of the multinational enterprise as discussed by Markusen (2002). In particular, this specification adds information on endowments of skilled labor to the traditional set of explanatory variables such as country size and trade costs. I apply the CMM specification to a unique panel of Icelandic FDI data and find estimates to differ considerably from those found by CMM and other researchers. In particular, my results for the skill labor measures run contrary to earlier findings. These results may be due to differences between the large country data used by other researchers, or that the CMM specification encounters data difficulties when there is a lot of difference in source and host country gross domestic products. Also, as explored in chapter four of this dissertation, they may arise from the omission of factor endowments important in the Icelandic economy such as energy or fishing stock.

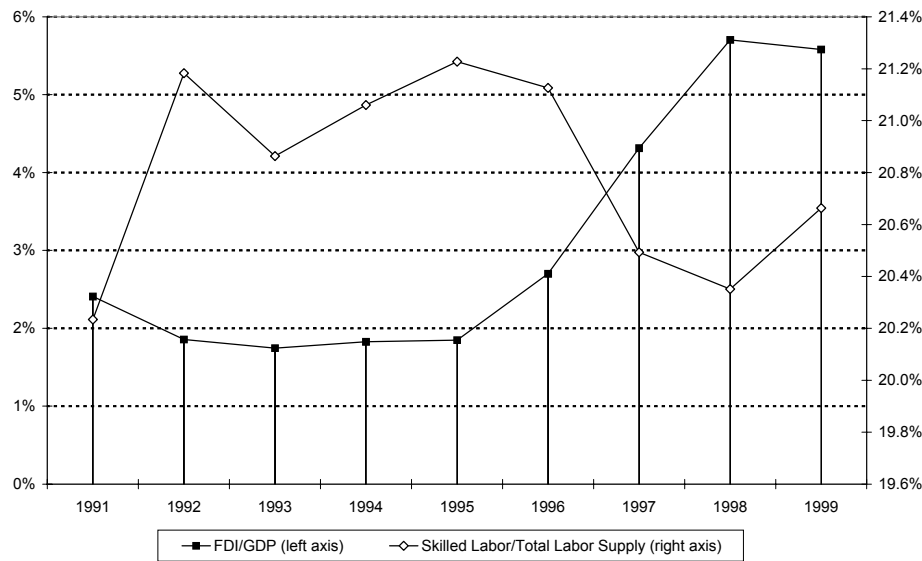
Multinational enterprises are firms that engage in activities transnationally, either by establishing subsidiaries or directly investing in foreign firms. The functionality of directly investing in foreign firms has been referred to as foreign direct investment in those cases where MNEs have a controlling stock in firms. Normally, a controlling stock refers to the interest in acquiring a lasting management interest ownership of 10% or more in a firm. This type of international capital investment has often been referred to as greenfield investment, or mergers and acquisitions. In this chapter, the issue of concern is FDI stock in Iceland. This is measured as gross FDI and is equal to the total amount of FDI coming into Iceland, without subtracting outward FDI.

The general belief is that the flow of foreign direct investment is primarily from

North to South, in other words, from the industrialized countries of the ‘North’ to the less developed world in the ‘South’. This is however not the case since most of FDI takes place between the more developed countries and therefore the flow of FDI is primarily between the East and West, rather than from North to South. In 1999, the developed countries accounted for 74% of world FDI inflows and 91% of outflows, whereas the developing countries accounted for 24% of world inflows and 8% of outflows. The Central and the Eastern European countries accounted for only 1% of world FDI inflows (Markusen, 2002, pp. 9).

Figure 3.1 shows the development of two ratios in Iceland: the FDI/GDP ratio and skilled labor as a ratio of total labor supply. More specifically, the skilled labor is measured as “professional, technical, kindred, and administrative workers” classified as the sum of occupational categories 0/1 and 2 by the International Labor Organization (ILO). The relationship between the two ratios appears to be inverse, however the observations for skilled labor supply on the right side axis only vary over a narrow range. Since skilled labor is a key variable in other FDI studies, one of the main objectives of this chapter is to analyze the relationship between skilled labor and FDI in Iceland. This will be done in order to determine how FDI is affected by skilled labor in small countries like Iceland, relative to other countries.

Figure 3.1: Development of FDI Stock and Skilled Labor in Iceland.



Source: World Bank, Central Bank of Iceland and the ILO.

Foreign direct investment is said to be horizontal when multinationals operate analogous corporate activities in different countries. A typical example of that would be a company like McDonald's. Generally, horizontal FDI is likely to take place between the developed countries of similar size and relative endowments. FDI is said to be vertical when multinationals place corporate facilities in different countries; this is often done to exploit differences in factor prices by gaining access to cheap raw materials.

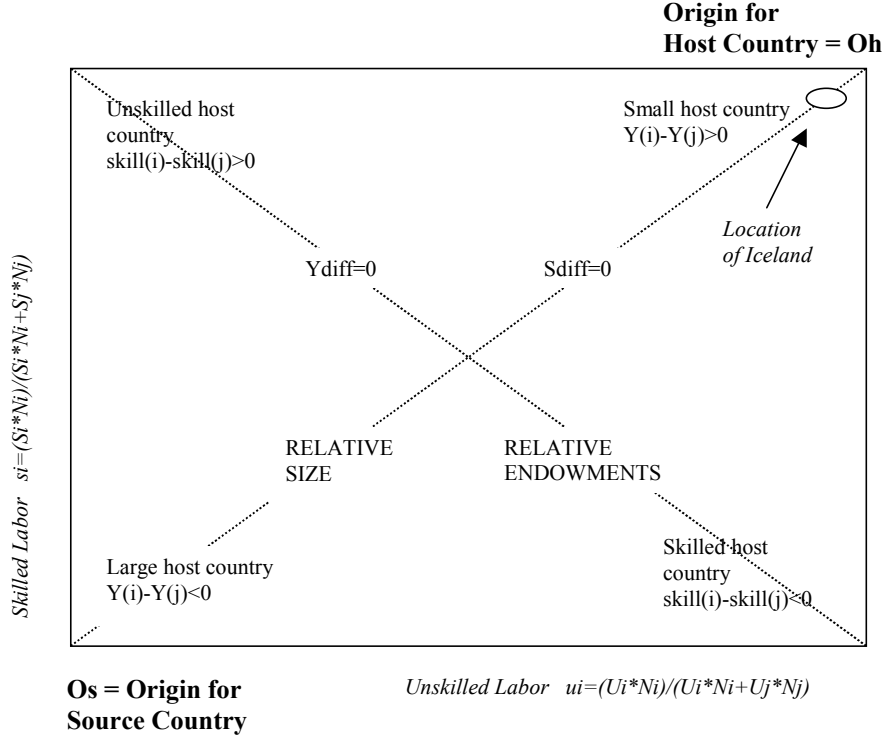
The literature on multinational enterprises and foreign direct investment is relatively recent. The models on horizontal FDI by Markusen (1984) and vertical FDI by Helpman (1984) have been widely used when explaining FDI. In a paper combining the main features of the vertical and horizontal models, Markusen, Venables, Konan, and Zhang (1996) laid the basis for the Knowledge-Capital (KK) model. The KK model draws its name from the fact that intangible assets such as human capital are sometimes referred to as knowledge-capital. One of the main features

of the KK model is that it explains how investment decisions of multinationals are affected by the difference of skilled-labor in the source and host country. Further research by Carr, Markusen, and Maskus (CMM, 2001) presented an empirical specification of the model, hereafter referred to as the CMM specification. CMM (2001) tested their econometric specification on a sample representing bilateral activities of US multinationals in a range of countries. However, the KK model has not yet been tested for small economies such as Iceland. Iceland is not only an interesting case because of its small size and how distant it is from other countries, but also because it is generally believed to be relatively skilled-labor abundant.

CMM (2001) observe FDI to be strictly increasing in the skill differences between the source and the host country. However, more recent estimates obtained by Blonigen, Davies, and Head (2003) indicate that FDI is increasing in negative skill differences, but decreasing in positive skill differences. Blonigen et al. estimates indicate that a relative increase in source skillness compared to host will increase FDI in cases when source is more skilled than host, but decrease FDI in cases when host is more skilled than source. They therefore conclude that the Markusen (1984) model capturing horizontal motives for FDI cannot be rejected in favor of the KK model. In a more recent paper, Davies (2003) estimation results indicate that FDI is increasing in negative skill differences, decreasing in slightly positive skill differences, and increasing again as skill differences become more highly positive. Finally, Braconier, Norbäck, and Urban (2003) report that they find support for the KK model, basing their estimates on a much richer database on factor prices than used in comparable studies. They conclude that in previous studies, the mapping from theory to empirics has suffered from a poor data coverage.

Figure 3.2 exhibits an Edgeworth Box based on the theory behind the Knowledge-Capital model. The idea behind this box is to relate the countries' size to their relative endowments. Being a small host country, Iceland is expected to be positioned in the northeast corner of the Edgeworth Box. In the northeast corner, the difference between the source and the host countries GDPs is positive given that the host country is much smaller than the source country.

Figure 3.2: World Edgeworth Box



Moreover, since Iceland is generally believed to be well endowed with skilled labor, it is presumed to be in the northeast corner on the SW-NE diagonal in the Edgeworth Box. This is due to the fact that on the east side of the diagonal, the host country is better endowed with skilled labor relative to the source country. However, actual data on job categories indicate that Iceland is not necessarily more skill abundant relative to the source countries. Therefore, Iceland appears to be located farther to the northeast than host countries used in empirical studies generally are, and on both sides of the SW-NE diagonal. The location of Iceland as a host country is better exhibited in Figures 3.4 and 3.5 in Appendix A.

This chapter is based on unilateral data of inward FDI stock in Iceland. The approach to the use of unilateral data on FDI is somewhat similar to a paper by

Markusen and Maskus (1999) on outward FDI. Another analogous example would be Brainard (1997), in which she estimated separately inward and outward FDI proxies by shares of total foreign sales. The data in this chapter cover foreign direct investment in Iceland from 1989 to 1999. The data are unique in that they have not been used before, and so is the approach in the sense that it has never before been applied to such a small country. Therefore, it is of particular interest to analyze how the CMM specification of the KK model applies to Iceland, and to consider the theoretical intuition behind the results. Several variations of the CMM specification are also estimated, including the Davies (2003) specification.

This chapter is organized as follows. Section 3.2 includes a literature review and the model specification. Data are presented in Section 3.3. Section 3.4 provides estimation results for some specification restrictions. Section 3.5 gives an overview of the impacts from removing large outliers from the sample. Section 3.6 shows the results from increasing the number of observations, whereas Section 3.7 examines the effects of changing the skilled-labor abundance proxy. In Section 3.8, the results from applying the Davies (2003) empirical specification are reported. Finally, conclusions are presented in Section 3.9.

3.2 The KK Model

3.2.1 Related Literature

In the beginning of the 1980s, the so-called “New Trade Theory” was added to the conventional international economic literature. Models of the New Trade Theory incorporate imperfect competition, increasing returns to scale, and product differentiation in both general and partial equilibrium models of trade (CMM, 2001, pp. 693). An important contribution to the literature was made by Paul Krugman in 1979. Later, the literature on Economic Geography developed, beginning again with Krugman (1991) explaining industry agglomeration within regions and countries.

There has been a growing literature on foreign direct investment made by multinational enterprises. Until recently, foreign direct investment has mainly been incorporated into two general-equilibrium models. These are the model on vertical FDI presented by Helpman (1984) and the model on horizontal FDI by Markusen (1984). FDI is said to be vertical when MNEs choose to facilitate their operations in different geographic locations depending on the stage of production. However, horizontal FDI takes place when MNEs locate analogous activities in different countries⁶⁶. In Helpman’s (1984) model, the incentive for vertical FDI is the difference in relative factor endowments. On the other hand, Markusen (1984) assumes that FDI is dominated by horizontal MNEs when countries are similar in size as well as in relative endowments, and trade costs are moderate to high⁶⁷. The main features of the horizontal and vertical models are combined in the Knowledge-Capital (KK) model of the multinational in the paper by Markusen, Venables, Konan, and Zhang (1996). In addition, an econometric specification of the KK model was introduced by Carr, Markusen, and Maskus (CMM, 2001). Different empirical specifications of the KK model have been developed by Bloningen, Davies, and Head (BDH, 2003) as well as Davies (2003).

⁶⁶More related literature on multinational firms can be found in Markusen (2002).

⁶⁷Aggregate data has shown the developed countries to be the main source as well the main recipient countries of foreign direct investment (Markusen, 2002).

By using an empirical specification slightly different from that of CMM and running regressions on subsamples of the data, BDH find evidence for a decrease in FDI when skill differences are positive and increasing. Therefore, BDH conclude that the horizontal model by Markusen (1984) cannot be rejected in favor of the KK model⁶⁸. An alternative empirical specification of the KK model is put forward by Davies (2003)⁶⁹. The specification applied by Davies finds FDI not to be strictly decreasing in positive skill differences, but that the relationship is non-monotonic. Davies therefore finds evidence supporting the KK model. Finally, Braconier, Norbäck, and Urban (BNU, 2003) test the CMM specification with a much richer dataset than has been used in earlier research. The results they observe from using the CMM specification are found to yield results much like the simulations in the CMM paper. BNU therefore conclude that strong support is found for the KK model. More specifically, by using data on factor prices instead of endowments, they find support for the CMM specification of the KK model. The findings obtained earlier give a motivation to analyze how the CMM specification of the KK model predicts for small countries.

⁶⁸Estimates obtained for the horizontal model indicate that FDI is decreasing in positive skill differences.

⁶⁹In his paper, Davies (2003) finds that while horizontal FDI is decreasing in positive skill differences, vertical FDI is increasing.

3.2.2 Theoretical Framework of the KK Model

The idea behind the CMM (2001) paper on the KK model is to translate trade theories into simulations⁷⁰ relating foreign direct investment to economic size and relative endowments. The paper is referred to by authors as the knowledge-capital model of the multinational enterprise. In the paper the authors apply industrial organization approach to international trade allowing for determination of how industry characteristics interact with country characteristics.

The knowledge-capital model specification estimated here is primarily based on three assumptions⁷¹. The first assumption implies that it is possible to geographically separate services referred to as knowledge-based and knowledge-generating activities from production. These would be services like research and development. Moreover, this first assumption implies that it is cheap to supply these services to production facilities. The second assumption is that knowledge-demanding activities require relatively a lot of skilled labor. Together, the first and second assumption allow⁷² for vertical activities, implying that R&D are located where skilled labor is available at low cost, but production location favored close to cheap unskilled labor. Production is also drawn to locations where firms can exploit economies of scale in production plants. The third main assumption implies that the type of services defined in the first assumption can be used simultaneously in various locations. The third assumption allows for scale economies at firm level and gives an incentive for horizontal multinational activity, implying production in different geographical locations.

The model is based on a world with two countries, two factors and two goods. The countries are here referred to as source and host⁷³. The two factors are internationally immobile factors, skilled and unskilled labor. The two goods in the

⁷⁰The numerical simulation procedure applied in the CMM (2001) paper is better demonstrated in Markusen et al. (1996) and Markusen (1997).

⁷¹See more on the KK model in (CMM, 2001, pp. 694) and in (CMM, 2003).

⁷²"allow" rather than "induce" is used for "create a motive for"...

⁷³The countries are either referred to as source and host or as home and foreign, the latter labelling is applied in the CMM (2001) paper.

model are labelled x and y , and are different in nature. The characteristics of good x are such that x is skilled-labor intensive and enjoys increasing returns to scale (IRS) under the conditions of Cournot competition, with the possibility of having individual plants geographically separated from headquarters. However, the second good y , is subject to constant returns to scale (CRS) and is labor-intensive.

In this model structure there are six firm types and the model allows for free entry and exit in and out of firm types. Firms are either horizontal, vertical or national. The horizontal multinationals H_h (H_f) are firms producing in the source and host country, with headquarters in the source country. The national firms N_h (N_f), are firms with headquarters and production in the source (host) country only, which may export to the other country. Vertical multinationals V_h (V_f), are those with single plant in the host and headquarters in the source country, with export possible to the source country.

The assumptions presented in the knowledge-capital model drawn from Markusen and Venables (1986) paper and Markusen (1987) are that horizontal multinationals H_h will be dominant in the source country if source and host are similarly endowed and similar in size, and trade costs are moderate or high. However, vertical multinationals V_h will be dominant in the source country in cases when source is small, relatively skilled labor abundant and trade costs are not extreme. Finally, national firms N_h will be dominant under conditions where source is large and skilled labor abundant, source and host are of similar size and similarly endowed and trade costs are low, or in cases where barriers to foreign direct investment are high in the host country.

The simulation results obtained for the KK model allow for development of predictions about volume of production of various firm types. In the empirical regressions estimated in the following sections, the two countries are labelled as source and host, referring to the citizenship of a particular multinational.

3.2.3 The Basic Empirical Specification Applied

The KK model is primarily based on the assumptions of Economic Geography, since the model balances closeness to consumer markets with market size to achieve economies of scale (Krugman, 1983; Horstman and Markusen, 1992; Brainard, 1993). In the model, closeness to consumers is proxied by distance, and market size is proxied by GDP. The KK model is also based on the foundations of the Heckscher-Ohlin theorem⁷⁴ by applying the *factor proportions hypothesis* when using skill differences as a proxy for differences in relative factor endowments.

$$\begin{aligned} FDI_{ij,t} = & \beta_0 + \beta_1 YSUM_{ij,t} + \beta_2 YDIFF_{ij,t}^2 + \beta_3 SDIFF_{ij,t} \\ & + \beta_4 YDIFF_{ij,t} * SDIFF_{ij,t} + \beta_5 INVC_{j,t} + \beta_6 TC_{j,t} \\ & + \beta_7 TC_{j,t} * SDIFF_{ij,t}^2 + \beta_8 TC_{i,t} + \beta_9 DIS_{ij} + \varepsilon_{ij,t} \end{aligned} \quad (3.1)$$

The basic model specification estimated in this chapter is introduced in Equation (3.1). In the equation above, the following relationship holds: $E[\varepsilon_{i,t} | x_{i,t}] = 0$ which means that the error term ($\varepsilon_{i,t}$) is independent of the explanatory variables ($x_{ij,t}$). A more careful description of the variables in the model is provided in Table 3.1 below.

In this chapter, a Tobit procedure is also used, and here this procedure implies a threshold with a lower limit of zero, so that⁷⁵ the following holds

$$\begin{aligned} FDI_{ij,t}^{TOBIT} &= FDI_{ij,t} \text{ if } FDI_{ij,t} > 0 \\ FDI_{ij,t}^{TOBIT} &= 0 \text{ if } FDI_{ij,t} \leq 0 \end{aligned} \quad (3.2)$$

The dependent variable $FDI_{ij,t}$ is defined as foreign direct investment going from country (i) to country (j) at time (t). More specifically, FDI is measured as stock of

⁷⁴The proposition of the Heckscher-Ohlin Model implies that countries will export goods that use relatively intensively their relatively abundant factors.

