Trade in Value Added: The Challenge of International Trade Statistics

With an Empirical Study on Trade in Norway and the Netherlands 2000-2012

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Thesis for Master in Philosophy in Economics
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Abstract

World trade today is fragmented, and compared to conventional statistics trade in value added provides a better measure on the value created in a country from trade. This because conventional statistics are subject to a double-counting when imported inputs are used in production of exports and therefore inaccurate as measure of the value from trade.

This thesis investigates the relationship between trade in value added and quality of international trade statistics. To calculate TVA an international input-output table is necessary, and this table is created from national input-output tables, combined with bilateral data on international trade. The challenge occurs when we find large deviations in data on international trade. Intuitively, reported imports in Norway from the Netherlands should equal reported exports from the Netherlands to Norway, after adjusting for transport costs. Instead, we find large deviations in such "mirror data", between two values reported on the same flow. Our analysis reveals that average import value reported in Norway exceeds the export value by 100%, and for Asian countries is it often even higher! Such deviations in mirror data affect trade in value added in two ways; first, we need to harmonize mirror values to create an international input-output table and calculate value added. Second, extra costs from services are reflected in some of the deviations, and this should be accounted for as part of the value chain.

We review theoretical and empirical results in the literature on trade in value added, followed by an empirical study on Norwegian imports from 114 countries, and a comparative analysis on the Netherlands trade with 182 countries. The goal of this analysis is to reveal systematic explanations in mirror data discrepancies, due to a country's position in trade. Norway and the Netherlands make good candidates; Norway being small and periphery, and the Netherlands having a central position with a large port in trade. To explain discrepancies in mirror data, we use a method of decomposing them into price and quantity effects, finding systematic differences between the two countries. For Norway price effect increases with distance to partner country, but quantity effect is prominent in explaining discrepancies. The Netherlands has many observations of exports reported as higher than matched imports, likely explained by its position as an entrepôt country .Letting such systematic differences influence harmonization of data can improve calculations of trade in value added.

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Ida Helene Berg

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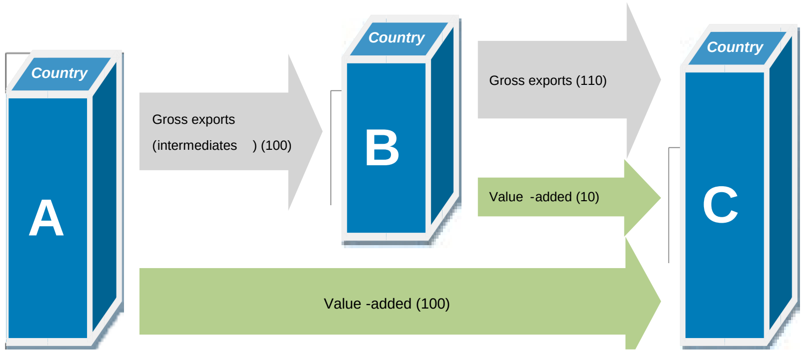
1 Introduction

Today, a final good is produced using inputs from several countries, and because of this conventional statistics using gross numbers are subject to a double-counting and therefore insufficient. To know how a country is affected by trade, we need the measure of trade in value added (TVA). Figure 1 illustrates how the difference between gross and value added trade occurs[1]:

Figure 1: Illustration of trade in value added



Source: OECD-WTO TiVA database, 2013

In this example country A produces goods worth 100 to B, where the goods is processed and a value of 10 is added before C imports the final good. In a conventional measure of total global trade there would be a double-counting, export and import amounts to 210, though only 110 of value added is created in production. Looking at gross bilateral trade, country C will have a 110 trade deficit with B, and no trade at all with A. Measured by value added, this deficit is only 10 to B, and 100 to country A, who is the main beneficiary from consumption in country C (OECD-WTO TiVA database, 2013).

The case study of the Apple iPod by Dedrick, Kraemer and Linden (2010) is an often cited contribution to the literature on trade in value added, investigating how global value chains function in the case of Chinese exports of iPods. The paper reveals that although the gross value of an assembled iPod from a Chinese factory is 144 dollars, only about 4 of these constitutes of Chinese value added. The authors further show that most of the benefit from the innovation of the iPod goes to the Apple Company in the U.S. and its employees, although the

[1] See appendix B for an illustration on sources of multiple-counting.

final product is manufactured abroad. Such measure of where trade generates value provides essential information to policymakers.

