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# A Gravity Model for Exports from Iceland

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**Abstract**

This paper applies a gravity model to examine the determinants of Icelandic exports. The model specifications tested allow for sector and trade bloc estimation. Also, a combination of an export ratio and a gravity model is tested, as well as marine product subsamples. The estimates are based on panel data on exports from 4 sectors, to 16 countries, over a period of 11 years. Estimates indicate that the size and wealth of Iceland does not seem to matter much for the volume of exports, not even when correted for the country's small size. Finally, results indicate that trade bloc and sector effects matter and that marine products vary considerable in their sensitivity to distance and country factors.

Keywords: Export, Gravity Model.
JEL Classifications Codes: F1, F15

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# 1 Introduction

Because of Iceland's small economy and population, the country is highly dependent on international trade. Generally, small economies export larger shares of their gross domestic product than larger ones. Iceland's export ratio could therefore be expected 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 1988-1997[1], 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 making an apple fall to the ground. He named the pulling force gravity force. The gravity force between two objects is dependent on their mass, and the distance between them. When the gravity model is applied in economics, exports correspond to the gravity force, and gross

[1] See Figure 1 in Section 2.

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 theoretic basis until Bergstrand (1985) laid out 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 1990[2] 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 2000[3]. Therefore it is useful 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

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

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

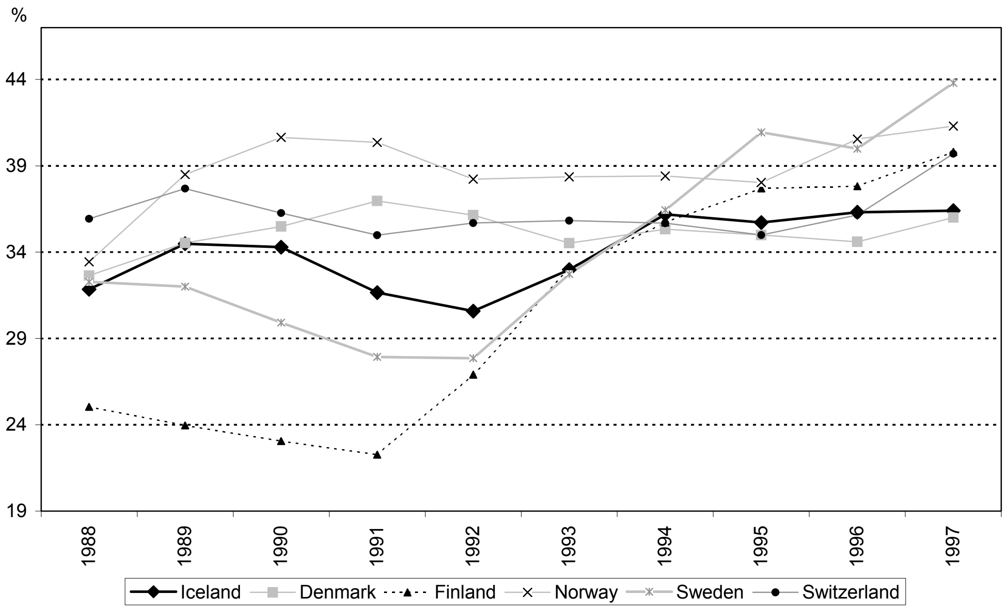
more influential in determining exports than the variables accounting for the size and wealth of the exporting country, Iceland. This is potentially due to the small time series variation of the Icelandic variables. Moreover the marine sector is estimated have the highest export share when corrected for size, wealth and distance, and non trade bloc countries to be the main receiving countries of exports. Furthermore, when an international export ratio is inserted into the equation in order to correct for the small size of Iceland, it is not estimated 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 paper 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.

## 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 export in overall economic activity. The term is expressed in terms of export share in gross domestic product (GDP). Around the First World War, 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.

Figure 1: Several Countries Export Ratios in 1988-1997 (%).