⁷⁵James Tobin (1959).

investment⁷⁶. This variable measures the FDI made in the host country by various source countries over time. The subscript (i) denotes the source country, running from 1 to 23, the subscript (j) refers to the host country Iceland, and time is denoted by (t). The first two explanatory variables, $Y_{SUM_{ij,t}}$ and $Y_{DIFF_{ij,t}}^2$ are inserted to represent economic size and size differences. The first variable, $Y_{SUM_{ij,t}}$, accounts for the joint market size of host and source countries, proxied by the sum of the countries' GDP. Here $Y_{SUM_{ij,t}}$ is used to represent the aggregate economic size of the source and host country, since investment is expected to increase with the size of the host and source countries. More FDI is expected to take place between large economies, and therefore the variable coefficient is expected to have a positive sign. The second explanatory variable, $Y_{DIFF_{ij,t}}^2$ is defined as the GDP of the source country minus the GDP of the host country, squared. The squared economic size difference is used here rather than plain difference to reflect the absolute difference in the size of the countries. $FDI_{ij,t}$ is expected to decrease with an increase in squared size differences, and therefore the $Y_{DIFF_{ij,t}}^2$ coefficient is expected to be negative. This is true because FDI is expected to be increasingly trending downward as a function of $Y_{DIFF_{ij,t}}$. More specifically, the $Y_{DIFF_{ij,t}}^2$ term is symmetric around zero. From there it follows that $FDI_{ij,t}$ is biggest around the zero point, but decreases on either side of zero. This term is included to capture horizontal FDI, since horizontal FDI is believed to decrease as the source and host country become dissimilar in size.

The $S_{DIFF_{ij,t}}$ variable is included in the model specification to capture differences in skilled labor endowments between the source and host country. $FDI_{ij,t}$ is expected to increase as skill differences increase, that is when the source country becomes more skilled than the host country. Therefore the $S_{DIFF_{ij,t}}$ variable is expected to have a positive sign. Horizontal investment is expected to be the greatest between equally skilled countries; that is, when skill differences between the source and the host country are zero.

⁷⁶The Central Bank of Iceland defines foreign direct investment (FDI) as solely investment in business activities, not including investment in real estate.

Table 3.1. Variable Definition for the Basic Sample

Variable		Predicted signs
$FDI_{ij,t}$	Foreign direct investment made by the source country (i) in the host country (j), over time (t).	
$YSUM_{ij,t}$	The sum of the Gross Domestic Product (GDP) of the source country (i) and the GDP of the host country (j), over time (t).	+
$YDIFF_{ij,t}^2$	The GDP of the source country (i) minus the GDP of the host country (j), squared over time (t).	—
$SDIFF_{ij,t}$	Skilled labor in the source country (i) minus skilled labor in the host country (j), over time (t).	+
$YDIFF_{ij,t}*SDIFF_{ij,t}$	Interaction term, capturing the interaction between the GDP difference of the source and host countries and the skill difference variable, over time (t).	—
$INVC_{j,t}$	The investment cost foreign investors are faced with when investing in the host country (j), over time (t).	—
$TC_{j,t}$	Trade costs in the host country (j), over time (t).	+
$TC_{j,t}*SDIFF_{ij,t}^2$	Interaction term, capturing interaction between trade costs in the host country and squared skill differences, over time (t).	+
$TC_{i,t}$	Trade cost in the source country (i), over time (t).	—
DIS_{ij}	Geographical distance between the source country (i) and the host country (j).	—

The interaction term $YDIFF_{ij,t}*SDIFF_{ij,t}$ is included in the model to account for interaction between $YDIFF_{ij,t}$ and the differences in skilled labor endowments, $SDIFF_{ij,t}$. The interaction term is intended to reflect how much skill differences $SDIFF_{ij,t}$ matter, depending on where countries are located in the Edgeworth box. In other words, the idea is that the interaction term captures the importance of differences in the level of skilled labor in the source and host country, depending on how much they differ in size. Skill differences between similarly sized countries are not expected to weigh as much as those between dissimilarly sized countries. Therefore, FDI is expected to decrease with an increase in $YDIFF_{ij,t}$, yielding a negative expected coefficient.

The variable $INVC_{j,t}$ capturing investment costs, is used as a proxy for investment barriers facing investors entering the host country. The $INVC_{j,t}$ variable is an index calculated from a range of other indices. The investment cost index runs from zero

to 100 with higher numbers indicating higher investment costs. An increase in the investment costs variable in the host country is expected to reduce inward FDI and therefore the investment cost has a negative predicted coefficient. The two indices for trade costs are intended to reflect the protectionist stance of each country's trade policy. More specifically, trade costs are defined as national protectionism accounting for whether foreign products and services are prevented from being imported. Therefore, as the value of the variable representing trade costs $TC_{j,t}$ increases, the host country (Iceland) is more prone to prevent foreign products and services from being imported. This also applies to the trade costs index calculated for source countries, the $TC_{i,t}$ index. Higher trade barriers in the host country are expected to aid $FDI_{ij,t}$, since MNEs in the source countries have more incentives to invest in, rather than export to, a host country with high trade barriers. Higher trade barriers in the source country, $TC_{i,t}$, are expected to reduce FDI. This is because higher trade barriers in the source country are believed to reduce the source country's incentives to invest in the host country in order to export back home. Therefore, the coefficient of the latter trade variable is expected to be negative.

Moreover, the interaction between trade and skill differences is captured by an interaction term, $TC_{j,t} * SDIFF_{ij,t}^2$, which is expected to have a positive coefficient sign. The coefficient sign is expected to be positive since it represents the effects of skill differences changes on the marginal effect of host trade costs on FDI. As mentioned before, FDI is expected to increase with an increase in trade cost in the host, since the MNEs have more incentive to invest in the host rather than export to the host. The interaction term indicates that the squared skill term magnifies the effects of the host's trade cost, which increase its marginal effects. Furthermore, a geographical distance variable, denoted as DIS_{ij} , is included to reflect proximity to customers. The distance variable is expected to have a negative coefficient. The use of distance as a proxy for transport costs is well established in the gravity model by Bergstrand (1985).

3.3 Data

The data used in this chapter cover overall foreign direct investment (FDI) in Iceland over the 1989-1999 period. The following countries are the source countries of foreign direct investment: Austria, Australia, Belgium, Canada, Chile, Denmark, Faeroe Islands, Finland, France, Germany, Gibraltar, Israel, Japan, the Netherlands, Norway, Latvia, Luxembourg, Russian Federation, Spain, Sweden, Switzerland, the United Kingdom and the United States. The data on FDI are obtained from the Central Bank of Iceland.

Foreign direct investment, $FDI_{ij,t}$, is measured as inward FDI, in millions of US dollars at 1995 prices. Here the accumulated stock of FDI is used rather than flows, since FDI stocks are generally believed to carry information about investment incentives from the past to the present, i.e. accumulated changes in investment up to the current year. In their paper, CMM use affiliate sales. However, FDI stock is used here since it is believed to better reflect long-term strategies of MNEs. Similar to FDI flows, affiliate sales are subject to short-term, rather than long-term objectives of MNEs operations. Advantages of using FDI stock, rather than affiliate sales, are well explained in a paper by Davies (2002).

The FDI stock data used are obtained in millions of Icelandic Kronur and converted to US dollars using the World Bank dollar exchange rate, and then put on a 1995 level by a World Bank GDP deflator. Thus, the FDI values become comparable to the variable values on the right-hand side of the model, since the host and the source country GDP values are obtained in 1995 US dollars.

Data for the first two explanatory variables, $YSUM_{ij,t}$ and $YDIFF_{ij,t}^2$, are based on the host and source countries' GDP, taken from the World Bank data base⁷⁷. These GDP data are obtained from the World Bank in constant 1995 USD values, but the variables are presented in trillions⁷⁸ of USD. Data on GDP in Germany in 1989

⁷⁷With the exception of data on GDP in the Faeroe Islands being obtained from the National Economic Institute of Faeroe Islands (Hagstova Føroya). The GDP data is obtained in Danish kronur and then converted into 1995 US dollars, using IMF exchange rate and a World Bank GDP deflator.

⁷⁸Trillion is defined as a million million.

and 1990 are not included here because these are the years before the unification of Germany.

The data used for the skilled labor endowments, $SDIFF_{ij,t}$, are identical to those used by CMM⁷⁹. These data are obtained from the International Labor Organization (ILO)⁸⁰ as the sum of occupational categories 0/1 and 2; where category 0/1 accounts for professional, technical, and kindred workers, and category 2 for administrative workers. Moreover, the skilled labor ratio is calculated as the sum of categories 0/1 and 2, divided by the sum of all occupational categories. The skilled labor ratio is used as a proxy for relative skilled labor abundance. The ILO data on skilled-labor in Iceland are available for the nine-year period, 1991-1999.

The indices for trade and investment costs are calculated in the same way as in the CMM paper⁸¹. The data used for the $INVC_{j,t}$ index here are also analogous to the data used in the CMM paper⁸². The index for investment costs is calculated using the following indices: restrictions on the ability to acquire control in a domestic company, limitations on the ability to employ skilled labor, restraints on negotiating joint ventures, strict controls on hiring and firing practices, the absence of a fair administration of justice, difficulties in acquiring local bank credit, restrictions on access to local and foreign capital markets, and inadequate protection of intellectual property. The resulting investment index runs on a scale from zero to 100, with a higher number indicating higher investment costs. The trade costs variable of the host country is presented as $TC_{j,t}$, while the source country trade

⁷⁹I greatly appreciate that David Carr and Keith Maskus provided me with the data used in the (CMM, 2001) paper on the KK model.

⁸⁰As in the case of CMM, data on skilled labor are taken from the ILO, *Yearbook of Labor Statistics*.

⁸¹The data on investment are obtained from a survey made by the World Competitiveness Report (WCR) on internationalization of countries. The values used are obtained by subtracting the original values in the report from 10 and then multiplying them by 100. This is done to make the values consistent with the investment cost index, with higher values representing higher barriers. As mentioned earlier, the investment cost is composed of a simple average of 9 individual indices. The simple average is then multiplied by 10 and subtracted from 100 as in the case of the trade cost index. Both of the cost indices run from 0 to 100, with 100 the highest possible barrier.

⁸²The only exception is that the index accounting for "market dominance" is not included in the investment index due to lack of data.

costs are represented as $TC_{i,t}$.

As Table 3.2 shows, the number of observations for the investment cost $INVC_{j,t}$ and the trade cost $TC_{j,t}$ in the host country are limited to 115, since the data are only available from the World Competitiveness Report from the period 1995 - 1999. However, for most of the source countries trade cost data are obtainable for a longer period.

Table 3.2. Summary Statistics for the Basic Sample

Variable	Units	Obs	Mean	Std. Dev.	Min	Max
$FDI_{ij,t}$	Million USD	253	9.39	24.82	-0.33	159.52
$YSUM_{ij,t}$	Trillion USD	240	0.97	1.78	0.01	8.59
$YDIFF_{ij,t}$	Trillion USD	240	0.96	1.78	-0.008	8.57
$YDIFF_{ij,t}^2$	Trillion USD	240	4.09	12.32	7.43e-7	73.51
$SDIFF_{ij,t}$	Index [-1,1]	155	0.03	0.06	-0.08	0.14
$SDIFF_{ij,t}^2$		155	0.004	0.005	9.57e-10	0.02
$YDIFF_{ij,t} * SDIFF_{ij,t}$		155	0.04	0.21	-0.27	1.11
$INVC_{j,t}$	Index [0,100]	115	33.01	1.92	29.92	35.28
$TC_{j,t}$	Index [0,100]	115	48.18	3.81	43.70	52.50
$TC_{j,t} * SDIFF_{ij,t}^2$		83	0.16	0.23	2.0e-5	0.85
$TC_{i,t}$	Index [0,100]	215	28.61	11.66	5.30	64.80
DIS_{ij}	Kilometers	253	3,899	3,600	450	16,609

Sources: World Bank, IMF, ILO, World Competitiveness Report, Central Bank of Iceland, National Economic Institute of Faeroe Islands, Distance Calculator, David Carr and Keith Maskus.

Table 3.2 provides summary statistics for the basic sample. As shown, the dependent variable $FDI_{ij,t}$ is measured in millions of USD, rather than trillions of USD, like the $YSUM_{ij,t}$ and $YDIFF_{ij,t}^2$ variables. This was done since the amount of FDI is considerably lower than the economic size of the source countries. What is also noteworthy in Table 3.2 is that $FDI_{ij,t}$ has a negative minimum value of USD -0.33 million, which represents the FDI made by France in Iceland in 1989. A total of five observations were found to be negative⁸³, but FDI stock can become

⁸³In the case of France and the Faeroe Islands.

negative if FDI flows become negative within that year. This might be the case if, for example, a dividend payment from the host country to the source country is higher than the investments made in a particular year.

As can be seen in Table 3.2, the number of observations is highest for FDI, with a total of 253 observations. The data provide full information on FDI, and the data are almost balanced for other variables. As explained earlier, the investment and trade cost samples are the most limited in size, including data running over five years from 1995 to 1999. As a result, the number of observations for the interaction term, $TC_{j,t} * SDIFF_{ij,t}^2$ is low, i.e. a total of 83 observations. The reason for the low number of observations for the interaction term is because the $TC_{j,t}$ and $SDIFF_{ij,t}^2$ variables do not overlap in all years. Furthermore, there is a balanced database on distance. Distance, DIS_{ij} , is measured in kilometers⁸⁴ between the capitals of the host and the source countries. FDI is expected to decrease as the source countries become more distant and the coefficient sign is therefore expected to be negative.

Finally, the new skill proxy in Section 3.9, measuring education, or "School enrollment, secondary (% gross)" is obtained from the World Bank indicators.

The regressions presented in following sections are estimated by the OLS or the Tobit estimators (Greene, 1997), and all regressions are obtained using STATA version 7.0.

⁸⁴The data on distance were obtained from the Distance Calculator (2000).

3.4 Estimation Results

3.4.1 The Econometric Specification Estimated

The basic CMM empirical specification is first estimated with two different estimation procedures, OLS and Tobit. The main differences between these two procedures is that Tobit accumulates all negative observations around zero⁸⁵, while OLS includes all observations regardless of their value. More specifically, Tobit is a censoring procedure that allows us to set upper and lower limits on the regression data. Here the lower limit is zero. Therefore, the Tobit procedure can be regarded to act as a robustness check for OLS.

The OLS regression results for the KK model are shown in Table 3.3 along with Tobit estimates⁸⁶. Although the coefficients vary in size, the estimates obtained are analogous for both regressions, having coefficients with the same signs. However, as shown in Table 3.3, most of the time the signs for both regressions are opposite of what is predicted by the CMM empirical specification. Even though the coefficient signs often differ from what is expected by CMM, it appears the results are in line with what could be expected for a small country like Iceland. That is, it should not be surprising that the CMM empirical specification predicts differently for small countries than larger ones. Being a small host country, Iceland is likely to be positioned in the northeast corner when considering the Edgeworth Box in Section 3.1, Figure 3.2.⁸⁷

⁸⁵Thus, values lower than zero are set as zero and used as such for the regression estimates.

⁸⁶For the Tobit estimates to be consistent, the error terms need to be normally distributed. However, even if the Tobit estimates do not provide as reliable results as the OLS estimates, they tell the same story since the coefficients are analogous in signs and magnitude.

⁸⁷The Figure 3.2 surface chart in the (CMM, 2001) paper gives a clearer indication of the landscape with which a small host country is faced, being in the northeast corner of the box.

Table 3.3. The Basic CMM Specification

Regressors	OLS	Are signs as predicted by the CMM specification?	Tobit	Are signs as predicted by the CMM specification?
YSUM _{ij,t}	-20.426*** (-2.77)	No	-19.177 (-1.45)	No
YDIFF _{ij,t} ²	3.193*** (2.65)	No	3.293 (1.37)	No
SDIFF _{ij,t}	61.994 (0.57)	Yes	39.596 (0.21)	Yes
YDIFF _{ij,t} *SDIFF _{ij,t}	28.173 (0.82)	No	13.476 (0.22)	No
INVC _{j,t}	-0.274 (-0.07)	Yes	-0.794 (-0.21)	Yes
TC _{j,t}	-0.731 (-0.38)	No	-1.353 (-0.69)	No
TC _{j,t} *SDIFF _{ij,t} ²	-45.758* (-1.72)	No	-32.718 (-0.75)	No
TC _{i,t}	0.798 (1.36)	No	0.845* (1.81)	No
DIS _{ij}	-0.003*** (-2.99)	Yes	-0.004* (-2.92)	Yes
CONSTANT	62.421 (0.94)		107.114 (1.39)	
TOTAL OBS.	78		78	
LEFT CEN. OBS.			15	
UNCEN. OBS.			63	
PSEUDO R-SQ. ⁸⁸			0.044	
R-SQUARED	0.32			
LOG-LIKELIHOOD			-323.30	

Note: Robust t-statistics are in parentheses below the coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

The first two variables have coefficient signs opposite to what is predicted by the CMM empirical specification of the KK model. The interpretation of countries' interactions in the Edgeworth Box⁸⁹ is that as countries i and j become dissimilar

⁸⁸It is not possible to calculate R squared for a non-linear model like the Tobit model, because R squared is designed for linear models. Therefore the so-called "Pseudo R squared" is calculated for the Tobit model. Pseudo R squared indicates how the model fits the data, but is not an R squared in the general sense.

⁸⁹For example, see Figures 1 and 2 in the CMM paper.

in size, $FDI_{ij,t}$ decreases. This happens as we move towards either the SW or the NE corner of the box. In our case, it can be thought of as if we are moving towards the NE corner over time. This occurs when the sum of GDPs ($Y_{SUM_{ij,t}}$) increases, which occurs mainly due to an increase in the GDP size of the source country (i).⁹⁰ As the source country becomes increasingly larger than the host, it corresponds to a movement along the diagonal towards the NE corner.

This needs not to be surprising, since along with an increase in the country size differences, we can expect overall FDI to decrease.⁹¹ This is also in line with the coefficient of the $Y_{SUM_{ij,t}}$ variable being negative, whereas it was expected to be positive in the CMM paper.

A similar story holds for the second variable in the KK model, $Y_{DIFF_{ij,t}}^2$, which captures squared GDP differences. However, this variable estimates simultaneous movements to either the SW or the NE corner, since it is squared. Here it appears that within the Edgeworth box, the movement towards the SW corner outweighs the movement towards the NE corner, resulting in a positive coefficient.