We use an international input output table (IO) to calculate trade in value added. This data on the international level is created using national Input-Output tables and Supply and Use Tables (SUT)[2]. SUT's are constructed in various steps; supply tables from total import flow in CIF terms, and use tables from total exports by product in FOB terms. This national data is then combined with bilateral data on international trade (Timmer et al., 2012). In this bilateral data on international trade the challenge occurs, and in their paper on TVA and methodological challenges Miroudot and Yamano state the following:

"Clearly the key challenges in the immediate future concern the quality of trade statistics (…)" (Miroudot and Yamano, 2013, p. 37)

What affects the quality of trade statistics? In bilateral data on international trade, every trade flow is recorded twice; as import in the importing country and as export from the exporting country. CIF values (Cost Insurance and Freight) includes transportation costs and are generally reported by the importer, and exporters report FOB (Free on Board) values. These two values are *mirror data* on the same flow. A study on such mirror data is in Hummels and Lugovskyy:

"*Matched partner data departs radically from national source data in levels*" (Hummels and Lugovskyy, 2006, p.83)

Intuitively these mirror values should be the same after adjusting for transport costs, but data consists of several observations on large differences between CIF- FOB that cannot be explained solely by transport cost. When we look at Norwegian statistics on imports from the USA and China in 2012, it is reported as 4.2 USD billions and 6.5 USD billions respectively. In matched partner data on exports reported from USA the value is 2.9 and 30% smaller, and for China the difference is as much as 56% with a value of exports at 2.8 (UN COMTRADE database).

[2] A supply and use tables is a type of input output table and is recorded as a matrix. The supply part consists of goods and services produced domestically, *and imports*. The use part is on how these supplies are allocated to produce final goods, intermediates *and exports* (OECD Glossary of Statistical Terms). Together with a symmetric input-output table showing output values for different inputs, these provide detailed information on the production and use of goods in an economy.

Such discrepancies in data influence the measure of TVA in the following two ways:

First, to calculate TVA, transport costs have to be cleaned out from CIF. In SUTs, the respective use tables needs to be compatible with export reported from partner countries, and imports have to be converted into FOB terms (Timmer et al., 2012, p.32-33). When CIF-FOB deviations are as high as 100% or 200%, these values needs to be further harmonized, and there is no conclusive method to do this. The international IO table is then created from the adjusted mirror values, hence: how deviations are adjusted can affect measures of TVA. This relationship is illustrated in figure 2:

Figure 2: Relationship between mirror data harmonization and calculation of TVA

Step 1: Collection of national statistics on trade and *harmonization* of discrepancies in data

Step 2: Construction of Supply and Use Tables (SUTs) and International Input-Output Tables (IO)

Step 3: Calculation of TVA by the use of SUTs and IO

Second, with such high deviations, we need to look for other explanations in addition to transport costs. If services add costs to exports on the way, then after excluding deviations coming from different errors, the remaining “true” CIF-FOB difference is a measure of this value added, and should be accounted for.

The thesis undertakes a theoretical and empirical research on the relationship between trade in value added and discrepancies in mirror data on international trade. The purpose of the theoretical part is to know more about development and policy implications from TVA, both in general and for Norway in specific. The empirical research is a descriptive analysis on discrepancies in Norwegian imports from 114 countries, and the Netherlands trade with 182 countries, using UN COMTRADE data on international trade downloaded from World Integrated Trade Solution (WITS). To explain discrepancies in mirror data, we use a method of decomposing them into price and quantity effects.

The goal of this comparative analysis is to reveal systematic explanations in mirror data discrepancies, due to a country’s position in trade. We chose these two countries because of their different position in trade; Norway is small and periphery, the Netherlands has a central position with a large port in trade. From the comparative analysis we found evidence on systematic difference in discrepancies between the two.

The paper is structured as follows: Chapter 2 shows the relevance of trade in value added compared to conventional statistics, and discusses previous literature and research together with a formal calculation. Chapter 3 introduces the term mirror data, explanations of discrepancies, different approaches to harmonize these, and examples of previous research on mirror data in Norway. Chapter 4 presents and describes the data and methodology, together with a descriptive analysis on Norwegian imports. In chapter 5, two hypotheses are developed together with a comparative analysis with the Netherlands, and chapter 6 presents the conclusions.

2 Literature overview

To better understand world trade today from the perspective of trade in value added, several papers have been published. The literature on TVA shows both its importance for policymakers, and complexity in measure.

One of the earliest works done to formalize the global nature of production can be traced back to the 1960s and Leontief's multiregional input-output models (Leontief and Strout, 1963). Leontief was the first to use a matrix representation of such a model, showing the interdependencies between different branches in national or regional economies. This tool has been further developed to study trade between countries, and TVA.

Later economic literature on TVA can be divided into two streams (OECD-WTO, 2013). The first stream is mostly conceptual in its analysis of trade in intermediate goods and services. The notion that intermediate goods not only consist of raw materials but also products containing value added, can be traced back to Sanyal and Jones (1982).

The second main stream is empirical in its approach. The concept of "vertical specialization", was first introduced by Hummels et al. (2001), focusing on the import content of export[3]. A survey on the importance of trade in intermediates is one of the first steps to measure trade TVA. Today as percentage of world trade, intermediates accounts for 56% of the trade in the case of goods, and 70% in the case of services (Miroudot et al., 2009).The challenge lies in separating foreign and domestic value added in gross exports because a final product is today likely to consist of different parts produced in different countries. In a classical Heckscher – Ohlin framework, we could understand this as countries utilizing their advantages from factor endowment in trade with intermediates, in addition to final products. This creates a vertical trading chain, and according to Hummels et al. (2001) there are three conditions that need to be met in order to have vertical trade: (1); a good (or service) is produced in two or more sequential stages, (2); two or more countries provide value-added to the production process, and (3); at least one country uses imported inputs in the process and some of the output is exported. Following these criteria, the share of vertical specialization in world trade amounts to 25%, if we take into account both direct and indirect imported inputs as suggested in the article. Important to notice is that Hummels et al. (2001) makes the assumption that a

[3] Using input-output tables for ten countries from 1970 to 1990.

country's export is entirely consumed abroad as a final good. This rule out scenarios where intermediates are exported, used in production of final goods abroad, and then "reflected" and consumed back home (Johnson and Noguera, 2012)[4].