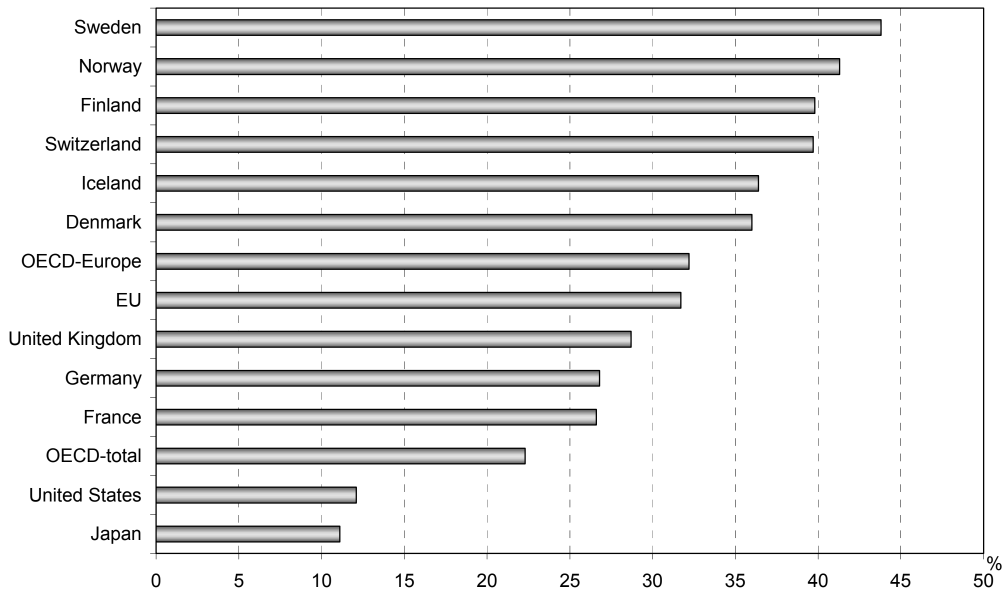

*Source:* The National Economic Institute of Iceland (2000).

Figure 1 gives an overview of several countries export ratios during 1988-1997[4],

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

i.e. merchandise exports[5] as percentage of GDP. The countries under consideration are the Nordic countries and Switzerland[6]. Switzerland is included since it has membership to EFTA like Norway and Iceland. In 1965-1997 all the Figure 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 EU 18-32%. Moreover, from Figure 1 it seems as the export ratio of Iceland is subject to more fluctuations than most of the countries, excepting Finland and Sweden[7].

Figure 2: Several Countries Export Ratios in 1997 (%).




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

Figure 2 exhibits[8] export ratios for a number of countries in 1997. Iceland is listed as being fifth from the top. Later in this paper the relatively low export ratio of Iceland will be corrected for by an international export ratio. This correc-

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

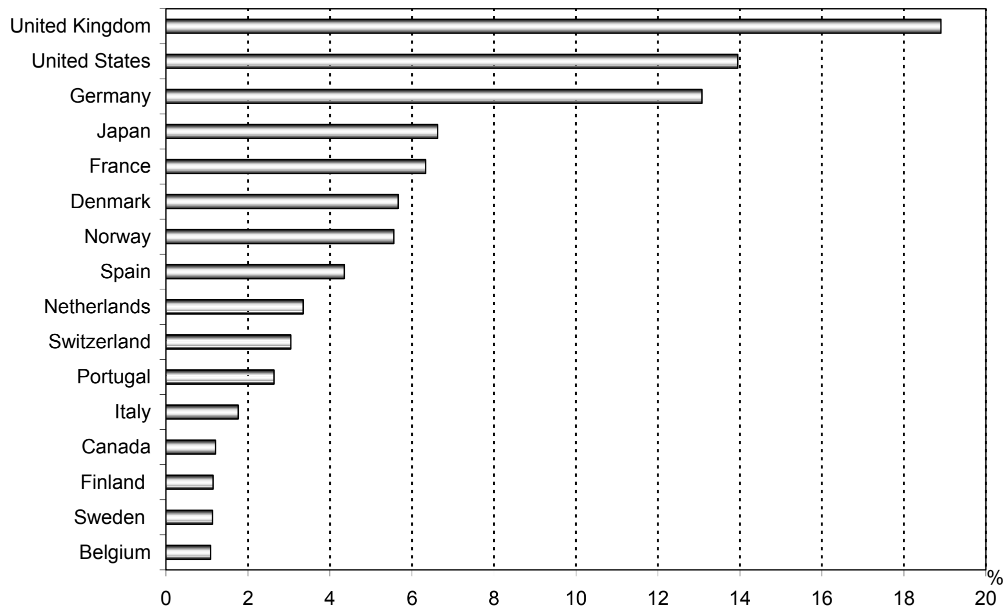
[6] Switzerland is also included since it is one of the EFTA member countries. The EFTA countries are Iceland, Norway, Switzerland and Liechtenstein.

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

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

tion 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 is used for Iceland's exports.

Figure 3: Iceland's Main Trading Partners in 1997 (%).




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

Figure 3 shows 1997 exports from Iceland to different countries by percentage decomposition[9]. About two-third of Iceland's merchandise exports went to Europe (that is the European Economic Area), 15% to 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 to EFTA.

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

# 3 Literature on the Gravity Model and Exports

## 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 and assumes Cobb-Douglas preferences and that products are differentiated by country of origin, referred to as the Armington Assumption[11]. 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-section 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, price[12] 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).

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

[12] Bergstrand 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) emphases 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 model[13]. 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,

[13]Deardorff (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 went 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 Heckschser-Ohlin models.

#### 3.1.1 Earlier Research on Trade in Iceland

In an earlier analysis of the gravity model, Kristjansdottir (2000) presents a gravity model for Iceland, based on export to different countries over time. The panel data covered 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. Kristjansdottir 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 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 Nordics[14]. 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 to the Nordic countries. Kristjansdottir (2000) applies the Byers, Iscan and Lesser estimates to Iceland. Kristjansdottir's results indicate the 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 paper 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 Kristjansdottir, 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 paper is the procedure attempts to correct for the smallness of the country.

