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Transport costs and bilateral trade: a gravity model analysis for the food industry in the Nordic Sea Region

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Abstract

Food plays a predominant role in everyday life, thus requires a very sustainable and reliable mode of transport. The aim of this paper is two-fold. First, it applies the gravity model to investigate the role of transport costs in deterring the bilateral food trade in the Nordic Sea region. Second, we estimate the sensitivity of trade flows to transport modal shift. This is motivated by the increased congestion on major European highways and governments' intervention to rebalance the modal split. Intermodal transport is often cited as a sustainable alternative to all-road transport, but its contribution to international trade has not been explicitly identified. The results from the gravity model show that transport cost is the most influential determinant of food trade, followed by exporter's food price and importer's income level. Making cost saving in transport will generate more trade volumes in food industry than in other sectors. In the second estimation, the current all-truck transport is substituted by an optimized intermodal transport considering both transport time and transport costs. The bilateral trade volumes are predicted to increase, although the relative growth across food groups varies greatly. This study combines the international trade and transport research and has implications on how to develop logistics as a strong and value adding sector supporting the food industry.

Keywords: Food trade, Transport costs, Intermodal transport, Gravity model

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1. Introduction

Transport costs adversely affect the volume of trade and limit the scope for international transaction. This has been amply demonstrated in extant studies (Geraci and Prewo, 1977; Limao and Venables, 2001; Baier and Bergstrand, 2001; Anderson and Wincoop, 2004; Martinez-Zarzoso and Suarez-Burguet, 2005; Martinez-Zarzoso *et al.*, 2008). For agriculture products in particular, transport costs account for a high proportion of the food prices (Korinek and Sourdin, 2009). Food exporters recently bear the brunt of increasing transportation costs and economic recession. Therefore, their tendency to source imports from countries with low transport costs is strong. As an outcome, it will stimulate the more efficient and cost-effective transport services, which in turn will influence the modal choice and the patterns of trade.

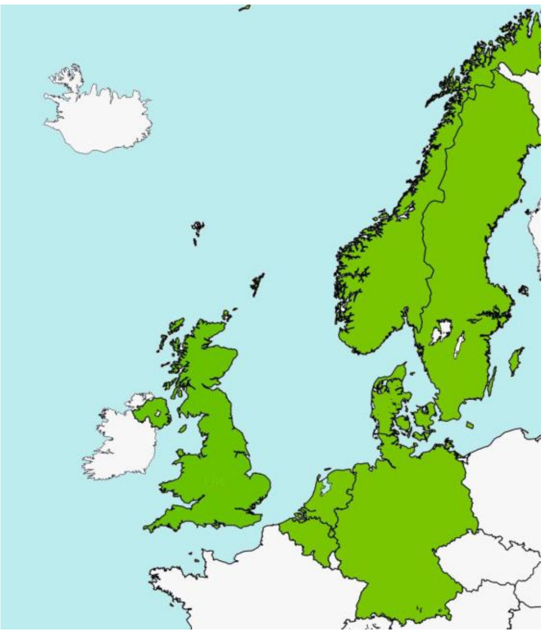

Figure 1 - The geographical map of the Nordic Sea Region

In this paper we aim to study the important role played by transport costs on the food trade in the Nordic Sea Region (NSR). As shown in Figure 1, the NSR area consists of 49 NUTS-2 (Nomenclature of Territorial Units for Statistics) level regions in seven countries[1]. These NSR countries account for approximately one third of the food production and one fourth of the food trade within the European Union 27 and Norway, thus forming a thriving food cluster (Eurostat, 2010). The huge trading volumes require a large distribution network and reliable transportation services. According to statistics, more than 80% of food transported in NSR

[1] These 49 regions include Norway, Denmark, the east of United Kingdom, parts of the Flemish Region of Belgium, the northwestern of Germany, the north and west of Netherlands and the southwestern of Sweden.

goes by road. This is mainly because of road transport's flexibility, speed and ability to provide door-to-door service. In recent years, however, the growth of road traffic, congestions and delays, are making food transportation less predictable and regular. Environmental pollution and human health risks related to road transport have also caused an extensive concern of the whole society.