The variable measuring skill differences, $S_{DIFF_{ij,t}}$, is estimated to have a positive coefficient. This was also predicted by the CMM empirical specification of the KK model. This is logical, since we expect FDI to increase as we move towards the SW corner of the Edgeworth Box.⁹² The $S_{DIFF_{ij,t}}$ coefficient sign obtained in Table 3.3 is positive but far from being significant. Therefore we do not find clear evidence for the CMM empirical specification on the basis of results from Table 3.3.

The sign of the interaction term, $Y_{DIFF_{ij,t}} * S_{DIFF_{ij,t}}$, is estimated to be negative. The sign of the investment cost variable $INVC_{j,t}$ is as could be expected. That is, FDI decreases as the investment cost in the host country increases. The variable $TC_{j,t}$ has a negative coefficient, however the test is inconclusive since the coefficient is insignificant. However, in the CMM paper, the substitutional effects

⁹⁰ An analogous case where the data mainly reflect variations in the host country's GDP can be found in a paper by Markusen and Maskus (1999). In that case the source of data is outward FDI from the US.

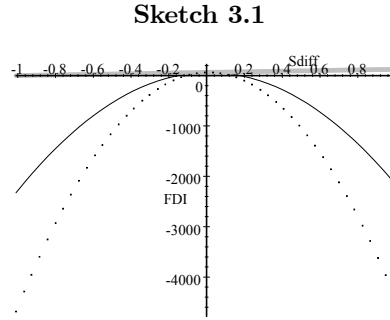
⁹¹ See Figure 2 in the CMM (2001) paper.

⁹² More specifically, the relationship between FDI and skill differences is shown in the first graph, identified as by CMM (2001) in Figures 3.3 and 3.4 in Section 3.10.

between trade and FDI seem to outweigh the complementary effects, indicating a predominance of horizontal FDI, since the $TC_{j,t}$ variable has a positive rather than a negative sign. The term $TC_{j,t} * SDIFF_{ij,t}^2$, which captures the interaction between skill difference and trade costs, has a negative sign, indicating FDI to be vertical rather than horizontal. On the contrary the trade cost coefficient in the source country $TC_{i,t}$, is positive, implying that higher trade barriers in the source country. Finally, the distance variable, DIS_{ij} , is estimated to have significantly negative impacts on FDI, as could be expected. This means that FDI decreases as distance increases. More specifically, the marginal relationship can be described such that a positive marginal change (in the mean value) of distance would have negative marginal effects on foreign direct investment.

3.4.2 Interpretation of Coefficient Estimates

When determining the interpretation of the coefficient signs and magnitude of individual variables, it is possible to explain the relationship by looking at the graphical relationship between the dependent variable and the explanatory variables.



Let us start by looking at the relationship between $FDI_{ij,t}$ and $SDIFF_{ij,t}$ as described in Sketch 3.1. In Sketch 3.1, three possible scenarios of the relationship between $FDI_{ij,t}$ and $SDIFF_{ij,t}$ is exhibited. These are the following:

	YDIFF _{ij,t}	TC _{j,t}	MODEL SPECIFICATION
Case 1	1	100	$62.421 + 90.167\text{SDIFF}_{ij,t} - 4,575.8\text{SDIFF}_{ij,t}^2$ (3.3)
Case 2	0	50	$62.421 + 61.994\text{SDIFF}_{ij,t} - 2,287.9\text{SDIFF}_{ij,t}^2$ (3.4)
Case 3	0	0	$62.421 + 61.994\text{SDIFF}_{ij,t}$ (3.5) ⁹³

In Sketch 3.1, Case 1 is represented by the *pointed line*, Case 2 with a *thin line*, and the Case 3 with a *thick line*.

The results shown in Sketch 3.1 are in line with the results of the BDH empirical specification, that support the horizontal model. That is, FDI is the highest when skill differences are close to zero. This is in line with the model on horizontal FDI, in that it predicts that FDI is the highest when skill differences (SDIFF_{ij,t}) are close to zero, trade costs (TC_{j,t}) are low, and the source and host countries are similar in size (YDIFF_{ij,t} is close to zero).

Another way of interpreting the estimation results is to explain the marginal effects of change in the YDIFF_{ij,t} variable as the following:

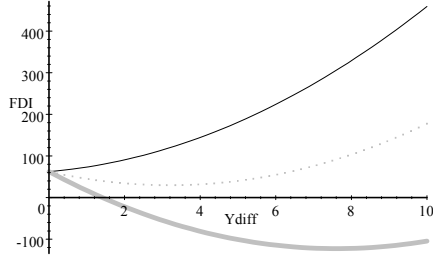
$$\frac{\partial \text{FDI}_{ij,t}}{\partial \text{SDIFF}_{ij,t}} = 61.99 + 28.17\text{YDIFF}_{ij,t} + 2(-45.76)\text{TC}_{j,t} = 61.99 + 28.17\text{YDIFF}_{ij,t} - 91.52\text{TC}_{j,t} \quad (3.6)$$

When the mean value for the YDIFF_{ij,t} variable (USD 0.96 trillion) is inserted into Equation (3.6), and TC_{j,t}=0, FDI gets a value of USD 89.04 million. However, if YDIFF_{ij,t} increases to USD 1 trillion, FDI gets a value of USD 90.17 million.

Now let us look at how the coefficients of the first two variables in Table 3.3 can be interpreted. Since most of the source countries are far larger than the host country (Iceland), much of the variation in YDIFF_{ij,t} is due to variation in the size of the source country (i). Therefore, the asymptotic relationship between the two variables (YSUM_{ij,t} and YDIFF_{ij,t}²) and FDI_{ij,t} can be shown in the equations below, and exhibited in Sketch 3.2.

⁹³The trade cost variable TC_{i,t} takes the lowest value of zero, since it is an index running from 0 to 100. Moreover, the YDIFF_{ij,t} variable is represented with the lowest value of zero, because it is not so realistic to talk of a negative value, since it would only take a negative value if the GDP of Iceland was bigger than the GDP of other countries, which is rarely the case.

Sketch 3.2



Sketch 3.2 exhibits three possible scenarios of the relationship between $FDI_{ij,t}$ and GDP of the source country ($Y_{i,t}$). These are the following:

	$SDIFF_{ij,t}$	MODEL SPECIFICATION	
Case 1	1	$62.421 - 20.426Y_{DIFF_{ij,t}} + 3.193Y_{DIFF_{ij,t}}^2$	(6)
Case 2	0	$62.421 + 7.747Y_{DIFF_{ij,t}} + 3.193Y_{DIFF_{ij,t}}^2$	(7)
Case 3	-1	$62.421 - 48.599Y_{DIFF_{ij,t}} + 3.193Y_{DIFF_{ij,t}}^2$	(8)

In Sketch 3.2, Case 1 is represented by the *pointed line*, Case 2 with a *thin line*, and the Case 3 with a *thick line*. However, when the marginal relationship between the $Y_{DIFF_{ij,t}}$ variable and is looked at more specifically, the effects of marginal change in $Y_{DIFF_{ij,t}}$ on $FDI_{ij,t}$ can be represented in the following way:

$$\frac{\partial FDI_{ij,t}}{\partial Y_{DIFF_{ij,t}}} = 6.39Y_{DIFF_{ij,t}}^{94} + 28.17SDIFF_{ij,t}.$$

So, for example when the mean value of the $Y_{DIFF_{ij,t}}$ variable (USD 0.96 trillion) is inserted into the equation and skill differences ($SDIFF_{ij,t}$) are equal to zero, then FDI has a value of USD 6.13 million. However, if $Y_{DIFF_{ij,t}}$ has a value of USD 1 trillion, FDI has a value of USD 6.39 million.

Overall, the estimates obtained in Table 3.3 indicate that, for other than the market size measures and distance, the specification does not perform very well. Nevertheless, it is possible that some restrictions on the specification perform better than the initial one. Therefore, the next section continues by estimating some restrictions of the initial empirical specification.

⁹⁴Since $2 * 3.193Y_{DIFF_{ij,t}} = 6.386Y_{DIFF_{ij,t}}$.

3.4.3 Specification Restrictions

Since the signs for some of the coefficients in Table 3.3 turned out to be different from what was anticipated, we now analyze whether restricting the model by eliminating the first two potentially correlated variables from the model has an effect on estimates for the remaining variables.

Table 3.4. Some Specification Restrictions

Regressors	(a)	(b)	(c)
YSUM _{ij,t}	−20.426*** (−2.77)		−3.251 (−1.26)
YDIFF _{ij,t} ²	3.193*** (2.65)	−0.396 (−0.88)	
SDIFF _{ij,t}	61.994 (0.57)	−62.610 (−0.69)	−67.630 (−0.74)
YDIFF _{ij,t} *SDIFF _{ij,t}	28.173 (0.82)	102.196*** (3.39)	100.297*** (4.25)
INVC _{j,t}	−0.274 (−0.07)	−0.287 (−0.07)	−0.257 (−0.07)
TC _{j,t}	−0.731 (−0.38)	−0.922 (−0.47)	−0.921 (−0.47)
TC _{j,t} *SDIFF _{ij,t} ²	−45.758* (−1.72)	−13.217 (−0.65)	−12.456 (−0.60)
TC _{i,t}	0.798 (1.36)	0.978 (1.61)	1.022* (1.75)
DIS _{ij}	−0.003*** (−2.99)	−0.002*** (−2.63)	−0.002** (−2.47)
CONSTANT	62.421 (0.94)	53.045 (0.79)	52.630 (0.80)
OBSERVATIONS	78	78	78
R-SQUARED	0.32	0.30	0.30

Note: Robust t-statistics are in parentheses below the regression coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

The regression is split up to find out whether it alters the estimation results for the first two variables. The regression results for the basic CMM empirical specification are shown in column (a). Two restricted versions of the specification are introduced in columns (b) and (c), where the size variables are omitted separately in order to analyze whether some restricted specifications provide better estimates than the basic specification.

Omitting $Y_{SUM_{ij,t}}$ in column (b) leads to a sign change and insignificance of the second variable, $Y_{DIFF_{ij,t}}^2$. Moreover, when the $Y_{DIFF_{ij,t}}^2$ variable is omitted in column (c), the sum variable $Y_{SUM_{ij,t}}$ also loses significance. In both cases the $S_{DIFF_{ij,t}}$ skill difference variable changes sign but remains insignificant. Finally, the variable omission affects the interaction term $Y_{DIFF_{ij,t}} * S_{DIFF_{ij,t}}$ such that it becomes significant and positive. A possible reason for that could be that size difference matters only in interaction with skill differences. A potential reason for why only few of the variable terms are estimated to be significant could be because the error terms of the regression are not a perfectly normal distribution.⁹⁵ As mentioned earlier in Section 2.2, in the variables of Equation (3.1) it holds that $E[\varepsilon_{ij,t} | x_{ij,t}] = 0$. These are the typical assumptions for OLS to give consistent estimates. Furthermore, the application of robust t statistics corrects for heterogeneity in the sample by estimating correct standard errors. Potential non-normality of errors is a severe difficulty. However, since the goal of this chapter is to show how the CMM model fits Icelandic data (which is a poor fit of best) rather than develop precise estimates for inference, I will ignore this issue in line with the rest of the literature.

It appears that the first specification represented in column (a) is the most preferred, because when either of the first two variables are dropped in columns (b) and (c), the remaining variables lose significance. Moreover, the higher R squared value for the first equation also indicates that the first regression has a better fit to the data than the other two.

Overall, estimating a restricted form of the specification indicates that when either of the two first variables in the regression ($Y_{SUM_{ij,t}}$ or $Y_{DIFF_{ij,t}}^2$) are left out, the interaction term ($Y_{DIFF_{ij,t}} * S_{DIFF_{ij,t}}$) seems to be picking up the variation in the data. Otherwise the results do not seem to shed further light on earlier results. I therefore continue by testing some alternatives of the CMM specification.

⁹⁵The distribution of the error terms is exhibited in Figures 3.3 and 3.4 in Appendix A.

3.5 Outliers Omitted

As Figure 3.5 in Appendix B exhibits, it appears that the long right tail of the distribution could be due to the existence of very few very large outliers in the sample. This could also be the reason why the distribution of the error terms in Figure 3.5 has a longer tail to the right. The existence of large outliers could be because some of the source countries of investment are considerably larger than others.⁹⁶

Table 3.5. Sample Estimated by GDP Size.

Regressors	All Countries	3 Biggest Countries	Rest
$Y_{SUM_{ij,t}}$	-20.426*** (-2.77)	-266.197** (-2.34)	-50.575* (-1.84)
$Y_{DIFF_{ij,t}^2}$	3.193*** (2.65)	26.043** (2.26)	40.142** (1.97)
$S_{DIFF_{ij,t}}$	61.994 (0.57)	1,660.536 (0.80)	331.185 (1.54)
$Y_{DIFF_{ij,t}} * S_{DIFF_{ij,t}}$	28.173 (0.82)	-362.534 (-0.88)	-506.340 (-1.27)
$INV_{j,t}$	-0.274 (-0.07)	2.967 (0.81)	0.014 (0.01)
$TC_{j,t}$	-0.731 (-0.38)	-2.580 (-0.88)	-0.082 (-0.04)
$TC_{j,t} * S_{DIFF_{ij,t}^2}$	-45.758* (-1.72)	176.533 (1.15)	-78.857** (-2.02)
$TC_{i,t}$	0.798 (1.36)	-0.749 (-0.86)	1.101 (1.54)
DIS_{ij}	-0.003*** (-2.99)	0.024 (1.30)	-0.003*** (-2.60)
CONSTANT	62.421 (0.94)	513.665** (2.45)	22.975 (0.30)
OBSERVATIONS	78	15	63
R-SQUARED	0.32	0.97	0.21

Note: Robust t-statistics are in parentheses below the regression coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

To correct for this potential effects of outliers, the data is now divided into two subsamples based on economic size. The second column represents estimates based

⁹⁶Source countries of FDI are listed in Section 3.3.

on FDI made by the three biggest source countries only. These countries are the US, Japan, and Germany, respectively.⁹⁷ The third column represents estimates for the remaining 20 countries. Overall, the results for the two subsamples presented in Table 3.5 indicate that economic size does not alter the preceding results. Thus the results from dividing the sample into two subsamples further supports the results obtained earlier.

⁹⁷In 1999, the GDP of the US and Japan, was substantially higher than the GDP of the third largest country, Germany. GDP in the US was 3.30 times higher than that of Germany, and Japan's GDP was 2.06 times that of Germany.

3.6 The Number of Observations Increased

In Table 3.6, the results are introduced from increasing the sample size by using different proxies for trade and investment costs. Table 3.6 presents results from enlarging the sample by almost half.

Table 3.6. Different Proxies for Trade Cost and Investment Cost

Regressors	(a)	(b)	(c)	(d)
YSUM _{ij,t}	−20.426*** (−2.77)	−15.978*** (−4.15)	−16.022*** (−4.18)	−15.449*** (−4.00)
YDIFF _{ij,t} ²	3.193*** (2.65)	2.254*** (3.66)	2.262*** (3.70)	2.140*** (3.43)
SDIFF _{ij,t}	61.994 (0.57)	−146.165*** (−3.60)	−147.111*** (−3.62)	−141.911*** (−3.48)
YDIFF _{ij,t} *SDIFF _{ij,t}	28.173 (0.82)	45.446*** (2.81)	45.314*** (2.80)	48.104*** (2.92)
INVC _{j,t}	−0.274 (−0.07)			
TC _{j,t}	−0.731 (−0.38)			
TC _{j,t} *SDIFF _{ij,t} ²	−45.758* (−1.72)			
TC _{i,t}	0.798 (1.36)	0.621** (2.16)	0.621** (2.15)	0.673** (2.29)
DIS _{ij}	−0.003*** (−2.99)	−0.002*** (−4.97)	−0.002*** (−4.98)	−0.001*** (−5.10)
CONSTANT	62.421 (0.94)	85.653 (1.35)	73.398 (1.54)	−0.728 (−0.06)
INVC _{j,t} ⁰		−2.163 (−1.15)		
DUMMY_INVC _{j,t} ⁰		−76.889 (−1.22)		
TC _{j,t} ⁰			−1.228 (−1.30)	
DUMMY_TC _{j,t} ⁰			−64.585 (−1.39)	
TIME_TREND _t				1.549 (1.54)
OBSERVATIONS	78	150	150	150
R-SQUARED	0.32	0.30	0.30	0.30

Note: Robust t-statistics are in parentheses below the regression coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

In order to see whether increasing the number of observations will possibly affect the previous results, the sample is enlarged. The number of observations is increased by adding dummies for trade or investment costs, and by inserting a time trend. More specifically, column (b) represents the inclusion of host investment costs, where $INVC_{j,t}$ is replaced by an adjusted investment cost variable, $INVC_{j,t}^0$, together with a dummy variable,⁹⁸ $DUMMY_INVC_{j,t}^0$. Observations go from 78 to 150, i.e. they almost double. The $DUMMY_INVC_{j,t}^0$ takes a value of zero in 1989-1994, but the sample value otherwise.⁹⁹ Also in column (c), the trade variable is replaced by $TC_{j,t}^0$ together with a dummy variable, $DUMMY_TC_{j,t}^0$. Finally in column (d), both investment and trade costs are replaced with a linear time trend¹⁰⁰. The approaches applied in columns (a) through (d) are meant to show the effects of enlarged sample size on the size and skill variables. The estimates obtained for the dummies and the time trend are not interpreted specifically, since they are not important for the overall regression results.¹⁰¹

The results are similar for all three regressions. The size variables continue having the same signs as the basic regression. However, skill labor $SDIFF_{ij,t}$, is estimated to be negative and significant in columns (b) through (d). In summary, application of dummies or a time trend¹⁰² backs up previous results except in the case of the skill difference. The negative sign of the skill difference variable can be interpreted such that FDI is decreasing in positive skill differences, and thereby increasing in negative skill differences. In other words, when skills are measured by occupational categories of the labor force, FDI is estimated to increase as the host (Iceland) becomes more skilled compared to the source country. Multinationals with headquarters in the source country can thereby be said to be attracted to more skilled labor when choosing Iceland as a host country.

⁹⁸ An explanation of the dummy approach can be found in Greene (1997, pp. 431).

⁹⁹ The dummy $DUMMY_INVC_{j,t}^0$ takes a zero value in 1989-1994, for the years when data on investment cost could not be obtained from the World Competitiveness Report.

¹⁰⁰ The time trend runs from 1 to 11 to cover all years included in the sample.

¹⁰¹ One additional regression was also run, including $TC_{j,t}^0$, $INVC_{j,t}^0$ and a dummy. However, this regression yielded results analogous to those in columns (b) and (c).

¹⁰² Recent examples of time trend include Heckman and Walker (1990), and Braunstein and Epstein (2002, pp. 16, 20).