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

### 3.2 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 1997[15]. An export index from the National Economics Institute of Iceland[16] is used to put all export data on 1995 level[17]. 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.

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 deflator[19] also obtained from the World Bank.

[15]During 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 covers exports of both goods and services.

[16]Source: 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.

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

[18]Could 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.

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

**Table 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). | |
| $\ln(Y_t)$ *Export Country GDP* | Logarithm (ln) of Host country Gross Domestic Product (GDP), over time (t). | + |
| $\ln(Y_{j,t})$ *Recipient Country GDP* | Logarithm (ln) of Source country (i) Gross Domestic Product (GDP), over time (t). | + |
| $\ln(N_t)$ *Export Country Pop* | Logarithm (ln) of Host country population (Pop), over time (t). | + |
| $\ln(N_{j,t})$ *Recipient Country Pop* | Logarithm (ln) of Source country population (Pop), over time (t). | + |
| $\ln(D_j)$ *Distance* | Logarithm (ln) of distance between the source and the host country. | − |
| $Sector_1$ *Fishing Industry* | Dummy variable accounting for the Fishing Industries. | + / − |
| $Sector_2$ *Manufacturing Ind.* | Dummy variable accounting for the Manufacturing Industries. | + / − |
| $Sector_3$ *Power Intensive Ind.* | Dummy variable accounting for the Power Intensive Industries. | + / − |
| $Sector_4$ *Other Industries* | Dummy variable accounting for all remaining Industries. | + / − |
| $Bloc_1$ *EFTA* | Dummy variable accounting for country membership to the EFTA trade bloc. | + / − |
| $Bloc_2$ *EU* | Dummy variable accounting for country membership to the EU trade bloc. | + / − |
| $Bloc_3$ *NAFTA* | Dummy variable accounting for country membership to the NAFTA trade bloc. | + / − |
| $Bloc_4$ *NON Bloc Members* | 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 distance[20] 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 cost is 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 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 IMF. These are 10 year panel data from 1988 to 1997, for 119 export countries[21].

**Table 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 2 shows an overview of the sample used in this research. Table 2 shows statistics for the variables both before and after they have been treated with the logarithm and inverse hyperbolic sine functions.

[21]See country list in Appendix C.

# 4 A Gravity Model Applied to Iceland's Exports

## 4.1 General Model Specification

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

Tinbergen (1962) and Pöynöhen (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 nicely 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 competition[22]. Factor prices are assumed to be unequal for each pair of countries to allow for non-FPE between countries[23]. 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

[22]Under 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 cost for every good.

[23]The 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 good[24]. Furthermore in the following setup it is assumed that each good is produced only by the country exporting it, and that consumers distinguish difference between the goods[25].

Then under the condition of an international trading equilibrium every single good (i) produced by a single different country (i), is 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, $\beta_i$ 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:

$$Y_i = p_i x_i = \sum_j \beta_i Y_j = \beta_i Y^w \tag{1}$$

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

$$T_{ij}^{cif} = \beta_i Y_j = \frac{Y_i Y_j}{Y^w} \tag{2}$$

The expression put forward in Equation (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 (3). Another way of presenting the above equations (1) and (2), is to say that since there

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

[25] Without relying on the Armington assumption implying that the difference between goods is due to 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).

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

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.

$$T_{ij}^{fob} = \frac{Y_i Y_j}{t_{ij} Y^w} \tag{3}$$

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).

$$U^j = \left( \sum_i \beta_i c_{ij}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)} \tag{4}$$

In Equation (4) the elasticity of substitution $\sigma$ 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 (5):

$$c_{ij} = \frac{1}{t_{ij} p_i} Y_j \beta_i \left( \frac{t_{ij} p_i}{p_j^I} \right)^{1-\sigma} \tag{5}$$

In Equation (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, can be presented more specifically as shown in Equation (6):

$$p_j^I = \left( \sum_i \beta_i t_{ij}^{1-\sigma} p_i^{1-\sigma} \right)^{1/(1-\sigma)} \tag{6}$$

Under the f.o.b. conditions, the export value of goods going from country i to country j, can then be presented in Equation (7):

$$T_{ij}^{fob} = \frac{1}{t_{ij}} Y_j \beta_i \left( \frac{t_{ij} p_i}{p_j^I} \right)^{1-\sigma} \tag{7}$$

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, $\beta_i$ represented the share of income spent on consumption, however under the CES preferences the consumption share is represented by $\theta_i$. It is possible to present the relationship between beta and theta and then solve for $\beta_i$:

$$\begin{aligned}\theta_i &= \frac{Y_i}{Y^w} = \frac{p_i x_i}{Y^w} \\ &= \frac{1}{Y^w}\sum_j \beta_i p_j x_j \left(\frac{t_{ij} p_i}{p_j^I}\right)^{1-\sigma} \\ &= \beta_i \sum_j \theta_j \left(\frac{t_{ij} p_i}{p_j^I}\right)^{1-\sigma}\end{aligned} \tag{8}$$

from which

$$\beta_i = \frac{Y_i}{Y^w} \frac{1}{\sum_j \theta_j \left(\frac{t_{ij} p_i}{p_j^I}\right)^{1-\sigma}} \tag{9}$$