Within this context, seven North Sea countries are brought together in the EU food port project. It aims to develop green transport corridors to improve the efficiency, effectiveness and sustainability of the food supply chains in the NSR. One practical solution would be shifting a certain amount of road freight to rail or waterborne transport. In other words, a transport chain where the main part of the transport is performed by rail or sea with a short road journey at both ends. The promotion of intermodal transport can curb the growth of heavy vehicle traffic, rebalance the modal split and integrate the comparative advantages of different transport modes. For this reason, the recent White Paper from the European Commission sets targets that 30% of road freight transport over 300km should shift to rail or waterborne transport by 2030, and more than 50% by 2050 (European Commission, 2011).

Despite this, there are ongoing discussions about intermodal transport in Europe. For instance, intermodal transport is often slower and can be only offered in selected corridors. Such modal integration also requires massive investments, but the current economic downturn, food price increases and soaring oil prices make such investments quite prone to risks and uncertainties. A better understanding of the relationship between international trade and modal shift is therefore needed. To what extent does the international trade benefit from shifting to intermodal transport? Is some food products' trade more sensitive to the modal shift than others? If so, which ones? These questions have received little attention in both international trade and transport research, and hence there is a clear need to bridge these two areas.

This study evaluates the impact of transport costs on the food trade in the NSR. The estimation proceeds in two parts. We start modeling the relationship between transport costs and NSR' food trade based on the workhorse model of international trade --- the gravity equation. Then we use this model to forecast the trade volumes by adopting the costs of intermodal transport. This investigation also attempts to determine whether the variation in transport costs will have different influences on trade volume across the food products.

This article contributes a connecting mechanism between intermodal transportation (on micro level) and the economic performance in international trade (on macro level). It provides a rigorous framework for evaluating the benefit of adopting intermodal transportation. Another contribution is the optimized network of NSR's intermodal transport considering both costs and time of transport. Most of the studies optimize transport network by minimizing the transport costs. However, not only cost but also efficiency and reliablity in getting food products to the market is especially important in explaining the pattern of food trade.

The remain of this paper is organized as follows. Section 2 presents the gravity model in terms of theoretical background and model specification. It is followed by the data description in Section 3. In Section 4, the results have been analyzed in details, together with the forecast of trade volume based on optimized costs of intermodal transport. Section 6 offers the conclusion.

2 The gravity model in international trade

Trade between nations is an essential part of the global economy and can be affected by a wide range of factors. Since the seminal work of Tinbergen (1962), the success of gravity model in analyzing international trade has been well known. In a simple gravity model, the volume of trade between two countries is proportional to their national incomes and inversely related to the distance between their economic centers (Martínez-Zarzoso *et al*, 2003; World Trade Organization, 2012). Theoretical foundations for the gravity model have been gradually developed over the past fifty years and are now well established (see Anderson, 1979; Bergstrand, 1985 and 1989; Deardorff, 1998). In this section, we first explain the theoretical foundation for the gravity model and then specify the model.

2.1 Theoretical background

Equilibrium bilateral trade flows are determined within a competitive supply and demand system. According to Anderson (1979), the total import demand of any given country for the specific commodity is derived from maximizing the constant elasticity of the substitution (CES) utility function. The supply equation is derived from the firm's profit maximization procedure in exporting countries with resource inputs allocated according to the constant elasticity of transformations during the production process (Anderson, 1979). The gravity equation is a reduced form of this demand and supply system (Bergstrand, 1985 and 1989).

Yet, the trade flow between two countries depends not only on their demand and supply conditions, but also on the trade resistance factors between them (Bergstrand, 1985; Geraci, and Prewo, 1977). These factors include transport costs, discriminatory (or preferential) trade arrangements, and non-quantifiable factors including whether the countries are landlocked, share a common language, land border, or colonizer and so forth (Anderson, 1979; Bergstrand, 1985; Baier and Bergstrand, 2001). It is expected that more goods will be sold to a region with which the exporter has a relatively low trade barrier.