3.7 Application of the Davies (2003) Specification

In a recent paper, BDH (2003) find evidence indicating that the model on horizontal MNEs presented by Markusen (1984) cannot be rejected in favor of the KK model. They base their results on findings that indicate that FDI is increasing in negative skill differences, but decreasing in positive skill differences. However, in a more recent paper, Davies (2003) finds it possible to reject the horizontal model in favor of the KK model. The model will be presented here as the Davies empirical specification.

Let us start by considering the regression part referred to as PART A in Table 3.7. In summary, all variations of the skill labor abundance variable in Part A are estimated to be positive although insignificant in most cases. This indicates that in our case, FDI is estimated to be increasing in skill differences. However, the adding of a cubed term to the regression in column three suggests a rejection of the horizontal model in favor of the KK model. The positive significant coefficient of the cubed term indicates that the horizontal model may be rejected in favor of the KK model.

Then in PART B, when squared skill differences are added to the regression in column two, the regression is estimated to be positively significant, providing some support for the Markusen model on horizontal MNEs.

Table 3.7. Davies (2003) Specification of the KK model.

PART A				PART B	
Regressors	Plain skill diff.	Squared skill diff.	Cubed skill diff.	Negative skill diff.	Positive skill diff.
$Y_{SUM_{ij,t}}$	-20.426*** (-2.77)	-19.423*** (-2.74)	-17.782*** (-2.75)	-21.639* (-1.75)	-48.351*** (-4.20)
$Y_{DIFF^2_{ij,t}}$	3.193*** (2.65)	3.018*** (2.60)	3.037*** (2.71)	5.881* (1.68)	-2.173 (-0.60)
$SDIFF_{ij,t}$	61.994 (0.57)	76.334 (0.69)	46.940 (0.51)	-905.237 (-0.65)	-2,704.41*** (-3.27)
$SDIFF^2_{ij,t}$		13,593.83* (1.69)	1,573.932 (0.16)	-87,703.05 (-0.72)	-2,817.94 (-0.47)
$SDIFF^3_{ij,t}$			65,074.47** (2.43)		
$Y_{DIFF_{ij,t}^*}$					
$SDIFF_{ij,t}$	28.173 (0.82)	28.563 (0.88)	17.142 (0.56)	102.669 (0.35)	670.550*** (3.55)
$INVC_{j,t}$	-0.274 (-0.07)	-0.164 (-0.04)	0.747 (0.19)	0.284 (0.10)	2.015 (0.43)
$TC_{j,t}$	-0.731 (-0.38)	0.264 (0.12)	0.488 (0.23)	1.169 (0.46)	-3.940** (-2.42)
$TC_{j,t}^*$					
$SDIFF^2_{ij,t}$	-45.758* (-1.72)	-332.925** (-1.99)	-254.299 (-1.51)	1,121.862 (0.54)	314.795* (1.92)
$TC_{i,t}$	0.798 (1.36)	0.847 (1.46)	0.822 (1.44)	2.480*** (2.65)	-2.169** (-2.42)
DIS_{ij}	-0.003*** (-2.99)	-0.003*** (-3.00)	-0.002*** (-3.22)	-0.017*** (-4.26)	-0.004** (-2.43)
CONS.	62.421 (0.94)	10.268 (0.13)	-22.413 (-0.30)	-50.352 (-0.45)	314.777** (2.47)
OBS.	78	78	78	39	39
R-SQ.	0.32	0.34	0.38	0.59	0.74

Note: Robust t-statistics are in parentheses below the regression coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

Another way of determining between horizontal and vertical FDI is to estimate the KK model based on positive and negative subsamples. The results from doing this are shown in Table 3.7, PART B. The first subsample includes observations when the skill difference is positive, and the second subsample includes negative skill differences. Analogous subsample division was used by BDH (2003), and Davies (2003). Observations are separated into those with positive skill differences

and those with negative skill differences. They obtained the coefficient estimates for skill differences to be positive for the negative subsample, but negative for the positive subsample. As in Davies, I find that splitting the sample significantly raises my R squared. Furthermore, the positive skill difference tends to show greater significance for source trade costs. However, unlike Davies, my skill estimates still cannot reject the horizontal model.

It is possible that these results may be explained by a small variation in $SDIFF_{ij,t}$, since it runs only from -0.08 to 0.14. In comparison, the $SDIFF_{ij,t}$ variable runs within a much wider range in the CMM paper, running from -0.277 to 0.277. A potential reason for limited variation in skill differences in this chapter could be due to a low number of observations. This gives an indication on how important variation is and how serious the lack of data can be for small countries.

3.8 Replacing the Proxy for Skilled Labor

We now turn to an alternative proxy for skilled labor over the same period to analyze if it alters previous results. Hence, the CMM specification of the KK model is now estimated after replacing the proxy for skilled labor with two different variables. First I replace the skilled labor proxy with *per capita* GDP, and then I use secondary school education as a new proxy for skilled labor. I begin by analyzing the effects of including *per capita* GDP. For clarification, the summary statistics for *per capita* GDP¹⁰³ are shown in Table 3.8.¹⁰⁴

Table 3.8. Summary Statistics for the New Variables

Variable	Units	Obs	Mean	Std. Dev.	Min	Max
YPCDIFF _{ij,t}	USD	240	-2,860.91	11,635.93	-28,487.45	21,976.91
YDIFF _{ij,t} *YPCDIFF _{ij,t}		240	2,354.48	15,489.56	-12,608.37	84,004.77
TC _{j,t} *YPCDIFF _{ij,t} ²	USD	110	7.50e+09	1.05e+10	405,288.30	3.55e+10
$\widetilde{\text{SDIFF}}_{ij,t}$	% gross	192	1.71	18.80	-35.56	50.69
YDIFF _{ij,t} * $\widetilde{\text{SDIFF}}_{ij,t}$		191	-2.13	18.89	-122.84	55.41
TC _{j,t} * $\widetilde{\text{SDIFF}}_{ij,t}$ ²	% gross	82	21,362.20	26,832.2	0.38	112,547.50

Source: Authors Computations.

The first new variable YPCDIFF_{ij,t} presented in Table 3.8 measures the *per capita* GDP¹⁰⁵ difference between countries. The *per capita* GDP difference variable is defined as the following: $\text{YPCDIFF}_{ij,t} \equiv \text{GDP}_{i,t}/N_{i,t} - \text{GDP}_{j,t}/N_{j,t}$, where GDP is measured in trillions of dollars. The regression results obtained for this new variable are presented in PART A in Table 3.9. This new variable is somewhat similar to a variable used by Brainard (1997). Brainard used *per worker* GDP¹⁰⁶,

¹⁰³The summary statistics for the YPCDIFF_{ij,t} refer to sample estimates for the "Enlarged Sample" as referred to in PART A in Table 3.9.

¹⁰⁴As a comparison to the variable definition in Table 3.1.

¹⁰⁵Another example of a similar proxy is the one used by Slaughter (2000, pp. 461). He proxies skilled labor with what he refers to as the share of the nonproduction wages bill when divided by the total wage bill of production and nonproduction workers.

¹⁰⁶Brainard (1997) included a *per worker* income differential to control for differences in factor proportions.

but I prefer to use *per capita* GDP in order to reflect the relative differences in wealth of countries.

The second new variable measures the educational¹⁰⁷ difference of the source and the host country. This is a new proxy for skilled labor, valuing skills based on *secondary school enrollment*.¹⁰⁸ This variable has been widely used in growth literature, an example that can be seen in *Economic Growth*¹⁰⁹ by Barro and Sala-I-Martin (1998). In order to stress the change in the proxy for skilled labor, it is denoted with tilda, as $\widetilde{\text{SDIFF}}_{ij,t}$ in Table 3.8 and Table 3.9.

To simplify the comparison between the two new variables, the first regression results presented in PART A in Table 3.9 (same sample) are based on the same sample size as the basic CMM regression presented previously in Table 3.3. However, estimates shown in the second column in PART A are obtained from an enlarged sample based on an increased number of observations for the new variable. The regression results for both columns in PART A indicate that replacing the original skill differences variable with *per capita* GDP backs up the results obtained for the size and skill differences in the basic regression in Table 3.3. In other words, the results in PART A indicate that source countries make more foreign direct investment as they become richer relative to Iceland.

Moreover, the regression results presented in PART B provide analogous results for size effects and skill differences, although the proxy for skill differences is estimated to be insignificant. This can be interpreted such that the level of FDI is not affected by a relative increase in education in the source country, compared to the host country. Put another way, it does not seem to affect investment incentives how well educated the domestic labor is compared to the labor in the source coun-

¹⁰⁷“Education improves the labor force and thus enables workers to use existing capital more efficiently” (Gylfason, 2002).

¹⁰⁸The World Bank defines the serie for secondary scholl enrollment, or *School enrollment, secondary (% gross)* in the following way: “Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Secondary education completes the provision of basic education that began at the primary level, and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers.”

¹⁰⁹More specifiically, in Chapter 3.12.

tries of investment, although a positive coefficient indicates that it might increase as source country labor is better educated. Also, distance loses significance under these circumstances.

Together, the results in PART A and PART B therefore back up the results obtained for the basic model specification presented in Table 3.3.

Table 3.9. Replacing Proxy for Skill Labor Abundance

Regressors	PART A		PART B
	$YPCDIFF_{ij,t} \equiv Y_{i,t}/N_{i,t} - Y_{j,t}/N_{j,t}$		$\widetilde{SDIFF}_{ij,t} \equiv E_{i,t} - E_{j,t}$
	Same Sample	Enl. Sample	
$Y_{SUM_{ij,t}}$	-2.647 (-0.67)	-9.916*** (-2.83)	-19.214*** (-2.82)
$Y_{DIFF_{ij,t}^2}$	1.423*** (2.67)	2.155*** (4.24)	2.621*** (2.77)
$YPCDIFF_{ij,t}$	0.004*** (5.87)	0.002*** (3.33)	
$Y_{DIFF_{ij,t}} * YPCDIFF_{ij,t}$	-0.002*** (-5.75)	-0.001*** (-3.69)	
$\widetilde{SDIFF}_{ij,t}$			0.039 (0.20)
$Y_{DIFF_{ij,t}} * \widetilde{SDIFF}_{ij,t}$			-0.231 (-1.21)
$INVC_{j,t}$	-0.998 (-0.47)	-0.556 (-0.21)	-2.459 (-0.45)
$TC_{j,t}$	-1.418 (-1.32)	-1.201 (-0.89)	-1.027 (-0.49)
$TC_{j,t} * YPCDIFF_{ij,t}^2$	$2.74e - 9$ *** (4.73)	$5.2e - 10$ (1.14)	
$TC_{j,t} * \widetilde{SDIFF}_{ij,t}^2$			$2e - 5$ (0.19)
$TC_{i,t}$	0.459* (1.85)	1.021*** (2.46)	0.832 (1.57)
DIS_{ij}	0.001** (2.25)	0.001 (1.22)	-0.002** (-1.96)
CONSTANT	95.201** (2.17)	64.367 (1.47)	141.192 (1.27)
OBSERVATIONS	78	100	74
R-SQUARED	0.74	0.49	0.26

Note: Robust t-statistics are in parentheses below the regression coefficients. ***, ** and * denote significance levels of 1%, 5% and 10%, respectively.

3.9 Concluding Remarks

This chapter offers a refinement and explores a resolution of the Knowledge Capital model for small countries like Iceland, since better understanding the desire of multinationals when making foreign direct investments in small countries is economically meaningful.

The main conclusion is that when the empirical specification presented by Carr, Markusen, and Maskus (2001) is applied to Iceland, the estimates obtained differ from the general case. The overall results indicate that the driving forces behind foreign direct investment in small countries like Iceland appear to be different from the forces driving FDI in larger economies or that the CMM specification encounters data difficulties when GDP's are highly mismatched. More specifically, the size effects appear to be reverse, indicating that investment incentives decrease with dissimilarity in size, and that FDI is likely to increase as the source countries decrease in size. An important result is that I obtain mixed evidence for the role of skilled labor, although in most cases investment is estimated to increase as the source country becomes more skilled than the host country. More specifically, estimates indicate that when skill is measured by occupational categories, FDI increases as the source country becomes more skilled in comparison to the host country (Iceland). Consequently, multinationals will be attracted by less skilled labor when choosing Iceland as a host country, or that multinationals tend to come from highly skilled countries. Secondly, when skills are measured as *secondary school education*, rather than by occupational categories like before, more education in the source countries is estimated to have positive, however insignificant impact on FDI. That is, it does not seem to affect investment incentives how well educated source country labor is compared to host country labor. Taken together the these two different skill measures indicate somewhat conflicting effects of skills on FDI, and therefore the research continues by investigating whether source country firms seek host countries with skilled labor or unskilled labor, when measured by its cost, i.e. expensive or cheap labor. The third skillness proxy applied, is measured as per capita GDP,

estimates indicate that an increase in skill differences increases FDI. Therefore, more foreign direct investment is made by source countries that are rich relative to Iceland.

A potential explanation for the results obtained for Iceland is that foreign direct investment is driven largely by one dominating industry, the power intensive industry. To dig deeper into this topic, further research into the forces behind sector specific FDI in Iceland may prove quite insightful.

3.10 Appendix A. The Edgeworth Box.

Figure 3.3: Scaled Relationship Between Skilled and Unskilled Labor.

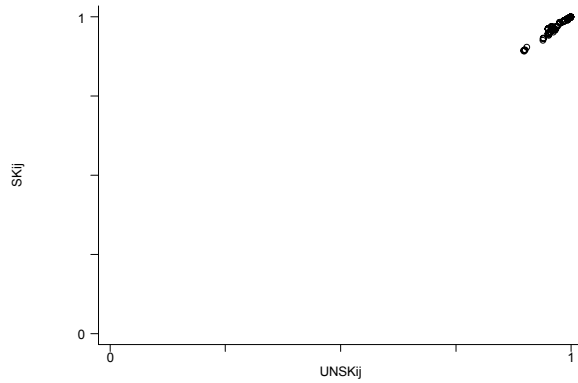
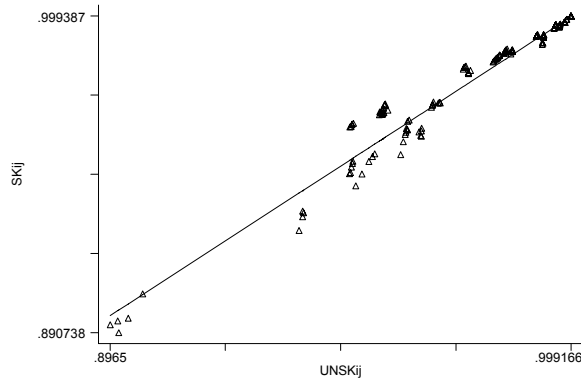


Figure 3.4: Relationship Between Skilled and Unskilled Labor.



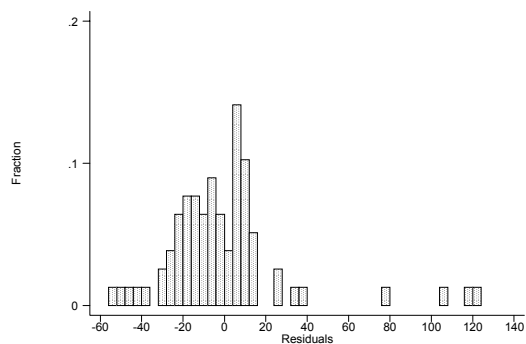
Source: International Labor Organization (ILO).

Figures 3.3 and 3.4 exhibit source country weighted skill labor (vertical-axis) and weighted unskilled labor (horizontal-axis) as in Barconier et al. (2002). These are derived as in the Figure 3.2 Edgeworth Box. Skilled labor is calculated as $SK_{ij} = (S_i * N_i) / (S_i * N_i + S_j * N_j) + j * N_j$ and unskilled labor as $UNSK_{ij} = (U_i * N_i) / (U_i * N_i + U_j * N_j)$. In Figure 3.3 all observations are in the upper right corner of the box, i.e. the northeast corner.

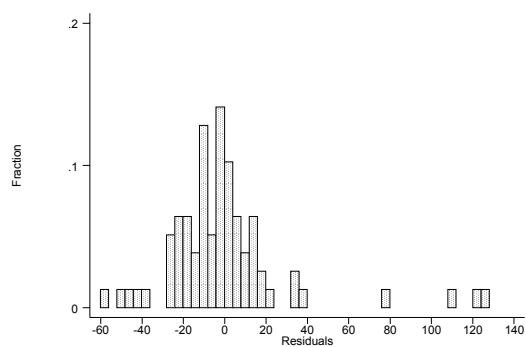
3.11 Appendix B. Distribution of Residuals

Figure 3.5: Distribution of Residuals in Table 3.4, Fraction (% of 100).

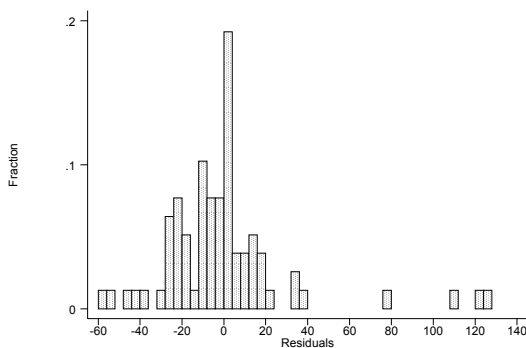
Distribution of Regression Residuals in Table 3.4. Column (a).



Distribution of Regression Residuals in Table 3.4. Column (b).



Distribution of Regression Residuals in Table 3.4. Column (c).



Source: Author's computations.

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4 Chapter IV. What Drives Sector Allocation of Foreign Direct Investment in Iceland?

4.1 Introduction

Foreign direct investment (FDI) has played an important role in the economic development of many countries and proven to be an engine of economic growth (Grosse, 1997). Not only does FDI provide capital for development, but it also diversifies the capital base of countries. It is important for a small country like Iceland, in need of a more diversified economy, to attract FDI in order to sustain economic development and growth. FDI is generally believed to fuel economic growth, however a recent study by Gylfason and Zoega (2001) shows that economic growth may be hindered by the crowding out of physical and human capital by natural resource capital. Moreover, an interesting study by Alfaro et al. (2001) finds economic growth to be promoted by FDI in economies with sufficiently developed financial markets. The nature of FDI in Iceland seems to differ somewhat from FDI in other countries; in the third thesis chapter, FDI in Iceland is found to flow particularly into one sector, the power intensive sector. Because of this, it is important to see to what extent natural resources drive Icelandic FDI and what factors lead to the diversification of this FDI across sectors.

A popular approach when analyzing the determinants of FDI is to apply the factor proportions hypothesis as to consider FDI dependence on factor endowments such as source and host country differences in skilled and unskilled labor. However, for small resource based economies like Iceland, the dependence on skilled and unskilled labor may not be the right endowment approach. Instead, resource based endowments need to be brought into the picture in order to reflect on the country's heavy dependence on marine and hydropower resources.