Applying this to Equation (7) we get

$$T_{ij}^{fob} = \frac{Y_i Y_j}{Y^w} \frac{1}{t_{ij}} \left[\frac{\left(\frac{t_{ij}}{p_j^I}\right)^{1-\sigma}}{\sum_h \theta_h \left(\frac{t_{ih}}{p_h^I}\right)^{1-\sigma}}\right] \tag{10}$$

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 $\delta^s$:

$$\delta_j^s = \left(\sum_i \beta_i t_{ij}^{1-\sigma}\right)^{1/(1-\sigma)} \tag{11}$$

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 $\rho_{ij}$:

$$\rho_{ij} = \frac{t_{ij}}{\delta_j^s} \tag{12}$$

By inserting the equation above into Equation (7), it simplifies to the following:

$$T_{ij}^{fob} = \frac{Y_i Y_j}{Y^w} \frac{1}{t_{ij}} \left[ \frac{\rho_{ij}^{1-\sigma}}{\sum\limits_h \theta_h \rho_{ih}^{1-\sigma}} \right] \tag{13}$$

The results in Equation (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.

## 4.2 The Gravity Model Specification for Exports

The gravity model specification presented by Bergstrand (1985) is shown in Equation (14)[28]. The equation captures the volume of exports[29] between the two trading partners as a function of their GDPs and the distance between them.

$$PX_{ij,t} = \alpha_0 (Y_{j,t})^{\beta_1} (Y_{j,t})^{\beta_2} (D_{ij})^{\beta_3} (A_{ij})^{\beta_4} \zeta_{ij} \tag{14}$$

In Equation (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 i at time t, $Y_{j,t}$ is the GDP of country j at time t, and $D_{ij}$ is the geographic distance[30] 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 $\zeta_{ij}$ is a log-normally distributed error term, with E(ln$\zeta_{ij}$)=0.

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

[29]Later in the text $\alpha_0$ is presented as $e^{\beta_0}$, as shown in Section 4.2, Equation (2).

[30]Distance 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 the 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 (14) as an additional determinant of trade. Generally the coefficient for recipient country population is expected to be positive, since bigger market in the recipient country is expected to demand more goods. And 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). It is typically negative, however.

## 4.3 The Model Specification Applied

When choosing a gravity model specification for Iceland, Equation (14) is used as a base case. The model specification in Equation (15) is an extension of Equation (14), where population has been inserted as an additional factor in the model:

$$EXP_{ij,t} = e^{\beta_0}(Y_t)^{\beta_1}(Y_{j,t})^{\beta_2}(N_{j,t})^{\beta_3}(N_{j,t})^{\beta_4}(D)_{ij}^{\beta_5}e^{u_{ij,s,t}} \tag{15}$$

Like in the Bergstrand 1985 paper[31], 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).

$$\begin{aligned} \ln(EXP_{j,s,t}) &= \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + u_{j,s,t} \end{aligned} \tag{16}$$

In Equation (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.

[31] Bergstrand (1985), pp. 474.

# 5 Empirical Results of the Gravity Model

## 5.1 The Basic Regression Results

The regression results for Equation (16) in Section 4.3, are shown in Table 3. The first column in Table 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 3. The Basic Model Specification**

| | LN ROBUST | IHS ROBUST | IHS ROBUST |
|---|---|---|---|
| **Regressors** | Only EXP>0 | Only EXP>0 | All EXP obs |
| $\ln(Y_t)$ *Export Country GDP* | $-0.715$<br>$(-0.45)$ | $-0.716$<br>$(-0.45)$ | $-0.361$<br>$(-0.09)$ |
| $\ln(Y_{j,t})$ *Recipient Country GDP* | $1.552^{***}$<br>$(5.18)$ | $1.552^{***}$<br>$(5.18)$ | $3.568^{***}$<br>$(5.17)$ |
| $\ln(N_t)$ *Export Country Pop* | $1.250$<br>$(0.27)$ | $1.250$<br>$(0.27)$ | $-7.712$<br>$(-0.62)$ |
| $\ln(N_{j,t})$ *Recipient Country Pop* | $-0.559^{**}$<br>$(-2.02)$ | $-0.559^{**}$<br>$(-2.02)$ | $-1.910^{***}$<br>$(-2.91)$ |
| $\ln(D_j)$ *Distance* | $-2.065^{***}$<br>$(-11.05)$ | $-2.065^{***}$<br>$(-11.05)$ | $-2.993^{***}$<br>$(-8.29)$ |
| *Constant* | 22.934<br>(0.35) | 23.626<br>(0.36) | 166.981<br>(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 3 presents results for the basic gravity model specification, for different functional forms[32]. The advantage of using the IHS function rather than the logarithm function is that the IHS function can be applied to zeros[33]. The gravity

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

[33] More 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 3 indicate that a one percent increase in 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 2) being about 7 billion $ (1995 base), but the GDP average of the recipient countries to be about 1200 billions $. 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 billions $ on average.