Stehrer (2012) divides the concept of value added in trade flows into two parts: "value added in trade" (VAiT) and "trade in value added" (TiVA), looking at how value is created on the supply side and the demand side separately.

First, akin to Hummels et al. (2001), "value added in trade" measures the domestic and foreign value added content in a country's gross exports and imports, focusing on the supply side and where the inputs come from. For Norwegian imports, this is value created from all stages of the vertical specialization chain, in the countries we import from both directly and indirectly.

Second, "trade in value added" looks at how value added is created in one country due to consumption in another country of both final and intermediate goods. This concept shifts the focus towards the demand side in international trade. In the previous example of countries A, B and C, this will be the value added created in A due to consumption abroad in country C[5].

How are these two ways of looking at value added related to each other? Stehrer argues that for both there are two requirements that need to be satisfied in bilateral relations:

First is *the adding-up requirement*, telling us that by summing up all bilateral flows, a country's *total* trade balance with the world does not change when measured in value added terms. The net trade balance for a country is the same as its value added. This is similar to looking at a national input and output table where exports include both intermediates and final goods (the nations value added), but the imported intermediates will be subtracted and not count as domestic value added. For a single country its net exports equals to income (export of both intermediates and final goods), minus consumption (import of both intermediate and final goods). If we add up for the entire world, the trade in intermediates will cancel out so world demand for products (world GDP) equals world consumption (Stehrer, 2012).

[4] See appendix B for an illustration.
[5] The input- output approach can be used to answer the question of how much of value added from one country is contained in the consumption of another country (Stehrer, 2012).

Second, *the symmetry requirement* requires that in bilateral relations, country 2's value added import from country 1, must equal the value added export from country 1. This requirement is also called *the negative symmetry property*, since one country's net trade in value added turns out negative in the other country's balance, for both TiVA and VAiT:

$$TiVA^{country1}{}_{net} = -TiVA^{country2}{}_{net}$$

If these two requirements are met, a country's net "trade in value added" (i.e. the total trade balance) equals its net "value added in trade". So both ways of measuring value added results in the same level of net exports in a country's *total* trade.

As previously mentioned, this is not necessarily the case for *bilateral* trade balances, where the net trade balance can differ from trade balance measured from the concept of "value added in trade". This corresponds to the previous example of US and China where value added trade balance and gross trade balance were different.

From the introduction we recall the problem of mirror data discrepancies in data on international trade, how such deviations can affect the calculation of TVA, and further causing that these two requirements are not met accurately.

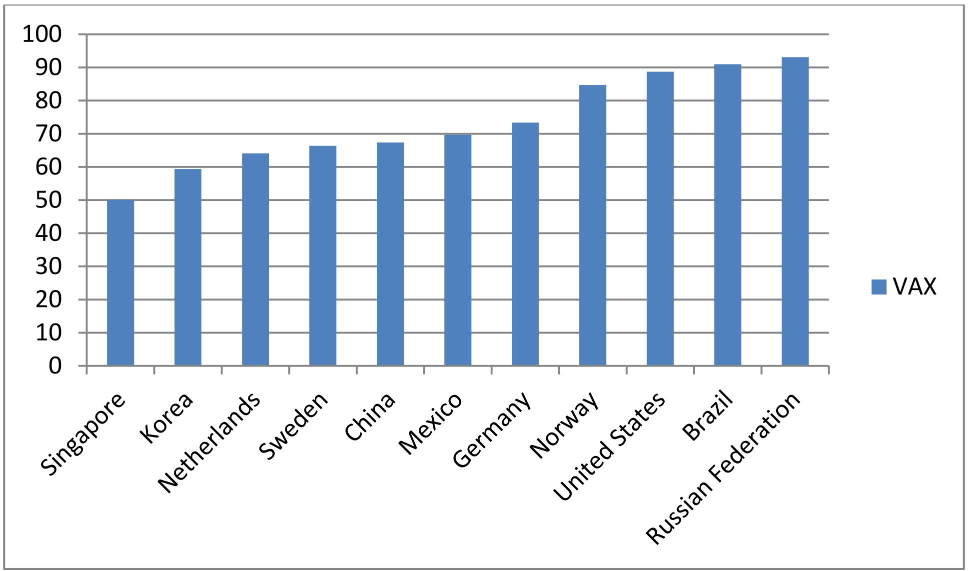
I will now mention some of the empirical results from Stehrer (2012), when trade between countries is measured in light of the two concepts of VAiT and TiVA[6]. On the aggregate level, we can recall that either of these two ways of measurement equals the country's trade surplus or deficit. China has the largest trade surplus on the aggregate level, followed by EU-27 and Japan and the USA has the largest deficit. For bilateral trade it is possible to see whether supply or demand side dominates as source of value added, by using Stehrer's two concepts. For emerging countries trading with developing countries, their trade surplus in TiVA (demand side) is reduced compared to VAiT (supply side). An explanation of this can be that VAiT in bilateral trade is vulnerable to double counting of import and exports already containing both intermediates and final goods. The general picture on the results shows that both trade surpluses and deficits tend to be smaller when measured from the demand side, compared to the supply side.