Anecdotally, the investment dominance of the sector incorporating power intensive industries is generally attributed to the smallness of Iceland, the nature of its natural resources (its natural resources composition), and how distant it is from other countries. In the third chapter of the dissertation (Kristjánsdóttir, 2004),

driving forces for Icelandic FDI are found to be different from the general case when applying the Knowledge Capital (KK) model specification presented by Carr, Markusen and Maskus (CMM, 2001). But does this help explain why the sectorial composition of Icelandic FDI seems to differ from other countries?

The objective of this chapter is to seek a clearer explanation for this by further analyzing the sectorial decomposition of FDI. This chapter is meant to explain the relative contribution of various sectors to foreign direct investment. One of the reasons for following the sectorial approach is to differentiate the power intensive sector from other sectors. This is comparable to a recent paper by Waldkirch (2003) where he seeks to explain heavy reliance of FDI in one particular industry in Mexico. However, Iceland differs from Mexico in various ways such as size, location, and stage of development.

According to the *factor proportions hypothesis*, multinationals seek to integrate production vertically across borders in order to take advantage of different factor prices resulting from relative differences in factor supplies between countries. The *factor proportions hypothesis* has been a dominant explanation of multinational activity within conventional trade literature (Helpman, 1984; Helpman and Krugman, 1985).

Since factor abundance is critically linked to factor intensity that may vary across industries, one goal of this chapter is to analyze whether the factor proportions hypothesis can help explain the sectorial composition of FDI. CMM use skilled labor percentages to represent factor abundance in the KK model specification.

Both the work of CMM and subsequent studies find that this is indeed important for aggregate FDI levels. This chapter offers a refinement of CMM's KK model by incorporating measures for small economic sizes in population and gross domestic product (GDP) along with adding natural resource endowments to the conventional specification. The result supports the hypothesis that there are more factors at work than the two factors of skilled and unskilled labor in the basic specification.

Furthermore, this approach allows me to discuss how factor abundance may influence the allocation of FDI across sectors. In particular the relation between FDI

and electricity prices may influence the predominance of FDI in the Icelandic power intensive industry. Also, by sectorial disaggregation, it is possible to determine how the economic size variables in the CMM specification affect individual sectors. Economic size is highly relevant in this chapter, not only because the source countries are considerably larger than the host country Iceland, but also because during the research period a large part of FDI comes from one particular country, Switzerland. The dominance of Switzerland brings us back to the discussion on electricity prices, hydropower and the power intensive industry. Switzerland has a history of being specialized in using hydropower, as a natural resource, to generate electricity for power intensive industries like the aluminum industry. However, in the 1990s Switzerland had almost fully exploited its hydropower production potential (Czisch et al., 2004, pp.8-3). Thus Swiss firms may have been especially intensive in hydroelectric power and actively seeking more of it. A prime example of this is AluSwiss, a Swiss headquartered multinational enterprise (MNE), which undertook greenfield investment in an aluminum smelter in Iceland in the 1990s. Overall, Icelandic foreign direct investment in power intensive industries greatly increased in the 1990s. Thus one of my goals is to determine how hydropower electricity prices affects FDI in the power intensive industries. This is in addition to the standard analysis of how skill differences between the source and the host country affect FDI.

Also, since fishing is very important to the Icelandic economy, I include the total fish stock caught in Icelandic waters in order to control for this factor. Moreover, issues such as infrastructure, pollution quotas, and fish catch are accounted for in this research. Since Iceland has a considerably larger pollution quota than all other countries engaging in the 1997 Kyoto Protocol on climate change, this may well affect the sector allocation of FDI.

The estimates obtained in this chapter are based on unique FDI panel data on investment sectors in Iceland. The FDI data cover investments made by 17 source countries over a period of 11 years. The FDI is classified into 4 major sectors. These are as follows: power intensive industries (as sector 1), Commerce and Fi-

nance (sector 2), Telecom and Transport (sector 3), and finally Other industries (sector 4). More specifically the fourth sector accounts for the following industries: Manufacturing, Agriculture and Fishing, Mining and Quarrying, and other industries. Estimates are obtained for sector shares of country's FDI as well as levels of FDI in each sector, since FDI shares reflect the relative size of each sector within a particular year of investment. The application of sector shares allows for analyzing the relative importance of the power intensive sector compared with other sectors. An example of an application of FDI share proxy can be found in a paper by Brainard (1997). Brainard uses outward shares of U.S. sales to proxy FDI sector shares. In the case of Brainard, it is reasonable to apply shares of U.S. affiliate sales abroad as a proxy for outward FDI, rather than applying actual FDI data, because a considerable amount of U.S. outward FDI is derived from mergers and acquisitions. However, in the case of Iceland it is more reasonable to capture FDI with actual FDI, since Iceland has a short history for FDI, and FDI in the dominating power intensive industry has primarily been in the form of greenfield investment. In a related manner, Slaughter (2000) constructs an investment share variable as the share of "majority owned affiliates" in overall multinational investment.

Finally, one notable feature of the data is the large number of zeros, i.e. countries that do not invest in a particular sector. Because of this, I control for whether sample selection is driving my results, by using the Heckman's (1979) two-step procedure. In particular, since the theories of FDI assume a crucial role for fixed cost in determining whether FDI occurs, these final results provide some potential insights into this issue in a manner heretofore unexplored.

The chapter is organized as follows. In Section 4.2 the model is laid out. Section 4.3 gives an overview of the data used in this research. Section 4.4 contains quantitative results from the sectorial decomposition. In Section 4.5 results from using a sample selection are introduced. Finally, conclusions are presented in Section 4.6.

4.2 Model Specification

The main issue of concern in this chapter is to capture the driving forces behind investment incentives across sectors. In other words, to see whether it is possible to capture sector specific determinants of foreign direct investment. In the third dissertation chapter, I provide analysis on how the CMM (2001) specification performs for small countries like Iceland. A potential reason for the specification's poor results could be the dominance of one sector, the power intensive sector. Therefore, the objective here is to refine to the baseline CMM specification in order to allow for decomposition of FDI, and to determine what drives sector specific FDI.

I do this in two ways. One is adding factors such as natural resources to an improved version of the CMM specification in order to adjust the model to a resource based host country like Iceland. Thus, this is akin to the empirical trade literature that found it necessary to bring in more factors in order to resolve Leontief's classic critique of the Heckscher Ohlin factor proportions theory. Potentially because the CMM specification is designed to capture the effects of the level of skill on FDI, rather than effects of natural resources.

The breakdown of industries reveals that CMM performs differently for different sectors, although overall it still does not perform as expected. This leads me to a gravity approach akin to that used in Chapter 2.

The motivation for estimating individual sector shares is obtained from Brainard (1997). In her paper, Brainard applies "the share of affiliate sales accounted for by exports"...that is the..."share of exports in total sales" (Brainard, pp. 528)¹¹⁰. This corresponds to capturing the share of non-affiliate sales in total sales. Brainard is thereby able to use an inverse proxy for the share of FDI in foreign MNEs activities¹¹¹. The idea of using export shares is based on a similar argument as the one

¹¹⁰Markusen (2002, pp. 409) says the following about the index used by Brainard in her 1997 paper: "The intra industry affiliate sales index measures the degree of international cross-investment in a particular industry: production and sales abroad by US MNEs and production and sales in the United States by foreign MNEs".

¹¹¹Outward affiliate sales relative to exports and inward affiliate sales relative to imports for 64 industries in the United States are given in Brainard (1997).

presented in this chapter. However, in this chapter the objective is to capture the sector shares of FDI. This is done by presenting the relative weight of sectors in those years when some investment takes place. One of the advantages of measuring sectorial FDI in shares, rather than levels, is that it reflects the relative weight of individual sectors. The way the model specification for shares is set up reflects the relative amount of investment made within each year, no matter the actual size of FDI.

Thus, even when there is little total FDI (as is often the case in small countries like Iceland) I can extract information from the data.¹¹²

An example using capital stock share to construct the dependent variable can be seen in Slaughter (2002). Slaughter calculates the share of MOFAs¹¹³ in overall MNEs investment (Slaughter, 2002, pp. 457), whereas here the estimates are based on the share of sectorial FDI in overall FDI. Slaughter places the share of skilled labor on the left hand side of the equation, and the share of capital stock on the right hand side¹¹⁴. In my case, the share of capital stock is placed on the left hand side, and skilled labor on the right hand side following the exogenous endowment literature precedent.

When formulating the model specification, I start by choosing the share of FDI stock to be the dependent variable. The basic equation specification can be estimated as follows:

¹¹²Brainard (1997) believes that use of the share measure "should mitigate some of the concern about industry - country pair effects". This reasoning applies to my chapter because I also deal with industry-country pairs, which may vary a lot in the amount they invest. CMM need not to deal with this issue in their paper, since they use time series data for countries and years. In his paper, Slaughter (2002, p. 454), says that he uses shares "Because shares offer a rough control for some of these other forces acting MNE-wide I mostly focus on the share data. I interpret rising shares of affiliate activity to be evidence of MNE transfer."

¹¹³MOFA refers to majority-owned affiliates in which parent MNEs hold at least 50% stake. In comparison, FDI generally refers to at least 10% ownership of a single parent MNE.

¹¹⁴The dependent share variable used by Slaughter is based on the skilled labor share in the total wage bill. More specifically, he captures the share of skilled labor in the overall labor force by deviding the wage of nonproduction workers (referred to as skilled labor) by the total wage bill to production and nonproduction workers.

$$\begin{aligned}
SHARE_{i,s,t} &\equiv \frac{F_{i,s,t}}{F_{i,t}} \\
&= \beta_0 + \beta_1 YSUM_{i,t} + \beta_2 YDIFF_{i,t}^2 + \beta_3 SDIFF_{i,t} \\
&\quad + \beta_4 YDIFF_{i,t} * SDIFF_{i,t} + \beta_5 INVC_t + \beta_6 TC_t \\
&\quad + \beta_7 TC_t * SDIFF_{i,t} + \beta_8 TC_{i,t} + \beta_9 DIS_i + \varepsilon_{i,s,t}
\end{aligned} \tag{4.1}$$

In Equation (4.1) the dependent variable $SHARE_{i,s,t}$ represents investment share of a particular sector s in particular year t by source country of investment i . Equation (4.1) has an error term $\varepsilon_{i,t}$ with $E[\varepsilon_{i,t} | x_{i,t}] = 0$, where $x_{i,t}$ represents the explanatory variables in the equation¹¹⁵. Note that because it is created from stock data, the dependent share variable represents sector specific FDI divided by accumulated investment. More specifically the dependent variable $SHARE_{i,s,t}$ is defined as $F_{i,s,t}$ divided by $F_{i,t}$, conditional on $F_{i,t} > 0$. The share of FDI in a particular sector¹¹⁶ is calculated as $FDI_{i,t} = \sum_{s=1}^n FDI_{i,s,t}$ where s runs from 1 to n , and n equals 4.

The explanatory variables on the right hand side of the first regression equation are the same as in the CMM model specification. I start out by including all the variables in the CMM model, and then apply some data-driven refinements. The first variable in Equation (4.1) is $Ysum_{i,t}$ representing the sum of the source and host countries' GDP. The variable coefficient is typically expected to be positive, since more investment is believed to take place with an increase in the economic size of the source and recipient country. The second explanatory variable represents the absolute size difference $YDIFF_{i,t}^2$ of source and host countries' GDP. The coefficient sign is expected to be negative, since less investment is expected to take place as size difference increases. The literature on horizontal multinational activities, e.g. by Markusen (1984), explains well why more FDI is believed to take place between countries of similar economic size.

According to the *factor proportions hypothesis*, multinationals take advantage

¹¹⁵The coefficient estimates are therefore consistent, although not efficient.

¹¹⁶The share observations do not include the years when no FDI takes place.

of factor price differences by fragmenting production vertically across countries dependent on difference in relative factor supplies. Factor price differences give rise to vertical FDI (Helpman, 1984). Here, I include skill differences which are meant to account for difference in relative factor endowments. An analogous variable is used by CMM (2001). FDI is expected to increase as the source country's labor force becomes increasingly more skilled relative to host, and therefore the variable has a positive expected coefficient sign. A term $YDIFF_{i,t} * SDIFF_{i,t}$ is also included to capture the interaction between size and skill differences. The interaction term reflects the importance of skilled labor differences, depending on the magnitude of GDP differences between the source and host country. Furthermore, variables for trade costs and investment costs are included in the model. The motivation for including variables for trade and investment costs is to determine how investment is affected by restrictions of this type. An increase in investment costs of the host country $INVC_t$ is expected to decrease investment in the host. An increase in the host country's trade costs TC_t is expected to trigger FDI, since then the source country is likely to prefer investment to costly trade. On the contrary, an increased trade cost in the source country $TC_{i,t}$ is believed to decrease its interest in investing in the host, since it becomes more costly for the source to import from overseas affiliates. Moreover, the interaction between skill differences and trade cost of the host $TC_t * SDIFF_{i,t}^2$ indicates the relevance of absolute skill differences, depending on the magnitude of trade costs in the host country. The higher the trade cost, the more important the skill differences. The variable coefficient is expected to have a positive sign.

The last variable in Equation (4.1) represents distance. Distance can be regarded to be a proxy for transport costs and associated transaction costs. The inclusion of distance to explain investment is well known in literature on FDI (CMM 2001; Jeon and Stone, 1999; Bergstrand, 1986). FDI is believed to decrease as distance between the source and host countries increases, and therefore the coefficient sign is expected to be negative.

In latter sections of this chapter, some extensions of the basic model specifica-

tion are used, including some additional control variables. These control variables are not in the model specification presented by CMM. First of all, I use a variable accounting for the catch in Icelandic waters. The main reason for including this variable is that it captures fluctuations in what has been referred to as the main natural resource of Iceland, the fish stock obtainable from the fishing grounds around the country. When the catch is large, this may draw labor or other resources from FDI. Furthermore this effect may vary across types of FDI. The variable $CATCH_t$ represents an index of the total fish catch in the host country Iceland. More specifically the variable is defined as "Total catch at fixed prices, Seasonal adj. Indices". The index runs through the whole estimation period from 1989 to 1999, where 1995 has been set as a base year with a value of one. The catch variable is obtained from the National Economic Institute of Iceland. The second control variable used in this chapter is $INFDIFF_i$ which represents difference in infrastructure between the source and the host country in 1999. More specifically the variable can be presented as $INFDIFF_i \equiv (INF_i - INF)$. All variables that represent differences between the source and host country are presented as the source country value minus the host country value. I use infrastructure to reflect host country competitiveness, partly because countries endowed with natural resources for the power intensive industry often suffer from poor infrastructure. These would for example be some of the African and South American countries. Furthermore, for multinationals seeking a power plant location, the strength of the infrastructure in Iceland can play an important role. This infrastructure measure is obtained from the World Competitiveness Yearbook 2000. The yearbook ranks countries by "competitiveness input factors", where infrastructure is one of them. Countries listed in the yearbook run from 1 to 47, with 1 being the most competitive country. By pooling a range of different competitiveness factors together, an overall competitiveness index is formed¹¹⁷. An increase in the $INFDIFF_i$ variable indicates that the host country has increasingly less infrastructure, which may or may not increase FDI in the host

¹¹⁷Iceland was listed as the 17th most competitive country in 1999, moving up from being number 19 in 1998.

(Iceland). Therefore the coefficient sign can be expected to be either positive or negative. Table 4.1 provides an overview of the variables used in this chapter.

Table 4.1. Variable Definition

Variable		Expected signs
$SHARE_{i,s,t}$	Share of foreign direct investment (FDI) made by the source country (i) in the host country (j), in sector (s), over time (t).	
$FDI_{i,s,t}$	Foreign direct investment made by source country (i) in the host country (j), in sector (s), over time (t).	
$YSUM_{i,t}$	The sum of the Gross Domestic Product (GDP) of the source country (i) and the GDP of the host country (j), over time (t).	+
$YDIFF_{i,t}^2$	The GDP of the source country (i) minus the GDP of the host country (j), squared over time (t).	—
$SDIFF_{i,t}$	Skilled labor in the source country (i) minus skilled labor in the host country (j), over time (t).	+
$YDIFF_{i,t} * SDIFF_{i,t}$	Interaction term, capturing the interaction between the GDP difference of the source and host countries and the skill difference variable, over time (t).	—
$INVC_t$	The investment cost foreign investors are faced with when investing in the host country (j), over time (t).	—
TC_t	Trade costs in the host country (j), over time (t).	+
$TC_t * SDIFF_{i,t}^2$	Interaction term, capturing interaction between trade costs in the host country and squared skill differences, over time (t).	+
$TC_{i,t}$	Trade cost in the source country (i), over time (t).	—
DIS_i	Geographical distance between the source country (i) and the host country (j), in kilometers.	—
$CATCH_t$	The "total catch index" for the host country, Iceland. The index represents development in overall catch in Icelandic waters. With 1995 as a base year.	+
$INFDIFF_i$	Infrastructure index differences between the source country (i) and the host country (j), in 1999.	+/-
$POLLDIFF_i$	Pollution Quota differences between the source country (i) and the host country (j). Based on the 1997 Kyoto Protocol.	—
$GMTSTDIFF_{i,t}$	Government Stability differences between the source country (i) and the host country (j).	+/-

Two more control variables are applied in the basic KK model specification, these are $POLLDIFF_i$ and $GMTSTDIFF_{i,t}$. The variable $POLLDIFF_i$ represents

the difference in pollution quota in the source and host country. The data are classified as "Quantified emission limitation or reduction commitment", (percentage of base year or period) and obtained from the Kyoto Protocol to the United Nations Framework Convention on Climate Change¹¹⁸. The Third Kyoto session was signed in December 1997¹¹⁹. An increase in pollution difference of the source and host country indicates an increase in the pollution quota of the source relative to the host. An increase in this type of pollution quota is likely to diminish investment in pollutive industries in the host country, such as the power intensive industry. The measures for government stability refer to both countries and time, and the variable is denoted as $\text{GMTSTDIF}_{i,t}$. Higher numerical value for stability is interpreted as a more stable economy. These Government Stability data are the year beginning data, however the data for Germany run only from 1991 (since German unification). This variable is meant to reflect the relative stability of the Icelandic government, where an increase in difference can be expected to either stimulate or hinder FDI. The government stability data is obtained from the International Country Risk Guide.

¹¹⁸What is of interest in this protocol is that Iceland has highest quota of all countries listed.

¹¹⁹More information on the Kyoto Protocol are to be found in Appendix B.

4.3 Data

The database on FDI and the share of FDI in various sectors in Iceland covers investments made by the main source countries of investment in Iceland over the time period 1989-1999. In order to give a taste of what is in the data, Table 4.2 classifies the sample countries by their share in overall FDI in Iceland. There are 17 source countries in the sample which account for about 99% of total FDI¹²⁰.

The percentage shares presented in Table 4.2 indicate that there is a substantial difference in the amount of investment made by various countries, with Switzerland being the main source country of foreign direct investment.