An increase by 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 counties about equally as distant from the exporting country (Iceland), but one about double 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 $, this would result in Sweden receiving export of 14*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 negatively[34]. More specifically, the coefficient can be interpreted such that by doubling distance between Iceland and the trading country, export becomes 13% of what it was before[35].

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 trading country economic size increases. However, recipient country population is estimated to negatively affect exports, implying negative interaction between demand and population, resulting in more exports to countries as they are less populated. Another way of interpreting the coefficient estimates for the

[34]The intuition behind the sign of the distance coefficient is explained in Section 4.1

[35]Since [2*Distance]^(-2.993) = Distance*2^(-2.993) = Distance*0.126. That is, a twofold increase in distance leads to a decrease to about 13% of what it was previously.

recipient country would be to say that, combined, the positive estimate for GDP and a negative estimate for population, indicates that exports increase with and increase in the income *per capita* of the recipient country. 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 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 how largely goods exports are driven by seafood exports, so that the supply potential is based primarily on natural resources that is the size of the fishing stock.

## 5.2 Fixed Sector Effects Estimated

In this section I continue by adding fixed sector estimates to the basic regression as presented in Equation (17). The fixed effects technique[36] is used to estimate Equation (17), where the $\gamma_s^{\prime} s$ are constants (s=1,2,...4) accounting for sector specific effects.

$$\begin{aligned} \sinh^{-1}(EXP_{j,s,t}) &= \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + \gamma_s Sector_s + \varepsilon_{j,s,t} \end{aligned} \tag{17}$$

Table 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 4 to those in Table 3. The sector specific effects are obtained by setting one of the sectors equal to zero, and estimate the fixed

[36] Greene W. H. (1997). Econometric Analysis. Prentice Hall, New Jersey.

deviation of other sectors. In this research I choose to fix sector three. The third sector accounts for *power intensive industries* (Ferro-silicon and Aluminium), and as a base sector is not presented[37] in Table 4.

**Table 4. Fixed Sector Effects**

| **Regressors** | IHS ROBUST |
|---|---|
| $\ln(Y_t)$ *Export Country GDP* | $-0.361$ <br> $(-0.11)$ |
| $\ln(Y_{j,t})$ *Recipient Country GDP* | $3.568^{***}$ <br> $(6.43)$ |
| $\ln(N_t)$ *Export Country Population* | $-7.712$ <br> $(-0.81)$ |
| $\ln(N_{j,t})$ *Recipient Country Population* | $-1.910^{***}$ <br> $(-3.64)$ |
| $\ln(D_j)$ *Distance* | $-2.993^{***}$ <br> $(-13.02)$ |
| $Sector_1$ *Fishing Industries* | $8.714^{***}$ <br> $(16.08)$ |
| $Sector_2$ *Manufacturing Industries* | $6.917^{***}$ <br> $(12.75)$ |
| $Sector_4$ *Other Industries* | $5.987^{***}$ <br> $(11.13)$ |
| *Constant* | $161.576$ <br> $(1.21)$ |
| 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 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

[37] To avoid the dummy variable trap of perfect collinearity.

the *power intensive sector*, the *manufacturing sector* comes second, and the *fishing sector* third with the biggest deviation. Another way of interpreting the sector specific results would be to say that, when corrected for market size and economic wealth as well as distance (trade cost), the *fishing sector* has the highest share in exports, whereas *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 used[38], 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 exports[39] is much lower. In 2000 the *marine industry* accounted for 41% of overall merchandise exports, compared to 64% share of goods exports[40].

In order to get an indication of whether the regression results presented in Table 4 are more reliable than those in Table 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 multiplied it by minus two. If this value is observed to be less than then 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 3) and should therefore be somewhat preferred.[42]

[38] The common average is calculated as (X1+X2+...+Xm)/m. However geometric average is calculated as (X1*X2*X3*....*Xm)^(1/m).

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

[40] The National Economic Institute of Iceland (2000).

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

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

## 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 (18) as $Bloc_n$, where n runs from 1 to 4. The model specification can the be expressed as the following:

$$\begin{aligned}\sinh^{-1}(EXP_{j,s,t}) &= \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + \pi_n Bloc_n + \varepsilon_{j,s,t}\end{aligned} \tag{18}$$

When the omitted category is set equal to zero, it holds that $\pi_2$=0 where $\pi_2$ 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 5 export country GDP becomes positive (was negative before), 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, than EU countries. However, NAFTA countries are not estimated to receive a higher share of exports than EU countries.