[6] Using The World Input-Output Database (WIOD), covering 41 countries and 35 industries.

2.1 Development of TVA

To describe the nature of international trade for the past 20 years, we use the terms “global manufacturing” and “international supply chains”. As previously mentioned, a export is often produced using inputs from different countries, and neither do we import only final goods. This process results in a “global value chain” (GVC), following the product from its conception to its end use. Import and export of intermediates and the value added from different stages in a GVC, plays an important role in analysing world trade today.

Figure 3: Domestic Value Added in Exports as Percent of Gross Value (VAX ratio), 2009



Source: OECD-WTO TiVA database.

In figure 3 we see that imported intermediates can account for a large share of a country’s export, as much as 50% in the case of Singapore. In relation to our topic on quality of international statistics on trade, these numbers might differ some. An example from UNCTAD[7] is reported VAX ratios for the following year at only 36% in Singapore and 47% in the Netherlands, implying 14% and 17% decrease from the 2009 TiVA database numbers, respectively. The general picture is still that many countries rely on imported intermediates in the production of exports.

There is now increased access to data on TVA, mainly coming from the OECD-WTO database on trade in value added launched in 2013. Initiative on TVA also comes from other

[7] United Nations Conference on Trade and Development.

databases covering world trade, such as The European Commission's World Input-Output Database (WIOD), the World Bank's WITS, and the United Nation's UN COMTRADE and UNCTAD.

Johnson and Noguera (2012) use global input-output tables from the OECD and IDE-JETRO database for Asia, analysing fragmentation and value added for 42 countries from 1970 to 2009. In the same paper, the value added to gross exports ratio (VAX ratio) is introduced to indicate whether fragmentation in trade is increasing or declining[8]. To better understand the relationship between product fragmentation and TVA, we can look back at the example from the OECD-WTO database in chapter 1. A country that trades in intermediates will have the conventional measured gross trade in excess of value added trade[9]. Thus, a *decrease* in VAX ratios implies an *increase* in product fragmentation, and the domestic value added share is *decreasing* when more imported intermediates is used.

Further, the development of VAX ratios is divided into three parts; for the world as a whole, individual countries and pairs of countries. The VAX ratio for the world is computed as the sum of value added exports, divided by the sum of gross exports across all country pairs and sectors (Johnson and Noguera, 2012, p. 14). For the world as a whole the results are divided between VAX including shipments to/from the rest of the world (RoW), and VAX excluding these. The main findings in Johnson and Noguera (2012) are as follows:

- The world VAX ratio declines by 0.10 including RoW, and by 0.13 excluding RoW[10].

This change world trade can be divided into two waves of increasing fragmentation; one in the 70's and one in the 90's, with no change in the 80's. The sharp decline of world trade in 2009 mitigated the decline in the VAX ratio for the world. Foreign direct investment (FDI) has increased notable during this same period (Contessi and Weinberger, 2009), and intuition tells us that the factors that increase production fragmentation, such as trade agreements, technology and openness, are likely to increase FDI as well.

- For individual countries, nearly all experience falling VAX ratios.

[8] See appendix B for an illustration of VAX ratio components.
[9] This assumption holds for intermediates used to produce goods absorbed in the destination, not accounting for redirection to source country or a third country (Johnson and Noguera, 2012).
[10] Vax ratio including RoW is larger partly because of the assumption that all export to the ROW is absorbed there (Johnson and Noguera, 2012).

The source and timing of the decline differ among countries, and are correlated with different country characteristics. A further look at heterogeneity between countries shows that the VAX ratio decline is on average larger for emerging markets[11]. Examples on levels of change in such emerging markets are -0.28 in Vietnam and -0.31 in Thailand, compared to -0.05 for Switzerland and -0.11 in the US. As in figure 3, countries with general large domestic production such as US, Russia and Brazil, rely less on imports of intermediates and the domestic value added share is high. This also goes for countries who exports raw materials, Norway making the special case here with an *increase* in VAX ratio of 0.07. This increase might follow high domestic value added content in exports from our specialization in oil extraction, and is further mentioned in section 2.4. Countries like Singapore and Korea supports intuition that smaller countries in general rely more on imported intermediates, and thus have a smaller domestic value added share.

- For bilateral relations there is wide variety for change in VAX ratios.