Table 4.2. Major Source Countries of FDI (1995 US dollars).

<i>The Countries Reported Account for the Biggest Part of FDI.</i>			
Switzerland	1,095,079,000	Sweden	65,178,950
United States	485,395,200	Luxembourg	58,259,560
Denmark	213,626,400	Germany	43,424,390
Norway	191,819,600	Finland	11,947,020
United Kingdom	112,070,400	Belgium	9,159,265
Japan	65,231,580	Netherlands	4,879,091

Source: Central Bank of Iceland.

The second major source country of investment in Iceland is the United States, with Denmark being the third. The sample countries with the least amount of investment in Iceland are Australia, Canada, Spain, Austria, and France. These countries are not displayed in Table 4.2, but are still used in estimation.

Table 4.3 exhibits the share of each sector in overall investment over the period of estimation. The sector disaggregation is as follows: the power intensive industry as sector 1, commerce and finance industry as sector 2, the telecom industry and the transport industry as sector 3, and finally sector 4 accounts for all other industries. More specifically, sector four accounts for the following industries: manufacturing, agriculture and fishing, mining and quarrying and other industries.

¹²⁰Countries accounting for the remaining investment are: Chile, Faeroe Islands, Gibraltar, Israel, Latvia, Russian Federation.

Table 4.3. Decomposition of FDI in Iceland (1995 US dollars).

<i>Sector Allocation of Industries</i>		
SECTOR 1	- Power Intensive	1,524,921,000
SECTOR 2	- Commerce	
	- Finance	468,544,300
SECTOR 3	- Telecom	
	- Transport	50,800,210
SECTOR 4	- Manufacturing	
	- Other	316,047,200
Total		2,360,312,710

Source: Central Bank of Iceland

Due to the low overall FDI, the procedure is to decompose investment into a few main subsectors. When doing this, it is logical to separate the power intensive industry from the others due to its size. Subsequently, following previous research, the sectors are now classified with Commerce and Finance as sector 2, and Telecom and Transport¹²¹ as sector 3. Sector 4 is primarily Manufacturing. However, Agriculture, Fishing, as well as Mining and Quarrying are classified with manufacturing, but these are a very small part of FDI. Together Agriculture, Fishing, and the Mining and Quarrying sector accounted for less than 2.5% of total FDI. It is worth noting that even though there is very small FDI in Fishing, the Fishing industry has been a dominant domestic industry in Iceland in the last several decades.

The numbers presented are inward stocks of FDI in Iceland, represented in 1995 US dollars. Data on FDI stock in Iceland are obtained from the Central Bank of Iceland. In a recent paper by Davies (2002), the advantages of using FDI stock are

¹²¹More specifically, the sector classification is often times "Transport & Communication" (Guo Ju-e, 2000), but I found it to be more direct to call it "Transport & Telecom".

well explained, as well as the reason it can be more applicable than FDI flows or affiliate sales representing multinational activities. Data on the level as well as the share of FDI are kindly provided by the Central Bank of Iceland.

Table 4.4. Summary Statistics

VARIABLE	UNITS	OBS	MEAN	STD.	MIN	MAX
SHARE _{<i>i,s,t</i>}	Index [0,1]	568	0.25	0.39	0	1
FDI _{<i>i,s,t</i>}	Million USD	748	3.16	13.89	-0.95	157.9339
YSUM _{<i>i,t</i>}	Trillion USD	740	1.23	1.96	0.02	8.59
YDIFF _{<i>i,t</i>} ²		740	5.29	13.78	0.00005	73.51
SDIFF _{<i>i,t</i>}	Index [-1,1]	516	0.03	0.06	-0.08	0.14
YDIFF _{<i>i,t</i>} *SDIFF _{<i>i,t</i>}		516	0.04	0.22	-0.27	1.11
INVC _{<i>t</i>}	Index [0,100]	340	33.01	1.92	29.92	35.28
TC _{<i>t</i>}	Index [0,100]	340	48.18	3.79	43.7	52.50
TC _{<i>t</i>} *SDIFF _{<i>i,t</i>} ²		260	0.18	0.25	0.00002	0.85
TC _{<i>i,t</i>}	Index [0,100]	748	27.88	11.18	5.30	64.80
DIS _{<i>i</i>}	Million Kilometers	748	0.004	0.004	0.002	0.02
CATCH _{<i>t</i>}	Fish Quota Index	748	1.01	0.04	0.92	1.07
INFDIFF _{<i>i</i>}	Compet. Index	748	-1.76	6.44	-11	10
POLLDIFF _{<i>i</i>}	Poll. Quota Index	748	-0.16	0.04	-0.18	-0.02
GMTSTDIFF _{<i>i,t</i>}	Govmt Stab. Index	740	-0.09	1.49	-4	5

Sources: Central Bank of Iceland, Economic Institute of Iceland, Distance Calculator, International Labor Organization, World Bank, World Competitiveness Report, Kyoto Protocol.

Table 4.4 represents an overview of the overall sample, where the total number of observations is the multiplication of the 17 countries, 4 sectors and 11 years.

In his paper, Slaughter (2002, p. 454), says that he uses shares "Because shares offer a rough control for some of these other forces acting MNE-wide I mostly focus on the share data. I interpret rising shares of affiliate activity to be evidence of MNE transfer."

Data on GDP, both in sum and squares, are taken from the World Bank CD Rom (2002), and are in constant 1995 US dollars. Data on GDP in Germany in

1989 and 1990 are not included here, since these are the years before the unification of Germany. Data on investment and trade costs are obtained from the World Competitiveness Report and data on distance comes from the Distance Calculator. The quota index for the catch variable is obtained from the former Economic Institute of Iceland. Data on Infrastructure are obtained from the World Competitiveness Yearbook 2000. Data on pollution quotas come from the Kyoto Protocol (1997) in the section on country-by-country emission targets. The government stability data is obtained from the International Country Risk Guide (ICRG), published by The PRS Group on Government Stability¹²². All regressions results are obtained using STATA version 7.0.

¹²²More specifically it is taken from: Political Risk Points by Component, Table 3B.

4.4 Estimation Results

4.4.1 FDI Shares, Basic Specification

This section provides us with results for shares of individual sectors. In the standard models, there are generally two sectors: an FDI sector x and a numerarie sector y . In reality, a single FDI sector x is really several sectors in which there is FDI. Here, I analyze four such sectors, i.e. I decompose x into x_1 , x_2 , x_3 , and x_4 .

An overview of the regression results for the CMM specification in Equation (4.1) as shown in Table 4.5¹²³.

Table 4.5. CMM Specification for Sector Shares

	SECTOR 1	SECTOR 2	SECTOR 3	SECTOR 4	S. 2 TO 4
Regressors	Power inten.	Com. & Fin.	Tel. & Trans.	Oth. Ind.	
YSUM _{<i>i,t</i>}	−0.29*** (−4.59)	0.13 (0.94)	0.19 (1.49)	−0.03 (−0.42)	0.09 (1.30)
YDIFF _{<i>i,t</i>} ²	0.05*** (4.02)	−0.02 (−0.94)	−0.02 (−0.88)	−0.004 (−0.25)	−0.02 (−1.12)
SDIFF _{<i>i,t</i>}	−1.19 (−0.66)	−3.78 (−1.52)	2.71 (1.19)	2.26 (1.23)	0.39 (0.28)
YDIFF _{<i>i,t</i>} *SDIFF _{<i>i,t</i>}	−0.56 (−1.39)	0.63 (1.12)	−0.21 (−0.37)	0.15 (0.34)	0.19 (0.51)
INVC _{<i>t</i>}	0.001 (0.03)	−0.01 (−0.27)	0.02 (0.80)	−0.01 (−0.47)	−0.0004 (−0.01)
TC _{<i>t</i>}	−0.009 (−0.53)	−0.001 (−0.04)	0.0002 (0.01)	0.009 (0.63)	0.003 (0.23)
TC _{<i>t</i>} *SDIFF _{<i>i,t</i>} ²	0.10 (0.30)	0.04 (0.09)	−0.54 (−1.15)	0.39 (0.99)	−0.03 (−0.10)
TC _{<i>i,t</i>}	0.03*** (5.67)	−0.01*** (−2.71)	−0.008** (−2.08)	−0.004 (−0.89)	−0.009*** (−3.02)
DIS _{<i>i</i>}	−30.99*** (−3.71)	−15.39* (−1.77)	−16.18* (−1.95)	62.57*** (7.77)	10.33 (0.72)
CONSTANT	0.23 (0.35)	1.09 (1.43)	−0.47 (−0.80)	0.14 (0.19)	0.26 (0.19)
OBSERVATIONS	57	57	57	57	171
R-SQUARED	0.64	0.39	0.31	0.51	0.09

Note: Robust t-statistics are in parentheses below coefficients. ***, ** and * denote significance levels of 1%, 5% and 10% respectively.

¹²³All robust t-statistics are calculated using White's (1980) heteroskedasticity correction.

Some changes in exogenous variables can be important for some sectors and not others. This is what the research for sector shares tests for. If variable estimates for an individual sector in Table 4.5 are insignificant, it does not indicate that chosen variables do not affect the level of FDI in any sector. What it does indicate is that the variable in question affects FDI levels in each sector in roughly a proportional fashion. If this were true for all variables, then the standard way of estimating FDI (aggregating across sectors and using a single FDI variable) might be sufficient. What this approach adds to the debate is that the standard approach may overlook important heterogeneity across sectors. Furthermore, this indicates that the factor proportions hypothesis can be important even within what is typically called x , i.e. it can affect x_1 and x_2 differently.

In Table 4.5, the first two size variables are estimated to be significant, however with coefficient signs different from what is predicted by the theory. The negative coefficient of the first variable indicates that the share of the power intensive sector, in overall investment, decreases with an increase in the sum of the economic size of the host and the source country. When the investment weight of small countries in Table 4.2 is considered, especially Switzerland, these results need not be surprising. As for the second variable, a positive coefficient indicates that as the squared difference between the source and host country increases, FDI in sector one increases relative to other sectors. Taken together the results for the first two variables are somewhat puzzling, since it seems as they go against each other. One way of interpreting this is to say that the share of sector one, in overall FDI, is negatively affected by an increased in the size of the source countries; however the relationship can be regarded as increasing based on the positive sign of the latter size variable, so that the relationship is negative but increasing¹²⁴. Estimates for sectors 2 to 4 indicate that the coefficient signs for the first two size variables have signs opposite from that which is obtained for the first sectors. This indicates that forces driving

¹²⁴This interpretation refers to the fact that the variation in the size variables is primarily due to variation in the size of the source country, since almost all source countries are considerable larger than the host country, Iceland.

investment in sectors 2 to 4 are of different nature from those driving investment in the first sector. What is interesting is that economic size is only estimated to be of significant importance in the case of the power intensive industry, not other industries.

The results obtained for distance indicate that an increase in distance of 1 million kilometers is predicted to decrease the share of the power intensive sector one by about 31%, or (based on the average distance measures in Table 4.4) a more realistic thing would be to say that a distance increase by 100,000 would result in a 3% decrease in sector one investment¹²⁵.

In Table 4.5 foreign direct investment (FDI) is disaggregated into four sectors. These are the power intensive industry in Iceland as sector one, commerce and finance as sector two, the telephone and transport industries as sector three, and other industries as sector four¹²⁶. Finally industries 2, 3, and 4 are aggregated in the last column. Sector one is not included in last column since by definition the share of all sectors combined is always one. The addition of sectors 2, 3, and 4, provided in the last column, is presented to reflect on the interaction between sector 1 and all remaining sectors. The first column shows estimates for sector one. Overall, an increase in distance shifts FDI from sectors 1 - 3 into sector 4. It may or may not increase the level of FDI in any single sector¹²⁷.

When the skill difference variable $S\text{DIFF}_{i,t}$ is considered, it turns out that it is not found out to be significant (neither when estimated individually, nor when estimated as an interaction term with other variables)¹²⁸.

¹²⁵Note that all inference assumes normality, thus the usual caveats to this discussion apply.

¹²⁶More specifically sector four accounts for the following industries: Manufacturing, agriculture, fishing, mining and quarrying and other industries.

¹²⁷For example, in Table 3.6, it could be that distance has a negative coefficient across the board, which it does. This means that an increase in distance decreases FDI in all sectors.

¹²⁸A potential way to analyze the skill variable further would be to apply the same procedure as Markusen and Maskus (MM, 2002). MM include skill differences in two interaction terms, accounting for the cases separately when skill differences are positive and negative. This approach has the advantage that only two more degrees of freedom are lost, when compared to the CMM model. However, the approach applied by Blonigen, Davies and Head (BDH, 2003) involves a much greater loss of degrees of freedom, since it implies a division of the sample to two subsamples, depending on the whether skill differences are positive or negative.

When it comes to the variables for host country investment cost $INVC_t$, and host trade cost TC_t as well as the interaction between trade cost host and skill differences $TC_t * SDIFF_{i,t}^2$, they are all estimated to be insignificant. Taken together these results may be interpreted such that the variables do not affect FDI allocation to different sectors. In other words, it can be said that MNEs do not choose one sector rather than another based on these factors; the sectors are all equally sensitive to changes in these variables. Recall, however, that FDI levels may change, thus this is not itself a rejection of the factor-proportions hypothesis.

Let us then consider the variable for trade cost in the source country $TC_{i,t}$. It is estimated to be positively significant in the case of sector 1 and negative for sectors 2 and 3. The positive coefficient can be interpreted such that an increase in source country trade cost has positive effects on the share of sector one in overall investment, while the contrary holds for other sectors. One way of interpreting these results is to say that only for sector one does high trade cost trigger investment. An increase in trade cost in the source country might trigger investment in sector one only if the goods produced by the power intensive sector are not faced with conventional trade costs when shipped back home. This possibility is explored in Section 4.5.

Finally, the distance variable is estimated to be significantly negative for sectors 1 through 4. This greater distances seem to hurt FDI in these industries relative to the manufacturing heavy sector 4.

The last column accounts for sectors 2, 3, and 4, and the number of observations in the last column is the sum of observation number for 1-3 sectors. The estimates obtained for the regression in the last column are insignificant, except the source trade cost, consistent with the regressions on sectors.

Many of the variables are estimated to be insignificant in Table 4.5. Therefore, it is interesting to continue the research by estimating levels of FDI, since the CMM is designed for level estimates and therefore has potential to do better for levels than shares. Furthermore, these results describe relative shares across sectors, which leaves out potential information regarding levels of FDI in each sector.

4.5 FDI Levels, Tobit Estimates

I next investigate the degree to which sectorial FDI can be explained, when presented in levels, rather than shares of FDI like before. By doing so, it is possible to capture the effects of the CMM specification variables on actual levels of FDI.

Table 4.6. Tobit Estimates for the CMM Model Specification

	SECTOR 1	SECTOR 2	SECTOR 3	SECTOR 4	S. 2 TO 4
Regressors	Power inten.	Com. & Fin.	Tel. & Trans.	Oth. Ind.	
YSUM _{<i>i,t</i>}	−123.43* (−1.92)	4.54** (2.09)	5.18** (2.18)	−4.85** (−2.09)	0.62 (0.35)
YDIFF _{<i>i,t</i>} ²	19.69* (1.92)	−1.10** (−2.01)	0.32 (0.38)	1.13*** (2.67)	0.15 (0.45)
SDIFF _{<i>i,t</i>}	323.54 (0.57)	−34.94 (−1.12)	65.42 (0.88)	12.79 (0.33)	−1.41 (−0.05)
YDIFF _{<i>i,t</i>} *SDIFF _{<i>i,t</i>}	−197.42 (−0.81)	85.76*** (3.32)	−31.29 (−0.85)	−8.37 (−0.72)	2.50 (0.27)
INVC _{<i>t</i>}	−0.46 (−0.06)	0.27 (0.59)	−0.07 (−0.11)	0.11 (0.15)	−0.02 (−0.03)
TC _{<i>t</i>}	−2.86 (−0.64)	0.12 (0.52)	0.01 (0.04)	−0.62* (−1.69)	−0.30 (−1.03)
TC _{<i>t</i>} *SDIFF _{<i>i,t</i>} ²	−147.62 (−0.99)	−50.32*** (−4.61)	−4.51 (−0.37)	−3.65 (−0.44)	−6.23 (−0.94)
TC _{<i>i,t</i>}	7.24*** (4.81)	−0.18*** (−2.98)	−0.34** (−2.24)	−0.22** (−1.98)	−0.21** (−2.49)
DIS _{<i>i</i>}	−25,621.77 (−1.12)	−6,422.14*** (−4.87)	−11,896.84* (−1.91)	−246.68 (−0.91)	−601.06** (−2.27)
CONSTANT	58.77 (0.32)	9.17 (1.01)	25.50 (1.55)	33.59** (2.33)	19.97* (1.72)
TOTAL OBS.	65	65	65	65	195
LEFT CENS. OBS. FDI≤0	47	29	50	21	100
UNCEN. OBS.	18	36	15	44	95
PSEUDO R-SQ.	0.21	0.29	0.38	0.17	0.07

Note: Robust t-statistics are in parentheses below coefficients. ***, ** and * denote significance levels of 1%, 5% and 10% respectively.

In Table 4.6 the results for level estimates are presented. The main difference between estimating shares or levels of FDI is that the level estimates allow us to determine the direct variable effects on the level of investment, while share estimates indicate how the share of FDI in individual sectors is determined.

By presenting FDI in levels rather than shares, estimates for individual sectors are independent of estimates for other sectors. In Table 4.6 the Tobit estimates for individual sectors are introduced. The row labelled "left censored" observations in Table 4.6 represents those observations that are zero or negative. The left censored observations are in most cases zero values¹²⁹, since the observations are rarely negative¹³⁰. There is a higher number of left censored observations in sectors 1 and 3 than there is in sectors 2 and 4. This is as could be expected, since sectors 2 and 4 are composed of a bigger variety of industries than 1 and 3.

It appears that the size variables continue to have the same signs for sectors 1 and 4 as those in chapter 3. This may provide further support for the hypothesis that estimates for sectors 2-4 combined are crowded out by the power intensive sector due to the power sector size.

What is also noteworthy in Table 4.6 is that the skill difference variable is not estimated to be significant for individual sector FDI. This suggests that skilled labor differences do not have significant impact on the amount of FDI in individual sectors. An exception, though, maybe found for sector 2, where both of the interaction terms are estimated to be significant. The significance of the interaction terms in the case of sector 2 can be interpreted such that endowments of skilled labor may be important in the telecom industry, especially during periods of Icelandic protectionism. What is also of particular interest in sector one is that distance is not estimated to be significant, indicating that other factors than distance are more important when multinationals choose to invest in Iceland.

¹²⁹The Tobit lower limit is set at zero, then negative values are not truncated but accumulated around the zero value. The overall results are weak because of how many observations are left censored.