Here, we emphasize the significant impact of transport costs on trade flows. Limao and Venables (2001) provide evidence that the elasticity of trade with respect to the freight cost factor in the range -1 to -2.5. Similarly, Clarke *et al.* (2004) estimate an elasticity of -1.3 for country-specific transport costs. A number of studies have used distance as a proxy for transport costs. But more recently work has sought to measure directly the determinants of transport costs, such as distance, unit value of traded goods, transport infrastructure and economies of scale (Clark *et al.*, 2004; Martinez-Zarzoso et al., 2008;).

2.2. Empirical model

A simple gravity model to estimate the trade flows from country i to country j can be expressed as:

$$T_{ij} = f\ (Y_i, Y_j, R_{ij}) \tag{1}$$

where T_{ij} is the export volumes from country i to country j, Y_i the total GDP for exporter i, Y_j the total GDP for importer j, and R_{ij} a vector of trade resistance factors for exports from country i to country j. The resistance factors include the transport costs from the origin to the destination market ($COST_{ij}$) and dummy variables. In this study, two dummy variables are included: the membership of a regional trading agreement (RTA_{ij}), and landlocked countries ($LANDLOCK_i$). RTA_{ij} takes the value 1 when trading partner i and j are members of the same regional trading agreement. $LANDLOCK_i$ takes the value 1 if country is landlocked and zero otherwise.

Furthermore, one of the simplifying assumptions for the gravity model is the perfect substitutability of goods across countries. However, studies have revealed that even the most disaggregated manufactured commodities marks them as differentiated products (Bergstrand, 1985). A gravity equation would be more appropriate if it considers the differentiation factors. In order to capture the different prices of product k in both country i and country j and their impacts on the trade volume, we introduce two price variables in the model. The augmented gravity model therefore is given as:

$$T_{ijk} = \beta_0 + \beta_1 Y_i + \beta_2 Y_j + \beta_3 COST_{ij} + \beta_4 RTA_{ij} + \beta_5 LANDLOCK_i + \beta_6 P_{ik} + \beta_7 P_{jk} + \sum_{i=1}^{K} \beta_m F_{ij}^k + \varepsilon_{ijk}$$
(2)

where T_{ijk} is the export volume of product k from country i to country j, P_{ik} (P_{jk}) the export price of product k in country i (j), F_{ij}^k ($k = 1, \dots, K$) the set of dummies representing k types of products exporting from country i to country j and ε_{ijk} is a normally distributed error term with $E\ (\varepsilon_{ijk}) = 0$. All variables except dummy variables take the natural logarithm.

The GDP captures the productive capacity of the exporting country and the purchasing power of the importing country. The coefficient of the GDP variables is expected to be positive, while the coefficient of the transport costs is anticipated to be negative. The coefficients are expected be positive for regional trade agreement dummy and negative for the landlocked dummy. Trade volume is assumed to be negatively correlated with exporter's price and positively correlated with importer's price.

3. The data

This study is motivated by the EU food port project and thus will focus on major trading partners. Instead of using aggregated volume of national trade, we choose the import volumes between NUTS-2 regions. It will lead to more precise estimation of transport distances and corresponding transport costs. We select ten NUTS-2 level regions from six North Sea countries, including West Flanders (Belgium), Southern Denmark (Denmark), Bremen (Germany), Västsverige (Sweden), East Yorkshire (United Kingdom), North Yorkshire (United Kingdom), South Yorkshire (United Kingdom), West Yorkshire (United Kingdom), Eastern Scotland (United Kingdom) and Vestlandet (Norway). These regions embrace a dynamic inter-regional trade, covering a wide range of food products. Nine major food products have been selected and can be categorized by SITC Rev. 4 (Standard International Trade Classification) as follows:

- SITC-01 - Meat and meat preparations
- SITC-02 - Dairy products and birds' eggs
- SITC-03 - Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof
- SITC-04 - Cereals and cereal preparations
- SITC-05 - Vegetables and fruit
- SITC-06 - Sugars, sugar preparations and honey
- SITC-07 - Coffee, tea, cocoa, spices, and manufactures thereof
- SITC-08 - Feeding stuff for animals (not including unmilled cereals)
- SITC-11 - Beverages

Due to the data quality issue, we cannot use panel data set. Instead, we collected data on the dependent and explanatory variables for the year 2010. As data on regional trade flow volumes are extremely rare, we make volume estimations in two steps. First, the amounts of national import have been collected from Eurostat and cross-checked with their national statistics databases. Second, national import data is disaggregated to regional level by weighted measures. These measures vary across food category and take into account various factors such food production volume, live animal population, land resources, regional population and regional employee number (see detailed calculation in Appendix 1). Similarly, national GDP (million Euros) is collected from the Eurostat and then multiplied by the population share of the region. The export price is calculated as the national export value in Dollars divided by its corresponding export volume in Kilograms. All GDPs, costs and prices are in 2010 values.

The transport costs is measured in Euros per ton based on a unit cost model developed for the food port project. The modeling process of transport costs is out of scope of this paper, but a brief description of distance calculation will be presented below. The cost of all-road transport by truck is estimated first. Instead of measuring the distance between regions' geographic midpoints, the distance between regional centers of gravity has been measured. The gravity center is found by choosing the three largest cities in each region and weighting by their city population (Figure 2). For the intermodal transport, Ro-Ro vessel is used in this study, which is one of the most dominant vessel types for food transport in the NSR. It is assumed that the intermodal transport is composed of short sea shipping by Ro-Ro vessel and land transport by truck from regional center of gravity to its nearest major port associated with food transport. Land distances were taken from Google map, and sea distances were obtained from the online calculator (http://sea-distances.com/). The center of gravity and port for each region are summarized in Table 1.

Table 1. NUTS-2 region, center of gravity and food port

Country	NUTS-2 region name	NUTS-2 code	Regional center of gravity (Latitude)	Regional center of gravity (Longitude)	Regional port
Belgium	West-Vlaanderen	BE25	51,061,502	3,171,278	Longitudee Zeebrugge 3,171,278
Denmark	Southern Denmark	DK03	55,441,711	9,756,775	Esbjerg
Germany	Bremen	DE50	53,159,443	8,764,611	Bremerhavn
Sweden	Västsverige	SE23	57,620,769	12,147,779	Gothenburg
United Kingdom	East Yorkshire and North Lincolnshire	UKE1	53,735,787	-0.272612	Immingham
	North Yorkshire	UKE2	54,112,143	-1,077,814	Immingham
	South Yorkshire	UKE3	53,431,639	-1,352,763	Immingham
	West Yorkshire	UKE4	53,799,152	-1,635,037	Immingham
	Eastern Scotland	UKM2	56,058,255	-3,242,413	Rosyth
Norway	Vestlandet	NO05	61,212,069	5,874,585	Kristiansund