This variety is found both over time and in cross section data for country pairs. The article suggests several explanations of the bilateral changes in VAX ratios. An example of this is the difference between countries in reflection/redirection of trade, where intermediates are shipped from one country to the other, but then "reflected" back as final goods produced by the second country. This decreases the VAX ratio, as it creates a double counting in gross exports when the shipments to the second country is not absorbed there but again exported back.

Following timing of change for VAX ratio in individual countries, it also differs for bilateral relations, with a sharp divergence after the 90's. In some cases like Mexico and Canada, this is explained by changes in trade policy from the creation of NAFTA[12]. Another explanation to changes in bilateral VAX ratios over time is trade costs. These are costs, or non-policy barriers, such as distance, language, and other borders. They also evolve over time from changes in technology and policies. Looking at VAX ratios for different sectors, the composition of export is the main source of change. Across sectors, the authors found that the ratio for manufacturers is low relative to services, since services are used as intermediates in production of manufacturing exports . I will briefly address the special role of services in the next section.

[11] Because these countries on average has higher growth than developed countries (Johnson and Noguera, 2012).
[12] North American Free Trade Agreement.

2.2 Services

Trade in services is of increasingly importance to both developed and developing countries. Trade in services differs from trade in goods for two main reasons; intangibility and non-storability. An additional third characteristic making services special is how it is affected differently by trade policies, than trade in products (Dee, 2001). Having quality data for trade in goods to calculate revenues from tariffs is important for policymakers. Data on trade in services might be of less importance in this sense, and is generally in poorer quality partly from the challenge of applying duties and measurement due to its different characteristics. (Timmer and Erumband, 2012) look at the supply side of trade in services, and divides them into four modes:

- Mode 1, Cross-border services supplied from the territory of one country to the territory of another.
- Mode 2, Consumption abroad services supplied in the territory of a nation to consumers of another.
- Mode 3, Commercial presence services supplied by any type of business or professional establishment of one country in the territory of another (FDI).
- Mode 4, Services supplied by presence of natural persons from one country in the territory of another.

These four modes are useful, since reporter countries might differ in how data on services is reported. An example of this is change in creation of data for Norwegian trade in services, from "currency statistics"[13] following country of ownership payments was made to, to surveys from a selection of enterprises. From 2009 registrations followed geographic locations, and for Norwegian shipping services this would shift from country classification in exports due to nationality of the firm paying for the service, to statistics being based on port registrations (Melchior et al. 2014).

Relevant for our analysis on TVA, Cernat and Kutlina-Dimitrova (2014) presents a Mode 5 approach to service trade. The authors look at the growing importance of services as inputs in manufacturing sectors, both inside and outside the EU. The "mode 5" covers this type of

[13] In Norwegian: "valutaregisteret", of the Norwegian Central Bank.

indirect services embodied in products, as they also create value added. Using the TiVA database to calculate the export share of "mode 5" services, the authors find that it is substantial in total merchandise trade, and in EU it accounts for 34% of merchandise exports. The substantial shares of indirect value added in merchandise trade changes manufactured goods into "*a complex bundle of products and services interactions*" (Cernat and Kutlina-Dimitrova, 2014, p.2).

Direct and indirect trade in services is part of the global value chains, and like trade in products it creates employment and value. Since data on trade in services is still a developing field and this is reflected in data available, the datasets used for the purpose of this thesis is on trade in products. Still, relevant for our analysis of CIF-FOB differences, is how these can be a measure of value from services added on the way. This relationship between mirror data and value added will be discussed when we look at the price component of CFR in chapters 4 and 5.

2.3 Policy implications

This section discusses the role of policymakers in light of increased fragmentation in international trade. We have seen that a country's bilateral trade deficit might differ between a measure in value added terms and a conventional measure on gross numbers. The US trade deficit with China is often referred to in this context. Measured in value added the trade deficit could fall with as much as 25% compared to traditional measure using gross export (Schneider, 2013). This is because a significant share of China's export consists of imported intermediates. Using the gross value of Chinese export gives the misleading image that everything is produced in China, and affects perceptions on the political volatile US-China trade deficit.

TVA tells policymakers where trade creates employment. If a value added measurement reveals a country depends largely on imported intermediates in the production of export goods, the overall dependency on export for job creation might be smaller than previously thought. This new knowledge can affect policymaker's decisions on topics such as tariffs and investment.

The OECD-WTO database presents a list of what measures of value added can tell us (OECD-WTO, 2013):

- The significantly higher contribution made by services in global value chains
- The role of imports of intermediate goods and services
- The true nature of economic interdependencies
- The role of emerging economies in global value chains
- How supply and demand shocks might impact on downstream and upstream production

Policy implications that arise from the knowledge of TVA can roughly be divided into three parts:

First, *imported intermediates are used as factors of production in a country's export.*

This issue complicates the use and effects from imposing a tariff on imported goods. A tariff imposed to protect domestic production might actually hurt the export sector, if it relies on imported intermediates in its production. Since competition today is mainly between international firms and not nations, it can be argued that the optimal tariff rate structure is flat (OECD-WTO, 2013). This to ensure access to inputs and technology that is likely to cross borders several times in the production process. Previously we mentioned the case of domestic value added in exported intermediates that is "reflected" back in imports. In this case "beggar thy neighbor" strategies could turn into "beggar thyself" from miscalculating the trade flows. Finally, fragmentation in trade highlights the importance and complexity when deciding the actual origin of a product, when tariffs are decided from the "Rules of Origin" (RO) in trade agreements.