¹³⁰However, negative observations are identified in the case of France, UK, Luxembourg, Norway and Sweden.

On the whole however, the CMM specification of the KK model does not seem to do well either when I estimate FDI in levels, since most of the variables are insignificant.

There is reason to expect that variation in the power intensive sector may be driving the results for level estimates of FDI. This is because investment in the power industry is often a lump sum investment indicative of high fixed costs. Alternatively, it may be that the baseline CMM specification ignores important omitted variables. I investigate this in the next section.

4.6 FDI Levels, Modification of the CMM Specification

Let us next investigate estimates for an alternative model specification. The new specification is presented in Equation (4.2):

$$\begin{aligned} \text{FDI}_{i,s,t} = & \beta_0 + \beta_1 \text{YSUM}_{i,t} + \beta_2 \text{YDIFF}_{i,t}^2 + \beta_3 \text{SDIFF}_{i,t} \\ & + \beta_4 \text{DIS}_i + \beta_5 \text{CATCH}_t + \beta_6 \text{INFDIFF}_i + \varepsilon_{i,s,t} \end{aligned} \quad (4.2)$$

The variables in Equation (4.2) that are originated in the CMM specification are the two first variables accounting for economic size, the third variable represents skills, and the fourth variable distance. The reason for the choice of those particular variables from the CMM specification is that, for the first thing, determination of size effects are a key issue in the case of Iceland (due to its smallness) and distance is also very important (due to the country's geographical location). Finally the variable accounting for skilled labor endowments is a crucial variable in the Knowledge-Capital framework.

Variables for trade costs and investment cost are not included in Equation (4.2) for two reasons. First, because there is reason to expect these not to be directly applicable to inward FDI in Iceland, since the host country trade and investment cost is estimated to have low significance. Second, although significant, source country trade cost is not of primary interest for inward FDI in Iceland. Also as Table 4.4 in Section 4.3 reveals, the trade and investment costs together with interaction terms have the fewest observations of all the variables and therefore act as being most restrictive.

Two new variables are introduced in Equation (4.2), these are CATCH_t which is an index for fish catch in Icelandic waters, and INFDIFF_i cross sectional variable accounting for differences in infrastructure of the source and the host. More specifically, the CATCH_t variable captures how investment incentives are affected by the size of available fish stock in Icelandic waters, and infrastructure INFDIFF_i in Iceland compared to the infrastructure in source countries (in the year 1999). These new variables are interesting for the reason that they reflect upon issues concerning

horizontal and vertical foreign direct investment. By incorporating a proxy for the main natural resource of Iceland, the fishing area, it helps indicate further whether the sources of FDI are of vertical nature (that is, whether FDI is driven by cheap access to natural resources, as a form of relative endowments)¹³¹. Based on the fact that FDI in fisheries (fish processing firms and trollers) is prohibited in the period analyzed, we now want to estimate whether we can identify whether FDI is affected by the catch variable.

Table 4.7. New Model Specification for FDI Levels

	SECTOR 1	SECTOR 2	SECTOR 3	SECTOR 4	ALL STs
Regressors	Power inten.	Com. & Fin.	Tel. & Trans.	Oth. Ind.	
YSUM _{<i>i,t</i>}	-22.342*** (-4.74)	0.934 (1.24)	0.588 (1.38)	-5.118*** (-3.19)	-6.485*** (-3.92)
YDIFF _{<i>i,t</i>} ²	3.343*** (5.21)	-0.095 (-1.02)	-0.054 (-0.77)	0.949*** (3.36)	1.036*** (4.00)
SDIFF _{<i>i,t</i>}	-207.470*** (-3.70)	6.182 (0.75)	-0.284 (-0.18)	-9.883* (-1.71)	-52.864*** (-3.42)
DIS _{<i>i</i>}	-964.076*** (-3.83)	-269.435*** (-5.41)	-57.889*** (-2.68)	-153.809*** (-2.88)	-361.302*** (-5.24)
CATCH _{<i>t</i>}	-60.442 (-0.73)	-2.749 (-0.27)	-5.488* (-1.67)	-16.691 (-1.43)	-21.343 (-0.93)
INFDIFF _{<i>i</i>}	-0.393* (-1.84)	-0.048 (-0.83)	-0.043* (-1.70)	-0.019 (-0.38)	-0.126** (-2.44)
CONSTANT	89.033 (1.06)	5.107 (0.50)	5.4695* (1.65)	20.484* (1.72)	30.023 (1.29)
OBSERVATIONS	129	129	129	129	516
R-SQUARED	0.19	0.09	0.16	0.60	0.07

Note: Robust t-statistics are in parentheses below coefficients. ***, ** and * denote significance levels of 1%, 5% and 10% respectively.

Furthermore, FDI in various sectors is potentially affected by fluctuations in the fishing industry. This is due to the dominance of the fishing industry and related

¹³¹Which brings us back to the *factor proportion hypothesis*.

industries. The inclusion of the catch variable is particularly interesting when considering FDI in the power intensive sector, for two reasons: First because the economy is heavily dependent on these two industries, and second because these industries are both related to the two main natural resources of Iceland. Estimates obtained for Equation (4.2) are presented in Table 4.7.

A negative sign of the catch coefficient would give indication of that there existed some substitutional effects, since it indicates that FDI decreases as catch increases, that is, an increase in the fishing industry has negative effects on FDI in other sectors¹³². Although the catch variable is estimated to have negative coefficient for individual sectors, as well as for all sectors combined¹³³, it is only significant in the case of the Telecom and Transport sector.

Moreover, estimates for the infrastructure variable $INFDIFF_i$ indicate that investment is reduced in sectors 1 and 3, as the infrastructure in the source countries improves. This would be consistent with a story in which power intensive firms would seek to invest in the power intensive sector (sector 1) in Iceland, dependent on Iceland's firm infrastructure. Another noteworthy result in Table 4.7 is that estimates are primarily significant in the case of sector 1 and 4. Also the skill difference variable is estimated to be insignificant in most cases, with the exception of the power intensive industry, where a negative coefficient indicates that FDI is increases in a sector as Iceland becomes more skilled than the source country.

¹³²"in other sectors" refers to the fact that FDI was only allowed in sectors other than the fishing sector, due to investment restrictions.

¹³³All sectors combined, are here referred to as ALL STS, that is the last column. Recall that here, I am using levels of FDI, not shares.

4.7 FDI Levels, Sectors of Allocation

Next I include sector dummies, as given in Equation (4.3), to capture sector specific effects.

$$\begin{aligned} \text{FDI}_{i,s,t} = & \beta_0 + \beta_1 \text{YSUM}_{i,t} + \beta_2 \text{YDIFF}_{i,t}^2 + \beta_3 \text{SDIFF}_{i,t} \\ & + \beta_4 \text{DIS}_i + \beta_5 \text{CATCH}_t + \beta_6 \text{INFDIFF}_i \\ & + \gamma_2 \text{DS}_2 + \gamma_3 \text{DS}_3 + \gamma_4 \text{DS}_4 + \varepsilon_{i,s,t} \end{aligned} \quad (4.3)$$

In Equation (4.3) the coefficient of the first sector γ_1 has been set equal to zero.

Table 4.8. Fixed Sector Effects for Levels of FDI

Regressors		Eq. from Table 4.7	Eq. w/ sectors
YSUM _{i,t}		−6.485*** (−3.92)	−6.485*** (−4.12)
YDIFF _{i,t} ²		1.036*** (4.00)	1.036*** (4.25)
SDIFF _{i,t}		−52.864*** (−3.42)	−52.864*** (−3.59)
DIS _i		−361.302*** (−5.24)	−361.302*** (−4.55)
CATCH _t		−21.343 (−0.93)	−21.343 (−0.97)
INFDIFF _i		−0.126*** (−2.44)	−0.126*** (−2.19)
DSector_2	Com. & Fin.		−7.911*** (−3.09)
DSector_3	Tel. & Trans.		−9.871*** (−3.89)
DSector_4	Oth. Ind.		−8.303*** (−3.26)
CONSTANT		30.023 (1.29)	36.544 (1.59)
OBSERVATIONS		516	516
R-SQUARED		0.07	0.13

Note: See note following Table 4.7.

The estimates obtained indicate that sector 2, 3, and 4 are estimated to have significantly less FDI than sector 1, since the coefficients of the dummy variables for sectors 2, 3, and 4 are all estimated to be negative. The other coefficients are comparable to the last column of Table 4.7, indicating that there is more variation within sectors over time than between individual sectors.

Furthermore, in order to consider other types of fixed effects than fixed sector effects, I also tested whether there was difference in investment between the three major legal regimes foreign investors are faced with when considering Iceland as an investment option.

”Icelandic legislation providing permission for inward foreign direct investment (FDI) in Iceland is from 1991. However, this legislation allowed for limited inward FDI, since FDI was not allowed in fisheries or the fishing industry. By laws from 1993 companies from all countries were allowed to invest in Iceland, regardless of domestic restriction in the parent country. Finally by legislation from 1996, foreigners were allowed to make indirect investment in fisheries and the fishing industry in Iceland.” Act on Investment (1996), based on the Icelandic Government Gazette.

The division applied to test for fixed effects between law regimes, relied on Act on Investment (1996). The fixed effects tested account for three legal regimes. The first regime ranges from 1989-1992, the second regime from 1993-1995, and the last regime from 1996-1999. However, the results obtained indicated that there did not appear to be a significant difference between subperiods. More specifically, legal regimes two and three do not appear to be different from the first legal regime. Therefore, these results indicated that relaxation in the legal environment over time did not trigger investment, and the results are therefore not reported.

4.8 Sample Selection

One of the features of Icelandic FDI data is the large number of zero observations. This is particularly true for sector level data. Therefore in order to determine whether my estimation results are driven by sample selection, I turn to using the so-called Heckman selection model, or the Heckman's (1979) two-step procedure estimation technique.

An example of Heckman applied to FDI data can be found in Razin, Rubinstein and Sadka (2003), where they apply the procedure to analyze FDI flows. Their reasoning for using Heckman is to offer what they refer to as "yet another reconciliation of the Lucas' paradox, based on fixed setup costs of new investments" (Razin et al., 2003). By referring to the Lucas (1990) paper, where Lucas asked why capital does not seem to have tendency to flow from rich to poor countries, they include the Heckman procedure in order to simultaneously estimate country selection for FDI and the determinants of FDI flows. Following the same procedure as Razin et al., I start out with the same set of variables in both the first and the second step of the Heckman procedure. According to Jeroen Smits (2003) discussion on the Heckman model, it is desirable for the selection equation to contain at least one variable that is unrelated to the dependent variable used in the second stage. If such a variable is not present (and sometimes even if such a variable is present), there may arise severe problems of multicollinearity. Addition of the correction factor to the substantial equation may also lead to estimation difficulties and unreliable coefficients. In addition to using the Heckman procedure in this section I focus only on sector one, the power intensive sector. The power intensive industries are important for Iceland, since it produces considerable amount of aluminum, despite its small economic size. In 1997 Iceland was ranked 27th on the list of world aluminum producing countries (Wagner, 1998), a high rank for such a small country. Because of the importance of aluminum production making it the single biggest investment industry, it is the biggest single industry in FDI, and thus my section of focus.

4.8.1 LEVELS Heckman for the KK model

Since the KK model is the one currently in vogue, here I begin using the KK model on level data. That is, the Heckman procedure¹³⁴ is applied to level FDI data on a modified version of the KK model.

Estimates in Tables 4.9A and 4.9B show results for three different regressions. More specifically, Table 4.9A shows results for the Heckman first step, while Table 4.9B shows results for the second step. The difference between the three results lies within the first Heckman step¹³⁵. In the first step, the likelihood of some FDI occurring is estimated by the Probit technique. In column (1) there is the same set of variables in the first and second step, in column (2) pollution $PDIFF_{i,1997}$ is added to the first step, and in column (3) difference in government stability is added $GMTSTDIFF_{i,t}$. The pollution variable is included in order to reflect on the pollution quota difference between Iceland and the source countries¹³⁶. It is based on percentage pollution quota deviation of source countries from the host country quota. These are obtained from the 1997 Kyoto agreement¹³⁷.

¹³⁴For more information see Greene (1997).

¹³⁵In the first Heckman model for FDI levels, regressions were done on the full KK model specification. These KK variables were included in both step one and two, but then I only get 18 observations. Therefore, I considered these to be too few for the Heckman procedure to work effectively. The next regression was run with fewer variables, leaving out the variables that limited the sample size the most. These are trade cost for host and source, as well as investment cost host and the term for interaction between trade cost host and skill differences.

Variables from the restricted version of the KK model are applied together with an energy index. This index is a proxy of the endowment factor of natural resources. Since data on wholesale electricity prices of various countries are only available for 1999, it only provides us with country specific data. I therefore chose to create my own energy index, which combines the price of wholesale electricity in Iceland with the world USD price of oil. The index was calculated so that it represents the electricity price of the dominating wholesale electricity company in Iceland, divided by the world oil price. Three versions of this index are applied here, firstly the plain ratio, then the ratio of one year lagged variables, and finally a ratio of two year lagged variables. None of these regression results are shown here, since these specifications did not turn out to be informative, especially not the marginal incentives for making FDI.

¹³⁶According to the Kyoto Protocol, the pollution submission allowance for Iceland is substantially higher than that for most other countries. Iceland received a quota of 110% while most other nations received a quota of 92%.

¹³⁷Quantified emission limitation or reduction commitment, (percentage of base year or period).

Table 4.9A. KK model (LEVELS) Sample Selection

<i>First Step Probit Results</i>			
	(1)	(2)	(3)
Regressors	Plain Vanilla	Pollution	Gvmt Stability
$PDIFF_{i,1997}$		42.261*** (2.64)	
$GMTSTDIF_{i,t}$			0.294** (2.03)
$YSUM_{i,t}$	-5.436*** (-3.68)	-3.912*** (-2.84)	-5.8571*** (-3.90)
$YDIF_{i,t}^2$	1.146*** (3.95)	0.773*** (3.25)	1.306*** (4.10)
$SDIF_{i,t}$	-5.559** (-1.76)	-12.769** (-2.33)	-5.329 (-1.60)
$YDIF_{i,t} * SDIF_{i,t}$	-28.442*** (-3.66)	-16.443*** (-3.18)	-34.8199*** (-3.85)
DIS_i	-1132.559** (-2.36)	-526.832*** (-2.61)	-1647.853*** (-2.86)
CONSTANT	3.551*** (2.72)	9.038*** (2.74)	4.869*** (3.06)

Note: Heckman's consistent Z - values are in parenthesis below coefficients.

***, ** and * denote significance levels of 1%, 5% and 10% respectively.

The variables presented in the Probit part determine the probability that some positive investment takes place in industry one. As in the Razin et al. (2003), the Probit zero/one binary distribution can be regarded to be a threshold measure of whether investment takes place, and can therefore be regarded to proxy fixed investment costs. However, in the second Heckman step, an OLS procedure is applied to capture marginal effects on the dependent variable by the explanatory variables.

The difference between the regressions presented in Table 4.9 is reflected in a different set of explanatory variables in Table 4.9A. One of the interesting things about the regression results is that skill differences are estimated to be negative. A negative sign indicates that as source country becomes more skilled abundant, fixed costs are higher (first step), and so are the marginal costs (second step). Other estimates for individual variables indicate that $PDIFF_{i,1997}$ is estimated to be positively significant, indicating that source countries with higher pollution quota

are more likely to invest in Iceland, a country that also has fairly high pollution quotas. The government difference $\text{GMTSTDIFF}_{i,t}$ is estimated as being positive; this indicates that countries with more stable governments tend to invest more than others.

Together, the economic size variables indicate that investment is more likely made by smaller countries than large countries (since sum GDP is negative and squared difference is positive). A negative interaction term indicates that as countries grow bigger, skill differences may have negative effects. Finally, the distance coefficient indicates that investment is more likely to take place by countries that are geographically closer.

Table 4.9B. KK model (LEVELS) Sample Selection

<i>Second Step OLS Results</i>			
	(1)	(2)	(3)
Regressors	Plain Vanilla	Pollution	Gvmt Stability
$\text{YSUM}_{i,t}$	−94.008 (−0.53)	−84.862 (−0.61)	−117.984 (−0.78)
$\text{YDIFF}_{i,t}^2$	11.255 (0.45)	10.548 (0.55)	11.852 (0.58)
$\text{SDIFF}_{i,t}$	−423.763 (−1.28)	−79.548 (−0.31)	−473.903* (−1.75)
$\text{YDIFF}_{i,t} * \text{SDIFF}_{i,t}$	50.581 (0.07)	−26.593 (−0.05)	156.234 (0.34)
DIS_i	26338.389 (0.29)	17183.577 (0.24)	42809.456 (0.71)
CONSTANT	−50.997 (−0.38)	−1.676 (−0.01)	−63.198 (−0.63)
MILLS RATIO (λ)	80.439 (1.20)	63.589* (1.67)	68.152* (1.92)
OBSERVATIONS	129	129	129
UNCENS. OBS.	30	30	30

Note: Heckman's consistent Z - values are in parenthesis below coefficients.
***, ** and * denote significance levels of 1%, 5% and 10% respectively.

The Mills ratio reported in Table 4.9B is estimated to be significant in the two latter regressions, indicating that the sample selection is estimated to be significant in these regressions; it is displayed in columns (2) and (3). Beyond this, the

regression results in Table 4.9B tell us little about the sign of investment. This implies that although the KK model does fairly well in explaining fixed investment cost, consistent with my results in chapter 3, it does not do well in explaining the level of investment.

4.8.2 SHARES Heckman for the KK model

Although the KK model did not perform well for the Section 4.1 FDI level, the results from before offer hope that it will perform for FDI shares in Section 4.1. In section 4.1, the sample selection basis is that investment shares are only observed when multinationals undertake investment in Iceland within a particular year t . Step one identifies only the cases when some investment takes place in sector one. Therefore, when FDI is presented in shares, the years of no investment are not accounted for (since each sector has zero investment), so the binary variable takes zero value in these cases. The results for this series of regressions are in Tables 4.10A and 4.10B.

Table 4.10A. KK model (SHARES) Sample Selection

<i>First Step Probit Results</i>			
Regressors	(1) Plain Vanilla	(2) Pollution	(3) Gvmt Stability
$PDIFF_{i,1997}$		42.261*** (2.64)	
$GMTSTDIFF_{i,t}$			0.294** (2.03)
$YSUM_{i,t}$	-5.436*** (-3.68)	-3.912*** (-2.84)	-5.857*** (-3.90)
$YDIFF_{i,t}^2$	1.146*** (3.95)	0.773*** (3.25)	1.306*** (4.10)
$SDIFF_{i,t}$	-5.559* (-1.76)	-12.769** (-2.33)	-5.329 (-1.60)
$YDIFF_{i,t} * SDIFF_{i,t}$	-28.442*** (-3.66)	-16.443*** (-3.18)	-34.819*** (-3.85)
DIS_i	-1132.559** (-2.36)	-526.832*** (-2.61)	-1647.854*** (-2.86)
CONSTANT	3.551*** (2.72)	9.038*** (2.74)	4.869*** (3.06)

Note: Heckman's consistent Z - values are in parenthesis below coefficients.