**Table 5. Fixed Trade Bloc Effects**

| **Regressors** | IHS ROBUST |
|---|---|
| $\ln(Y_t)$ *Export Country GDP* | 0.188 (0.04) |
| $\ln(Y_{j,t})$ *Recipient Country GDP* | $2.466^{***}$ (3.40) |
| $\ln(N_t)$ *Export Country Population* | −5.085 (−0.41) |
| $\ln(N_{j,t})$ *Recipient Country Population* | −0.827 (−1.17) |
| $\ln(D_j)$ *Distance* | $-5.567^{***}$ (−5.55) |
| $Bloc_1$ *EFTA* | $0.982^{*}$ (1.82) |
| $Bloc_3$ *NAFTA* | 0.813 (0.83) |
| $Bloc_4$ *NON Bloc Members* | $5.122^{***}$ (2.87) |
| *Constant* | 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 5 is compared to those obtained previously indicates that the trade bloc regression is roughly the same as the basic one in Table 3, which is again less preferred to the sector-specific results.

## 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 6:

**Table 6. Fixed Sector and Trade Bloc Effects**

| **Regressors** | IHS ROBUST |
|---|---|
| $\ln(Y_t)$ *Export Country GDP* | 0.188<br>(0.06) |
| $\ln(Y_{j,t})$ *Recipient Country GDP* | 2.466***<br>(4.05) |
| $\ln(N_t)$ *Export Country Population* | −5.085<br>(−0.54) |
| $\ln(N_{j,t})$ *Recipient Country Population* | −0.827<br>(−1.46) |
| $\ln(D_j)$ *Distance* | −5.567***<br>(−6.21) |
| $Sector_1$ *Fishing Industries* | 8.714***<br>(16.29) |
| $Sector_2$ *Manufacturing Industries* | 6.917***<br>(12.84) |
| $Sector_4$ *Other Industries* | 5.987***<br>(11.25) |
| $Bloc_1$ *EFTA* | 0.982**<br>(2.33) |
| $Bloc_3$ *NAFTA* | 0.812<br>(1.14) |
| $Bloc_4$ *NON Bloc Members* | 5.122***<br>(3.07) |
| *Constant* | 132.295<br>(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 6 Sector 3 (power intensive industries) and Bloc 2 (EU) are kept fixed simultaneously. The estimates in Table 6 imply that the coefficient estimates those obtained for the first five variables, and the last three variables, are analogous to estimates obtained in Table 5. Moreover, the estimates obtained for fixed sector differences are very similar to those obtained in the sector specific regression presented in Table 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 for 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.

# 6 Correcting for a Small Country Size

## 6.1 The Export Ratio Used

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 estimate for the remaining variable measuring size of Iceland, that is 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 ratio[43] is calculated as export divided by GDP[44]. 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 159 countries in 1994. The equation estimated he estimated is presented as Equation (19):

$$\frac{EXP_{i,t}}{Y_{i,t}} = \tau_0 + \tau_1 \ln(N_{i,t}) + \varphi_{i,t} \qquad (19)$$

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 is small nations export higher percent of their

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

[44] However, 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%.

## 6.2 The Export Ratio Applied in This Research

The Equation (19) applied in the previous section is the same as estimated by Gylfason (1999). Gylfason used cross-sectional data for 1994, but here a panel data are estimated for a 10 year period from 1988 to 1997 for 119 countries[45]. The data used here are obtained from an IMF database. The regression results for Equation (19) are shown in Table 7.

**Table 7. Export Ratio, Level Estimates for Eq. (19)**

| **Regressors** | ROBUST |
|---|---|
| $\ln(N_{i,t})$ *Export Country Population* | $-0.049^{***}$ <br> $(-19.22)$ |
| *Constant* | $1.137^{***}$ <br> $(26.53)$ |
| 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 7 are compared[46] 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, that is 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 7. The differences from the research performed by Gylfason earlier is likely to be due to differences in data.

[45] Iceland included, see other countries included listed in Appendix C.

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

The next step is then to rewrite Equation (19) so the left hand variable is presented in logarithms. The model can therefore be rewritten, and presented as Equation (20).

$$\ln\left(\frac{EXP_{i,t}}{Y_{i,t}}\right) = \tau_0 + \tau_1 \ln(N_{i,t}) + \varpi_{i,t} \tag{20}$$

The regression results for Equation (20) are then presented in Table 8. The coefficient estimates obtained for the logarithm estimates are slightly lower than those obtained for level estimates earlier.

**Table 8. Export Ratio, Logarithm Estimates for Eq. (20)**

| **Regressors** | LN ROBUST |
|---|---|
| $\ln(N_{i,t})$ *Export Country Population* | $-0.137^{***}$ <br> $(-16.10)$ |
| *Constant* | $0.899^{***}$ <br> $(6.65)$ |
| 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 the constant estimate is 89.9%.