Second, *a country's participation in GVC's sheds light on where employment is created.*

How does trade liberalization affect employment, and how can we estimate the "job content" of trade? These questions can only be answered by looking at the value added content of trade. The problem of conventional multiple counting when goods cross borders several times can overstate the importance of exports to GDP, a country's imports can reflect domestic value added and a “made in China” label can actually mean “made in Taiwan, Thailand and Vietnam”. Kommerskollegium (2007) shows that antidumping measures taken to protect European companies can actually hurt themselves. To understand this we must divide between the “production” part and the “manufacturing” part in making the final product. The manufacturing part is often outsourced to a low cost country, but the study shows that the production part , mainly services such as research, marketing and logistics, contains high skill tasks often performed in industrialized countries. Within the multinational enterprise the better paid production part captures a larger share of the value added than the manufacturing part, and the comparative advantage is applied to “tasks” rather than “final products” (OECD-WTO Joint note, 2013, p .8). This explains why anti-dumping measures can in some cases hurt the countries initially meant protected.

Third, *taxes are imposed on the national level; firms operate on the international level.*

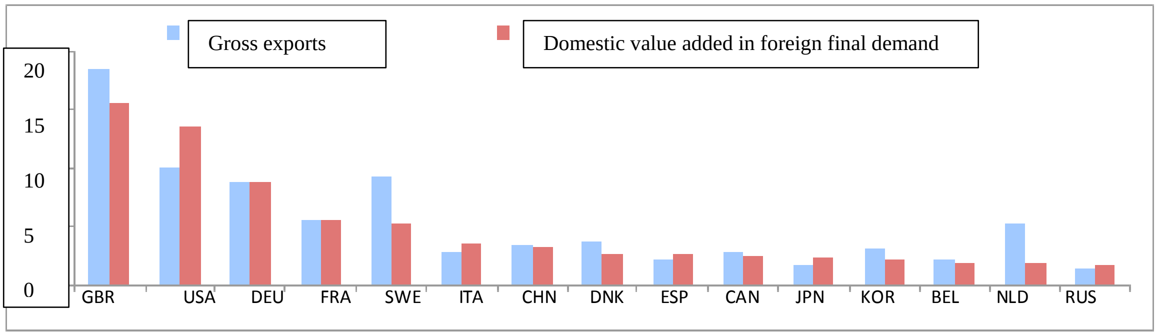
This gives rise to economic incentives for firms to allocate profit and resources in order to avoid taxes. This can have an effect on national employment, and is of importance for policymakers when deciding taxes and tariffs. When profit is allocated to avoid taxes it is often referred to as “transfer pricing”, and might explain some of the initially mentioned mismatches we find in trade data. When taxes and tariffs are decided from “Rules of Origin”, international firms can have further incentives to allocate production in order to benefit from such agreements.

2.4 TVA in Norway

Measures of Norwegian TVA are from the OECD-WTO database, if not otherwise stated. This database covers 5 years between 1995 and 2009, looking at development for individual countries.

The upstream activity of oil extraction (Mining) plays a significant role in the Norwegian economy. In value added terms it accounted for just over 50% of total exports in 2009, an increase from 40% in 1995. As shown in figure 3, domestic value added content of export for 2009 amounts to 85%, which is a relatively high number compared to other OECD economies. When most of the other countries had an overall decline in VAX ratio, Norway experienced a fall in the share of foreign content of exports in between 1995 and 2009, for most sectors. This was mainly caused by a fall in European content, mostly in the transport and telecommunications sector (OECD-WTO TiVA country note Norway, 2013). When trade in Norway is measured in value added terms the trade balances might differ, as illustrated in the following 3 figures:

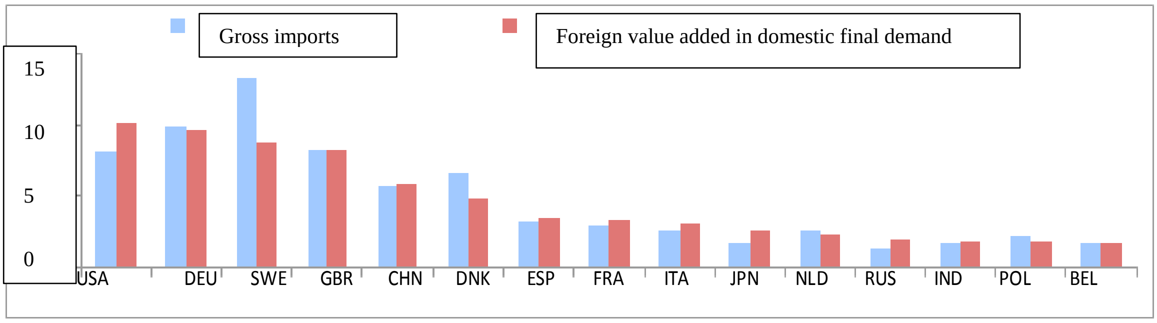
Figure 4: Partner shares in Norwegian exports, gross and value added terms, in % of total, year 2009



Source: OECD-WTO *TiVA Indicators, country note for Norway* (2013).