***, ** and * denote significance levels of 1%, 5% and 10% respectively.

Since the sample selection stage in Tables 4.9A and 4.10A are the same, there is obviously no difference between them. New results are in Table 4.10B, which account for the marginal effects on the FDI of sector 1 relative to other sectors.

Table 4.10B. KK model (SHARES) Sample Selection

<i>Second Step OLS Results</i>			
	(1)	(2)	(3)
Regressors	Plain Vanilla	Pollution	Gvmt Stability
YSUM _{<i>i,t</i>}	0.015 (0.10)	0.014 (0.12)	-0.012 (-0.11)
YDIFF _{<i>i,t</i>} ²	-0.011 (-0.52)	-0.013 (-0.87)	-0.018 (-1.21)
SDIFF _{<i>i,t</i>}	0.544* (1.96)	0.807*** (3.89)	0.706*** (3.17)
YDIFF _{<i>i,t</i>} *SDIFF _{<i>i,t</i>}	0.177 (0.29)	0.274 (0.59)	0.687** (2.01)
DIS _{<i>i</i>}	56.761 (0.75)	68.562 (1.16)	118.704** (2.54)
CONSTANT	0.754*** (6.77)	0.765*** (7.62)	0.685*** (9.04)
MILLS RATIO (λ)	0.067 (1.20)	0.039 (1.26)	0.006 (0.22)
OBSERVATIONS	129	129	129
UNCENS. OBS.	30	30	30

Note: Heckman's consistent Z - values are in parenthesis below coefficients.

***, ** and * denote significance levels of 1%, 5% and 10% respectively.

Given the share results from earlier in the chapter, it is no surprise that many of the variables in Table 4.10B are insignificant. What is primarily interesting about the results in Table 4.10B is that the skill difference variable is estimated to be positive and significant in all three regressions even though it is insignificant in step one. These positive estimates for skill differences indicate a tendency for investment to occur in sector 1 relative to other sectors, because the source country becomes more skilled¹³⁸ relative to Iceland.

As Iceland becomes more skill abundant relative to the source, SDIFF_{*i,t*} falls, and the price of Icelandic skilled labor is expected to fall relative to skilled labor price in the source country. According to these estimates, this increases the probability of FDI in sector 1, but reduces its importance relative to overall FDI. Thus, cheap Icelandic skill is important in fixed costs but not in production in sector 1.

¹³⁸Since skill differences are defined as skillness of the source country minus the skillness of the host country.

4.8.3 LEVELS Heckman for the GRAVITY model

When the results for Tables 4.9A, 4.9B, 4.10A, and 4.10B are taken together, it appears as if the KK model analysis say something about whether countries are likely to overcome fixed cost. However, it appears that the KK model does not do too well in explaining the level of investment. Thus, for comparison, I turn to the gravity model presented and used earlier in Chapter 2.

As with the KK results in previous sections, I now explore sector 1 levels and shares. The levels results are in Tables 4.11A and 4.11B. Again, following Razin et al. (2003), my approach is to initially include the same variables in each stage. As presented in column (1), the traditional gravity model does not do well in the second stage. Therefore, in columns (2), (3), and (4), some additional factors are added to the original gravity specification to overcome the multicollinearity. problem. In column (2) source country skill¹³⁹ is added to step 1. Since the point of the KK model is that endowments matter, it seems reasonable to include an endowment proxy in the model. The level of skill is also added to the second step in column (3) and (4).

In all three of these new specifications, higher source skill is associated with a higher probability of investment in sector 1. However, it is not significant in stage 2. The abundant, i.e. cheap source skill may be important for whether investment occurs but not in the level of FDI. Source GDP is also positively correlated with the likelihood of some FDI in sector 1. However, it is significantly and positively related to the level of FDI. Contrast this with source population, which is significantly negatively correlated with both the probability and level of FDI. Thus, at least for levels, the wealth story of chapter 2 is again found. The Icelandic variables appear insignificant for the selection stage. In the second stage, however similar to the source wealth, higher Icelandic wealth is positively correlated with FDI levels.

¹³⁹Source skill is used here, rather than skill difference for three reasons mainly. First, the sample size would have too few observations, since skill difference may turn zero or negative in several occasions, because of the logarithm use. Second, when including skill differences in the KK model, sample size was limited considerable because of few observations for level of skill in the host country and insufficient overlap of those with f.x. trade cost variables.

A noteworthy difference is that whereas the source GDP and population have coefficients of roughly equal magnitudes, the Icelandic population's coefficient is roughly four times that of Icelandic GDP. Moreover, distance seems only important in the level stage, where it has the now the familiar negative coefficient. Finally, the Mills ratios imply that the sample selection is not driving the unconditional OLS estimates.

When everything is considered, it appears that one of the main advantages of applying the gravity specification rather than the KK specification to the Heckman model is that the gravity specification gives an indication of how host country characteristics affect FDI, whereas the KK specification does not. It is nevertheless important to include endowment data in the gravity model, a lesson that needs to be credited to the KK literature.

Table 4.11A. Gravity (LEVELS) Sample Selection

<i>First Step Probit Results</i>				
	(1)	(2)	(3)	(4)
Regressors	Plain Vanilla	Skill in St 1	Skill in St 1&2	Gvmt Stab.
$\ln(\text{GMTSTOTH}_{i,t})$				-2.514^{**} (-2.08)
$\ln(\text{SKILLOTH}_i)$		3.326^{***} (2.76)	3.326^{***} (2.76)	4.678^{**} (2.03)
$\ln(Y_t)$	1.057 (0.30)	2.763 (0.55)	2.763 (0.55)	3.616 (0.51)
$\ln(Y_{i,t})$	9.162^{***} (4.87)	17.728^{***} (3.40)	17.728^{***} (3.40)	28.870^* (1.96)
$\ln(N_t)$	-20.199^* (-1.73)	-22.552 (-1.40)	-22.552 (-1.40)	-52.182 (-1.47)
$\ln(N_{i,t})$	-8.438^{***} (-4.94)	-17.085^{***} (-3.53)	-17.085^{***} (-3.53)	-27.735^{**} (-2.02)
$\ln(D_i)$	-1.485^{**} (-2.04)	-1.560 (-1.05)	-1.560 (-1.05)	-3.361 (-0.93)
<i>Constant</i>	-1.650 (-0.17)	38.012^{**} (2.26)	38.012^{**} (2.26)	31.621 (1.09)

Note: Heckman's consistent Z - values are in parenthesis below coefficients.

***, ** and * denote significance levels of 1%, 5% and 10% respectively.

Table 4.11B. Gravity (LEVELS) Sample Selection

<i>Second Step OLS Results</i>				
Regressors	(1)	(2)	(3)	(4)
$\ln(\text{SKILLOTH}_i)$			1.183 (1.64)	0.628 (0.75)
$\ln(Y_t)$	6.525 (0.44)	7.353*** (2.98)	7.674*** (3.02)	7.309** (2.23)
$\ln(Y_{i,t})$	-9.577 (-0.28)	9.905*** (4.80)	12.215*** (5.06)	9.424*** (5.48)
$\ln(N_t)$	-7.816 (-0.12)	-30.955*** (-4.33)	-31.291*** (-4.24)	-29.559*** (-4.08)
$\ln(N_{i,t})$	10.017 (0.32)	-8.184*** (-4.34)	-10.583*** (-4.55)	-7.967*** (-4.78)
$\ln(D_i)$	-3.529 (-0.70)	-5.509*** (-8.65)	-5.048*** (-7.30)	-4.745*** (-4.26)
CONSTANT	-24.912 (-0.45)	-5.794 (-0.68)	7.467 (0.59)	0.318 (0.02)
MILLS RATIO (λ)	-4.319 (-0.58)	0.189 (0.33)	0.638 (1.12)	0.013 (0.03)
OBSERVATIONS	185	159	159	107
UNCENS. OBS.	36	36	36	27

Note: Heckman's consistent Z - values are in parenthesis below coefficients.

***, ** and * denote significance levels of 1%, 5% and 10% respectively.

4.8.4 SHARES Heckman for the GRAVITY model

The final regression results presented in this chapter include the Heckman procedure applied to a gravity specification on FDI share data. These are presented in Tables 4.12A and 4.12B.

Like in the case of the KK model in Tables 4.9A and 4.10A, the estimates for the first step in gravity level and gravity share data are fully identical. This is due to the fact that both represent the likelihood of investment taking place in sector one in general. However estimates obtained for the second step for share in Table 4.12B, differ considerably from those in 4.11B.

Table 4.12A. Gravity (SHARES) Sample Selection

<i>First Step Probit Results</i>				
	(1)	(2)	(3)	(4)
Regressors	Plain Vanilla	Skill in St 1	Skill in St 1&2	Gvmt Stab.
$\ln(\text{GMTSTOTH}_{i,t})$				-2.514** (-2.08)
$\ln(\text{SKILLOTH}_i)$		3.326*** (2.76)	3.326*** (2.76)	4.678** (2.03)
$\ln(Y_t)$	1.057 (0.30)	2.763 (0.55)	2.763 (0.55)	3.616 (0.51)
$\ln(Y_{i,t})$	9.162*** (4.87)	17.728*** (3.40)	17.728*** (3.40)	28.870* (1.96)
$\ln(N_t)$	-20.199* (-1.73)	-22.552 (-1.40)	-22.552 (-1.40)	-52.182 (-1.47)
$\ln(N_{i,t})$	-8.438*** (-4.94)	-17.085*** (-3.53)	-17.085*** (-3.53)	-27.735** (-2.02)
$\ln(D_i)$	-1.485** (-2.04)	-1.560 (-1.05)	-1.560 (-1.05)	-3.361 (-0.93)
CONSTANT	-1.650 (-0.17)	38.012** (2.26)	38.012** (2.26)	31.621 (1.09)

Note: Heckman's consistent Z - values are in parenthesis below coefficients.

***, ** and * denote significance levels of 1%, 5% and 10% respectively.

First, it is obvious that although the gravity model variables might help to describe levels of FDI in sector one, they do little to describe the share of FDI in that sector. They do indicate that as the Icelandic GDP grows, FDI is diversified away from sector one. Estimates for distance indicate that once countries overcome the threshold of investing in the power intensive sector, they are more likely to be

attracted to sector one than other sectors, with an increase in costs associated with increased distance.

These last results give a nice end to the story, since the power intensive goods are normally shipped and likely to be less distance sensitive than many other products. They might therefore become an increasingly preferable investment option, compared to other investment opportunities, as distance increases.

All considered, it appears as if anything, the gravity model does marginally better than the knowledge-capital approach, since the estimates obtained are slightly more significant than those of the knowledge-capital model.

From Table 4.12B it can be concluded that a 1% increase in the source country level of skill¹⁴⁰ can be expected to result in about 0.2% increase in sector one share of total FDI. Economically, this corresponds to the situation where if the source country skilled labor (average of 21.35%) would move up by 1% i.e. to 21.56%, then the share of sector one would increase from being 94.14% on average, to being 94.33% (note that the observations in the second step include only the years of investment in sector one, and therefore the mean is very high).

Moreover, estimates indicate that as GDP in Iceland increases by 1%, then the share of sector one in FDI decreases on by about 0.6%. The economic significance of these estimates could be interpreted such that a 1% increase in Iceland GDP from \$7 billion¹⁴¹ to \$7.07 billion would affect FDI such that the share of sector one would go down from 94.14% to 93.67%.

As for source country GDP and population, as well as the population of Iceland, coefficient estimates indicate that these economic factors would not effect the share of sector one in overall FDI.

¹⁴⁰These data are obtained from the International Labor Organization (ILO) as the sum of occupational categories 0/1 and 2; where category 0/1 accounts for professional, technical, and kindred workers, and category 2 for administrative workers. Moreover, the skilled labor ratio is calculated as the sum of categories 0/1 and 2, divided by the sum of all occupational categories. The skilled labor ratio is used as a proxy for relative skilled labor abundance.

¹⁴¹GDP values are on an 1995 base.

Table 4.12B. Gravity (SHARES) Sample Selection

<i>Second Step OLS Results</i>				
Regressors	(1)	(2)	(3)	(4)
$\ln(\text{SKILLOTH}_i)$			0.208* (1.73)	0.112 (1.35)
$\ln(Y_t)$	-0.563*** (-2.54)	-0.617*** (-2.77)	-0.561 (-1.32)	-0.722** (-2.15)
$\ln(Y_{i,t})$	0.066 (0.13)	-0.026 (-0.14)	0.381 (0.95)	0.053 (0.29)
$\ln(N_t)$	0.073 (0.08)	0.424 (0.65)	0.364 (0.30)	0.287 (0.38)
$\ln(N_{i,t})$	-0.215 (-0.46)	-0.129 (-0.78)	-0.552 (-1.43)	-0.234 (-1.34)
$\ln(D_i)$	0.357*** (4.70)	0.366*** (6.39)	0.447*** (3.88)	0.444*** (4.05)
CONSTANT	-0.092 (-0.11)	-0.108 (-0.14)	2.229 (1.06)	0.130 (0.07)
MILLS RATIO (λ)	0.043 (0.38)	0.031 (0.62)	0.110 (1.17)	0.061 (1.24)
OBSERVATIONS	185	159	159	107
UNCENS. OBS.	36	36	36	27

Note: Heckman's consistent Z - values are in parenthesis below coefficients.
 ***, ** and * denote significance levels of 1%, 5% and 10% respectively.

Finally, estimates for distance indicate that an average increase in distance of 1% would involve an average increase in the share of sector one by about 0.4%. The economic relationship effects of these changes could be interpreted such that if distance would increase from its average by 1%, moving up from an average of 4000 kilometers to 4040 kilometers, then the share of sector one is estimated to go up from 94.14% to 94.52%.

4.9 Conclusion

This chapter presents analysis of foreign direct investment (FDI) allocated to different investment sectors in Iceland. Both levels of FDI and shares of FDI are estimated. When estimated separately, it appears that different forces are driving investment in individual sectors. These results may possibly explain why the Knowledge Capital (KK) model specification of Carr, Markusen, Maskus (CMM) did not perform particularly well for aggregate Icelandic data in chapter three.

In order to take a closer look at the dominating investment sector in Iceland, the power intensive sector, the sector is analyzed specifically by applying the Heckman two-step procedure to test for sample selection. Estimates indicate the threshold of overcoming fixed cost does seem to be a critical issue when multinationals choose to invest.

When sample selection is analyzed with a set of KK model variables, the proxy for skill difference endowments is estimated to be negative for FDI levels, but positive in step two for FDI shares. This may indicate that source countries are attracted by the level of skill in Iceland at the beginning stage of operations when faced with fixed threshold cost. Once the plants have overcome fixed costs, there are positive impacts on marginal investment the more skilled the source country is compared to the host. The KK model estimates by the Heckman procedure indicate that it appears as if the KK model analysis helps in explaining why countries are likely to overcome fixed cost. Finally, when a set of gravity model variables are applied in the Heckman procedure, it appears that they do a better job in explaining the incentives for FDI. Estimates for endowments such as the level of skill of the other country becomes more clear in the case of the gravity model, indicating that an increase in the level of skill in the source country tends to positively effect both on the investment undertaken initially and the marginal increase thereafter. Also, source and host country market sizes have a clearer interpretation in the gravity model case, especially the host country estimates. It therefore appears that the gravity model does a better job explaining investment.

4.10 Appendix A. The Sample Selection Procedure

The sample selection procedure can be described as follows. I start by presenting the equation determining sample selection equation (Greene, 1997, pp. 978) as Equation (4.5):

$$z_i^* = \gamma' w_i + u_i, \quad (4.5)$$

Following this I can present the basic model specification as shown in Eq. (4.6):

$$y_i = \beta' x_i + \epsilon_i. \quad (4.6)$$

Most of the time, the selection variable z^* is not observed, but only its sign. In our example, I observe only whether a source country invests in Iceland in a particular year or not. This information implies the sign of z^* , but not its magnitude. Because I do not have information on the scale of z^* , it is impossible to estimate the selection equation variance.

Then the selection mechanism, capturing whether investment takes place or not, can be put forward as shown in Eq. (4.7), where *Prob* refers to probability.:

$$\begin{aligned} z_i^* &= \gamma' w_i + u_i, \quad z_i^* = 1 \text{ if } z_i^* > 0 \text{ and } 0 \text{ otherwise}; \\ \text{Prob}(z_i = 1) &= \Phi(\gamma' w_i) \text{ and} \\ \text{Prob}(z_i = 0) &= 1 - \Phi(\gamma' w_i). \end{aligned} \quad (4.7)$$

The regression equation can be presented as follows:

$$\begin{aligned} y_i &= \beta' x_i + \epsilon_i \text{ observed only if } z_i^* = 1, \\ (u_i, \epsilon_i) &\sim \text{bivariate normal}[0, 0, 1, \sigma_\epsilon, \rho]. \end{aligned} \quad (4.8)$$

If I then suppose that z_i and w_i are observed for a random sample of observations, and that I only observe y_i when $z_i=1$, then I can present the model as follows:

$$(E[y_i | z_i = 1] = \beta' x + \rho \sigma_\epsilon \lambda(\gamma' w)). \quad (4.9)$$

4.11 Appendix B. The Kyoto Protocol

Kyoto Protocol to the United Nations framework convention on climate change¹⁴².

Third session Kyoto, 1-10 December 1997¹⁴³.

Quantified emission limitation or reduction commitment

(percentage of base year or period)

Australia	108%	Liechtenstein	92%
Austria	92%	Lithuania*	92%
Belgium	92%	Luxembourg	92%
Bulgaria*	92%	Monaco	92%
Canada	94%	Netherlands	92%
Croatia*	95%	New Zealand	100%
Czech Republic*	92%	Norway	101%
Denmark	92%	Poland*	94%
Estonia*	92%	Portugal	92%
European Community	92%	Romania*	92%
Finland	92%	Russian Federation*	100%
France	92%	Slovakia*	92%
Germany	92%	Slovenia*	92%
Greece	92%	Spain	92%
Hungary*	94%	Sweden	92%
Iceland	110%	Switzerland	92%
Ireland	92%	Ukraine*	100%
Italy	92%	United Kingdom of Great Britain	
Japan	94%	and Northern Ireland	92%
Latvia*	92%	United States of America	93%

* Countries that are undergoing the process of transition to a market economy

¹⁴²English conference of the parties.

¹⁴³Source: www.cnn.com/SPECIALS/1997/global.warming/stories/treaty/index4.html

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