## 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 (20). In order to do so the gravity model first needs to be rewritten. Therefore it is logical to start rewriting Equation (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 (21). The gravity equation can therefore be rewritten as:

$$\begin{aligned} \ln(EXP_{j,s,t}) - \ln(Y_t) &= \beta_0 + (\beta_1 - 1)\ln(Y_t) + \beta_2 \ln(Y_{j,t}) \\ &\quad + \beta_3 \ln(N_t) + \beta_4 \ln(N_{j,t}) \\ &\quad + \beta_5 \ln(DIS_j) + \varepsilon_{j,s,t} \end{aligned} \tag{21}$$

The expression shown in Equation (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 (20). Equation (21) is rewritten into an export ratio form and becomes Equation (22):

$$\begin{aligned} \ln\left(\frac{EXP_{j,s,t}}{Y_t}\right) &= \beta_0 + (\beta_1 - 1)\ln(Y_t) + \beta_2 \ln(Y_{j,t}) - 0.13\ln(N_t) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(DIS_j) + \varepsilon_{j,s,t} \end{aligned} \tag{22}$$

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 very much different from Equation (16) before. Then Equation (22) is rewritten and the regression Equation (23) is obtained:

$$\begin{aligned} \ln\left(\frac{EXP_{j,s,t}}{Y_t}\right) &= \phi_0 + \phi_1 \ln(Y_t) + \phi_2 \ln(Y_{j,t}) - 0.13\ln(N_t) \\ &\quad + \phi_4 \ln(N_{j,t}) + \phi_5 \ln(DIS_j) + \varepsilon_{j,s,t} \end{aligned} \tag{23}$$

As estimates for Equation (23) in Table 9 reveals, the export country population coefficient has been restricted to be -0.137 (which corresponds to the export ratio coefficient obtained for Equation (20) in Table 8). All the variables in Equation (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 (23) is shown in Table 9.

**Table 9. Gravity Model Corrected for Small Population Size, Eq. (23)**

| **Regressors** | IHS ROBUST |
|---|---|
| $\ln(Y_t)$ *Export Country GDP* | $-2.567$ <br> $(-1.12)$ |
| $\ln(Y_{j,t})$ *Recipient Country GDP* | $3.542^{***}$ <br> $(5.08)$ |
| $\ln(N_t)$ *Export Country Population* | $\mathbf{-0.137}$ |
| $\ln(N_{j,t})$ *Recipient Country Population* | $-1.888^{***}$ <br> $(-2.87)$ |
| $\ln(D_j)$ *Distance* | $-2.988^{***}$ <br> $(-8.65)$ |
| *Constant* | $61.081^{***}$ <br> $(4.20)$ |
| 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. Or in other words, the results indicate that even if Iceland was faced with similar international conditions as other countries, 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.

# 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.

$$\begin{aligned} \sinh^{-1}(EXP_{j,f,t}) &= \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_t) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(D_j) + \varepsilon_{j,s,t} \end{aligned} \tag{24}$$

Based on the above discussion, Equation (24) represents exports of various fish products f, from Iceland toa recipient country j, over time t, as a function of the variables of the basic gravity model specification.

The HNR number listed in the top of each column in Table 10 refers to the product classification number, as listed in Table 11 in Appendix B[47]. What is first noteworthy in Table 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, the more they tend to be interested in buying dried or uncured salted fish. There 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 for that uncured salted fish is expensive to export to all possible destinations. More specifically, if it expensive to export uncured salted fish to all

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

possible destinations, the threshold cost is so high that overcomes marginal effects of distance increase.

**Table 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) |
| *Const* | 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 products exports indicate that they are not significantly affected by Iceland's or the recipient GDPs or population. 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 countries wealth, population and distance is estimated to matter.

Overall, the results for Table 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.

# 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 the most of the determinant 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) size and wealth do not seem to drive exports.

Regression estimates indicate that the marine sector strongly dominates all other export sectors. And 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, it does not seem that the export country factors would be more relevant in driving exports although the model would be corrected for market size.

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

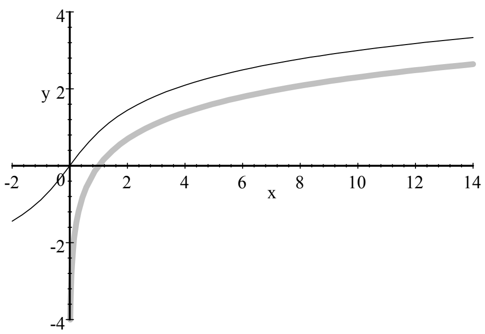
# 9 Appendix A. Various Functional Forms

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

$\ln(Y) = \alpha_0 + \alpha_1 \ln(x_1) + \ldots + \alpha_m \ln(x_m)$. 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 by the inverse hyperbolic sine function: $\sinh^{-1}(Y) = \alpha_0 + \alpha_1 \ln(x_1) + \ldots + \alpha_m \ln(x_m)$.

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

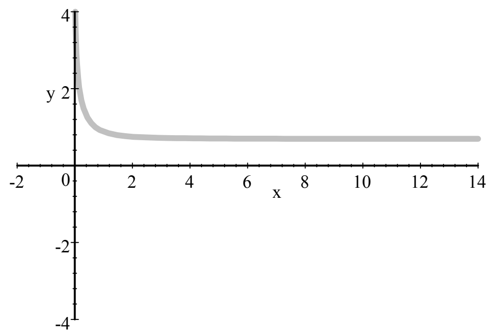
**Sketch 1**




Sketch 1 exhibits that the two functions are similar for large values of Y.