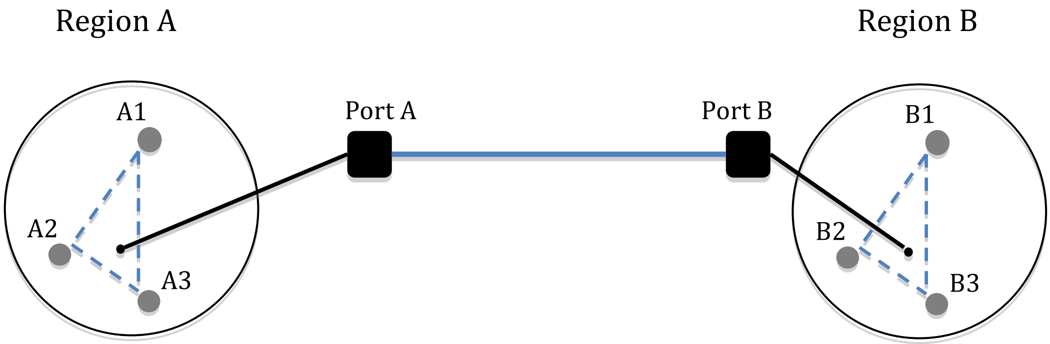

Figure 2. Conceptual framework of intermodal transport

4. Estimation results and simulation

4.1. Estimation of gravity model

The estimation is run on the pooled data across nine food categories differentiated by eight product dummy variables. There are 594 observations. All variables except dummies are in natural logs. The Ordinary Least Square technique is performance on Equation 2 and results are shown in Table 2.

Model 1 presents the results based on a simple gravity model, including GDPs and transport costs as explanatory variables. All coefficients have the expected signs and are highly significant. The cost of transport is the most influential factor for the trade flow. One per cent cost increase can reduce the import volume by 2.13 per cent. The result also shows that importer and exporter income variables have a positive influence on the bilateral trade. Importer income elasticity (1.94) is higher than exporter income elasticity (1.26), indicating that exports are more sensitive to changes in importer's income. Two other trade resistance factors, regional trade agreement and landlocked country, are included in Model 2. Being landlocked significantly deters trade, showing a negative impact that geographical variables could exert for trade. On the other hand, regional trade agreement has a positive but small effect on international trade. This may due to that all six countries except for Norway are EU members who already enjoy free trade among each other.

In Model 3, export food prices for two markets have been added and both price variables are highly significantly. The model's fitness ($Adjusted\ R^2$) has also improved by 0.042, suggesting that one needs to account for price terms in bilateral trade analysis. In particular, the export price in the origin market is the second most important determinants of export volume, after the transport costs. The opposite signs of two price terms denote that a country's higher export prices strongly discourage its export volume but have a positive effect on its import volume. In Model 4, food category dummies are included. The model's fitness is improved, but only F_3, F_6, and F_8 are significant.

Table 2. Gravity models of food trade flows (2010)

	1		2		3		4	
Constant	18.32***	(5.85)	23.52***	(7.48)	23.21***	(7.63)	23.505***	(8.03)
GDP_i	1.26***	(6.15)	1.52***	(7.66)	1.65***	(8.57)	1.71***	(9.20)
GDP_j	1.94***	(9.43)	2.07***	(10.53)	1.94***	(10.08)	1.97***	(10.57)
$COST_{ij}$	-2.13***	(-13.43)	-1.93***	(-11.45)	-1.92***	(-11.74)	-1.88***	(-11.71)
RTA_{ij}			0.53**	(2.38)	0.55***	(2.58)	0.52**	(2.43)
$LAND_i$			-1.76***	(-7.66)	-1.64***	(-7.34)	-1.60***	(-7.46)
P_i					-1.44***	(-6.01)	-1.90***	(-4.49)
P_j					1.03***	(4.23)	0.65*	(1.64)
F_1							0.09	(0.11)
F_2							0.01	(0.01)
F_3							2.00**	(2.13)
F_4							-0.23	(-0.54)
F_5							0.01	(0.05)
F_6							-0.87**	(-2.10)
F_7							0.41	(0.44)
F_8							-1.06**	(-2.10)
R^2	0.281		0.349		0.393		0.451	
$Adjusted\ R^2$	0.277		0.343		0.385		0.437	
$F\ statistics$	76.686	(0.000)	62.999	(0.000)	54.115	(0.000)	31.627	(0.000)

Notes: Dependent variable is T_{ij} and all variables are for the year 2010. All variables except for dummies are in nutural log form. White Heteroskedasticity-Consistent t-values are in brackets for coefficients. Significances are in brackets for F statistics.