In figure 4 we see increased importance of USA as export market for Norway, compared to a decrease for both UK (GBR) and Sweden (SWE). This can be explained by Norwegian value added imported in UK and Sweden as intermediates, and then the final goods are exported to USA.

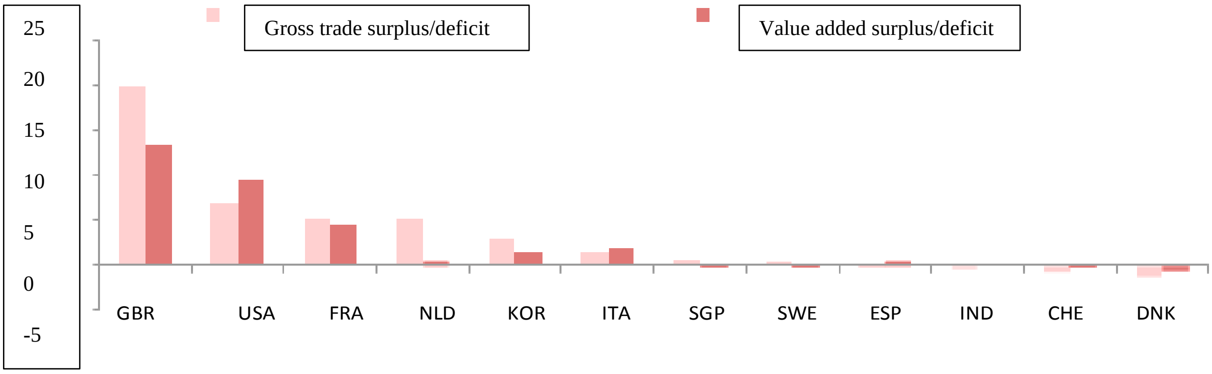
Figure 5: Partner shares in Norwegian imports, gross and value added terms, in % of total, year 2009



Source: OECD-WTO *TiVA Indicators, country note for Norway* (2013).

Sweden is one of the main countries we import from, but it depends less on exports to Norway when measured in value added terms. The opposite is the case for USA and their value added from Norwegian final demand exceeds Norwegian imports in gross numbers.

Figure 6: Bilateral trade Balances, gross and value added terms, USD 1000 million, year 2009



Source: OECD-WTO *TiVA Indicators, country note for Norway* (2013).

Due to the same mechanisms described from figure 4, we see the opposite changes in trade surplus for UK and USA when measured in value-added terms. From running a small trade surplus with Sweden in gross terms, we run a small deficit in value added terms due to the change in both imports and exports. We also see a large change from gross to value added trade balance in the case of the Netherlands.

2.5 Formal calculation

In the literature, different methods are used to calculate TVA from international IO tables. To give an example of a formal calculation, I use the two-country case from Koopman et al. (2010). This to make it simple, but without loss of explanatory power. In this two-country case bilateral trade will equal total trade, but we can still see the need for a symmetric input-output table where bilateral trade is harmonized, in order to calculate value added in each country.

We start with the market clearing condition for country *r* is given in equation (1):

$$(1) \quad X_r = A_{rr}X_r + A_{rs}X_s + Y_{rr} + Y_{rs} \qquad r,s = 1,2$$

X_r is the $N \times 1$ gross output vector for country *r*, and the two last terms Y_{rr} and Y_{rs} denotes the $N \times 1$ final demand vector in country *r* for final goods produced in r, and final demand vector in country *s* for final goods produced in *r*, respectively.

The two middle terms come from the use of intermediates in production. A_{rr} is the $N \times N$ Input-Output coefficient matrix giving intermediate use in *r* for goods produced in *r*[14]. Similarly, A_{rs} is the Input-Output coefficient matrix of intermediate use in *s* for goods produced in *r*. This two-country production and trade system can be written in an Inter Country Input-Output block matrix notation, as in equation (2):

$$(2) \quad \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} Y_{11} & + & Y_{12} \\ Y_{21} & + & Y_{22} \end{bmatrix}$$

Using rules for the identity matrix and the inverse of a matrix, we can rearrange the terms:

$$(3) \quad \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} I - A_{11} & -A_{12} \\ -A_{21} & I - A_{22} \end{bmatrix}^{-1} \begin{bmatrix} Y_{11} & + & Y_{12} \\ Y_{21} & + & Y_{22} \end{bmatrix}$$

Writing $X = (I - A)^{-1}Y$ into the form $X = BY$,where X and Y are $2N \times 1$ vectors and A and B are $2N \times 2N$ matrices, B_{rs} denotes the $N \times N$ block Leontief inverse matrix in equation (4):

$$(4) \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}$$

We interpret the Leontief inverse matrix as the total requirement matrix for the producing country. For a one-unit increase in final demand for country *r*, it gives the necessary amount of gross output production in country *s*. Another way to interpret the "Leontief system" by the coefficients in B representing the technology, and the solution gives us the necessary production level in one sector/country in order to satisfy the demand in other sectors/trading countries. In the two-country case, it is not too cumbersome to find the solutions for B_{rs}

[14] See the appendix D for a numerical example of an Input-Output coefficient matrix.