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

**Sketch 2**



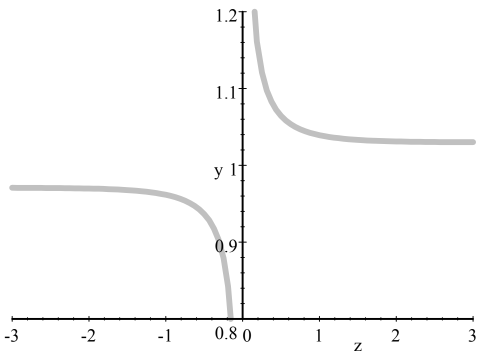

This means that for large values of y, the modified model behaves analogous to the original model. What effect does this have on the interpretation of the coefficients $\alpha_i$? In the case of the logarithm the effect is quite clear. Suppose $x_i$ increases $s$ fold, then

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

so $y_{new} = s^{\alpha i} y_{old}$, that is, $y$ increases by the factor $s^{\alpha i}$. 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 3**




Sketch 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 1% increase in a variable with coefficient equal to 3 results in 3% increase in y, just as when 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 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 $\alpha_0$ 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.

# 10 Appendix B. Merchandise Classification

Table 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 þorskflök | Block-frozen cod fillets |
| 175 | 1 | Önnur fryst þorskflök | 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 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 þaramjöl | 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.þ.h. | Fishing lines, cable, nets etc. |
| 860 | 3 | Prjónavörur, 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 |

# 11 Appendix C. Export Ratio Sample

The regression estimates obtained for the export ratios in Equations (19) and (20) in sections 6.1 and 6.2 are based on a the following sample of 119 countries obtained from the IMF database.

Table 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 12. Cont.

| |
|---|
| 34399Z..ZF...JAMAICA |
| 36199Z..ZF...ST.KITTSANDNEVIS |
| 36499Z..ZF...ST.VINCENT&GRENS. |
| 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 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...PAPUANEWGUINEA |
| 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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# 12 Sector Specific Effects, more detailed discussion

The function $\sinh(x+7)/\sinh(x)$ reflects the interaction between different sectors. In Table 4, sector 3 is kept fixed, and sector 2 is estimated with an coefficient around 7 (6.917). Then the question is, what does that mean in quantitative terms.

The gravity model is generally estimated in natural logarithms as:

$$\begin{aligned}\ln(EXP_{j,s,t}) &= \beta_0 + \beta_1 \ln(Y_{j,t}) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_{j,t}) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(DIS_j) + \gamma_s D_s + u_{j,s,t}\end{aligned} \tag{25}$$

but now the inverse hyperbolic sine function is applied to the left hand side:

$$\begin{aligned}\sinh^{-1}(EXP_{j,s,t}) &= \beta_0 + \beta_1 \ln(Y_{j,t}) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_{j,t}) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(DIS_j) + \gamma_s D_s + u_{j,s,t}\end{aligned} \tag{26}$$

The estimated equation becomes:

$$\begin{aligned}\sinh^{-1}(EXP_{j,s,t}) &= \beta_0 + \beta_1 \ln(Y_{j,t}) + \beta_2 \ln(Y_{j,t}) + \beta_3 \ln(N_{j,t}) \\ &\quad + \beta_4 \ln(N_{j,t}) + \beta_5 \ln(DIS_j) + \gamma_1 S_1 + \gamma_2 S_2 + \gamma_4 S_4\end{aligned} \tag{27}$$

and we need to figure out the interaction between individual sectors. Let us say, what does a coefficient equal to 7 tell us in this case. And let us simplify the equation by writing all explanatory variables (and dummies) in one as z, and the left hand variable as y.

$$\sinh^{-1}(y) = z + 7S_2 \tag{28}$$

This can be simplied further and written as:

$$\sinh^{-1}(y) = z + 7 \tag{29}$$

Then the functional form can be moved from the left hand side to the right hand side so the equation becomes:

$$y = \sinh(z + 7) \tag{30}$$

The ratio can then be written as:

$$\sinh(z + 7)/\sinh(z) \tag{31}$$

And when inserted in the exponential expression of the hyperbolic sine function it becomes:

$$\frac{\frac{1}{2}\left(e^{z+7} - e^{-z-7}\right)}{\frac{1}{2}\left(e^{z} - e^{-z}\right)} \tag{32}$$

And then it holds that, as z goes to infinity, then the ratio apporaches the exponential function of 7, which is close to being 1100. So the difference between the sectors is about 1100 millions.

$$\frac{\frac{1}{2}\left(e^{z+7} - e^{-z-7}\right)}{\frac{1}{2}\left(e^{z} - e^{-z}\right)} \longrightarrow e^{7} \tag{33}$$