***,** and * indicate significance at 1, 5 and 10% levels respectively.

We compare the coefficient of transport costs with previous studies and found its effect is higher in food sector than in other sectors such as motor vehicle and electronic home appliance, as well as in aggregated trade flows (Martínez-Zarzoso *et al*, 2003; Clark *et al.*, 2004; Martinez-Zarzoso et al., 2008;). This can be proved by Korinek and Sourdin (2009) who found that maritime transport cost overall accounted for 10% of imported value of traded agriculture goods in 2007. Therefore, changes in transport costs will cause severe fluctuation on food trade.

3.2 Simulation of intermodal transport costs

Moving beyond the present truck transport, we introduce the intermodal solution to the food transport in the NSR. Most of food product is now moved by truck because of its feasibility. But there is an increasing demand from public to minimize road traffic and build sea corridors for cargo transport. For longer distance in particular, shipping is more environmental friendly and can relief the congested European highways. Yet, it also has weakness in terms of frequency and transit time. Moreover, infrastructure linking the inland cities with the port may be underdeveloped. Naturally, shippers will only choose intermodal route when it can make saving on transport costs compared to all-road transport. However, for certain products, shippers' concern goes beyond the competitive transport costs. Most fresh foods, such as fresh meet, fish, vegetables and fruits, are expected to move to market as quickly as possible. Longer transport time or delays will significantly increase the risk of food deterioration during transport. For this reason, transport time is also crucial in keeping the taste and value of fresh food.

As an outcome, an optimized intermodal transport is proposed for bilateral food trade in the NSR. More specifically, the current truck transport between certain trading partners will be replaced by intermodal transport only when the latter has lower costs and less transport time. Otherwise, food shippers keep using all-road transport. Costs of optimized intermodal transport can be found in Table 3.

Table 3. Costs of optimized intermodal transport

Destination / Origin	BE25	DK03	DE50	SE23	UKE1	UKE2	UKE3	UKE4	UKM2	NO05
BE25										
DK03	49.14									
DE50	37.93	26.12								
SE23	92.36	32.53	47.55							
UKE1	37.99	49.68	47.27	56.01						
UKE2	39.53	53.07	50.65	59.4	3.53					
UKE3	35.49	52.19	49.78	58.52	3.98	3.98				
UKE4	37.33	53.83	51.41	60.15	4.3	2.57	2.44			
UKM2	65.34	52.26	53.37	55.96	17.52	13.48	16.43	14.95		
NO05	99.09	86.45	91.51	54.18	90.7	94.09	93.21	94.84	82.41	

Note: Costs are assumed to be symmetrical between orgin and destinations, therefore costs for only one-way transport are presented in the above table. Cells with colour refers to the costs of intermodal transport, otherwise the costs of all-road transport.

In order to estimate the relative contribution of intermodal transport to trade flows, we apply the optimized transport costs in Table 3 to Model 3. It can be seen that the bilateral trade volumes on intermodal transport route have generally increased. Volumes have risen significantly among certain trading partners, including West- Vlaanderen (Belgium), Vestlandet (Norway), Bremen (Germany), United Kingdom, and Västsverige (Sweden). Each food type also responses differently to the modal shift and the average growth in trade volume can be found in Table 4. It is noticed that sugar (SITC-06), meat (SITC-01), animal foods (SITC-08), and coffee and tea (SITC-07) have the largest growth rates.

Table 4. Average increase in food trade

Food type	Increase (%)	Food type	Increase (%)
SITC-01 meat	16.85	SITC-06 sugar, salt and honey	17.47
SITC-02 diary and birds' eggs	10.02	SITC-07 coffee, tea, cocoa, etc.	13.60
SITC-03 fish	1.43	SITC-08 animal foods	15.54
SITC-04 cereals	5.87	SITC-11 beverages	3.06
SITC-05 vegetables and fruits	13.33		

5. Conclusion

The relationship between transport costs and bilateral food trade has been tested in this study by using the gravity model. As a trading barrier, transport cost is the single most important determinants of food trade volume, followed by exporter's food price and importer's income level. Compared with previous studies, transport costs tend to have a larger influence on food trade than in other sectors. We also exam the sensitivity of trade flows when shifting the current all-road transport to an optimized intermodal transport. It shows that the level of trade has been improved significantly, although the relative growth differs greatly across the food categories.

One limitation for this study is the time-fixed effect due to the data unavailability. It may be interesting to collect reliable trade data in other years and compare the results by replicating the model. Future estimations for sectors with different logistics process will also be of interest to optimize the cargo transport and promote the international trade.

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Appendix 1. Estimation of regional trade flows

Inputs and definition:

- F_{IJ}: Food trade flows between NSR countries, where *I* and *J* are the country indexes;
- p_j: Population in each region, where *j* is the region index in country *J*;
- a_i: Live animal population, where *i* is the region index in country *I*;
- m_i: Cow's milk production, where *i* is the region index in country *I*;
- f_i: Fish production, where *i* is the region index in country *I*;
- c_i: Land for cereals, where *i* is the region index in country *I*;
- v_i: Land for fruits and vegetables, where *i* is the region index in country *I*;
- s_i: Land for sugar, where *i* is the region index in country *I*;
- g_i: Land for animal food, where *i* is the region index in country *I*;
- n_i: Employee number in food manufactory, where *i* is region index in country *I*;
- b_i: Employee number in beverage manufactory, where *i* is region index in country *I*;
- t_i: Employee number in tobacco manufactory, where *i* is region index in country *I*.

The estimation method:

- Denote food trade flows between NSR regions with f_{ij}, where *i* and *j* represent the origin and destination respectively;
- For SITC 01 – meat, we assume 'the more animals live in a region, the more meat is exported' and 'in the destination region, the more population are there, the more meat is imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{a_i}{\sum_i a_i} \times \frac{p_j}{\sum_j p_j}$
- For SITC 02 – dairy products, we assume 'the more milk is produced in a region, the more dairy products are exported' and 'in the destination region, the more population are there, the more dairy products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{m_i}{\sum_i m_i} \times \frac{p_j}{\sum_j p_j}$
- For SITC 03 – fish products, we assume 'the more fish is produced in a region, the more fish products are exported' and 'in the destination region, the more people are there, the more fish products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{f_i}{\sum_i f_i} \times \frac{p_j}{\sum_j p_j}$
- For SITC 04 – cereal products, we assume 'the more land is used for cereals in a region, the more cereal products are exported' and 'in the destination region, the more people are there, the more cereal products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{c_i}{\sum_i c_i} \times \frac{p_j}{\sum_j p_j}$
- For SITC 05 – vegetable and fruits, we assume 'the more land is used for vegetable and fruit in a region, the more vegetable and fruit products are exported' and 'in the destination region,

the more people are there, the more vegetable and fruit products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{v_i}{\sum_i v_i} \times \frac{p_j}{\sum_j p_j}$

- For SITC 06 – sugar, we assume 'the more land is used for sugar in a region, the more sugar products are exported' and 'in the destination region, the more people are there, the more sugar products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{s_i}{\sum_i s_i} \times \frac{p_j}{\sum_j p_j}$
- For SITC 07 – coffee and tea, we assume 'in a region the more employees are in the food industry, the more coffee and tea products are exported' and 'in the destination region, the more people are there, the more coffee and tea products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{n_i}{\sum_i n_i} \times \frac{p_j}{\sum_j p_j}$
- For SITC 08 – animal feeding stuff, we assume 'the more land is used for animal foods in a region, the more animal feeding products are exported' and 'in the destination region, the more live animals are there, the more animal feeding products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{g_i}{\sum_i g_i} \times \frac{a_j}{\sum_j a_j}$
- For SITC 11 – beverage, we assume 'in a region the more employees are in the beverage industry, the more beverage products are exported' and 'in the destination region, the more people are there, the more beverage products are imported'. So the flow is estimated as: $f_{ij} = F_{IJ} \times \frac{b_i}{\sum_i b_i} \times \frac{p_j}{\sum_j p_j}$