In order to use this framework to measure TVA, we need to decompose into domestic and foreign content of both production and trade. We start out with production and let V_s be the $1 \times N$ direct value added coefficient vector in total output. By saying "direct" we exclude domestically produced intermediates, so each element of V_s equals one minus al intermediate input share from any country:

$$(5) \quad V \equiv u\left(I - \sum\nolimits_s A_{sr}\right)$$

Where u is a $1 \times N$ unity vector. Further, V is defined as the $2 \times 2N$ matrix of direct domestic value added for both countries:

$$(6)\ V \equiv \begin{bmatrix} V_1 & 0 \\ 0 & V_2 \end{bmatrix}$$

In the following calculations, Koopman et al. makes use of the block matrix inverse as their mathematical tool to trace all sources of value added.

We now combine the direct value added shares from equation (5) with the Leontief inverse matrices in (4) and get the $2 \times 2N$ value added share (VAS) matrix:

$$(7)\ VAS \equiv VB = \begin{bmatrix} V_1 B_{11} & V_1 B_{12} \\ V_2 B_{21} & V_2 B_{22} \end{bmatrix}$$

Equation (7) gives the information needed to measure value added by source and at the sector level. The first column represents home production of goods in a particular sector, with $V_1 B_{11}$ and $V_2 B_{21}$ being domestic and foreign value added shares, respectively. Similarly, the second column of $V_1 B_{12}$ and $V_2 B_{22}$ is the domestic and foreign value added shares of production in country 2. To aggregate the analysis from the sector level, one can either use final goods exports or total exports as weights to calculate these shares.

The total value added in production of a good must be either domestic or foreign, so the sum of each column is unity[15]:

$$(8) \quad V_1 B_{11} + V_2 B_{21} = V_1 B_{12} + V_2 B_{22} = u$$

[15] This result from the two country case can be applied the world as a whole, where each country's net trade balance must equal its value added as in the *adding-up requirement* in Stehrer (2012).

We now want to capture all the contributions the value added in each sectors exports to further be able to study supply chains of sectors and products. To do this, Koopman et al. (2010) first introduces gross exports:

$$(9) \quad E_{r*} = \sum\nolimits_{s \neq r} E_{rs} = \sum\nolimits_{s} (A_{rs}X_s + Y_{rs}) \qquad\qquad r,s = 1,2$$

In equation (9) we sum up from equation (1) for intermediate use and final demand in s ,for goods produced in r. E_{rs} is then the $N \times 1$ gross exports vector from r to s.

This use of gross exports links their measures to official trade statistics and also to other measures of value added in the literature.

Second, equations (10) and (11) give the export matrices to be used as weights to calculate the shares of value added:

$$(10) \qquad E = \begin{bmatrix} E_{1*} & 0 \\ 0 & E_{2*} \end{bmatrix}$$

E is a $2N \times 2$ matrix capturing gross exports in both countries.

$$(11) \;\; \hat{E} = \begin{bmatrix} diag\ (E_{1*}) & 0 \\ 0 & (diag\ E_{2*}) \end{bmatrix}$$

From equation (10) we find (11), with Ê is a $2N \times 2N$ diagonal matrix. We can now combine the VAS matrix in equation (7) with the export matrix and use these as weights to get a disaggregated measure of value added by sector and source country:

$$(12) \qquad VAS\_\hat{E} \equiv VBE = \begin{bmatrix} V_1B_{11}\hat{E}_1 & V_1B_{12}\hat{E}_2 \\ V_2B_{21}\hat{E}_1 & V_2B_{22}\hat{E}_2 \end{bmatrix}$$

The interpretation of the $2N \times 2$ matrix in equation (12) is similar to that of equation (7); only here all the upstream sectors contribution to value added is captured. So for a steel product, the value added in the steel producing sector itself is accounted for, and also value added from inputs such as design and transportation. This approach is useful to analyze supply chains, like in the previously mentioned case study of the iPod by Dedrik et al. (2010).

Further, equation (12) is analogous to the interpretation of vertical specialization from Hummels et al. (2001) or “value added in trade” from Stehrer (2012), where it is measured from foreign and domestic content in sector level gross exports. This measure does not take into account how the importers use the product, so in order to look at how value added is absorbed we turn to the final demand as in the concept of "trade in value added" in Stehrer (2012).

$$(13) \qquad V\hat{A}T \equiv BY = \begin{bmatrix} \hat{V}_1 & 0 \\ 0 & \hat{V}_2 \end{bmatrix} \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}$$

The first term $\hat{V}_r$ is a N by N diagonal matrix with the direct value added coefficients along the diagonal like in equation (6). Y_{sr} is an N by 1 vector and the entire Y is a $2N$ by 2 final demand matrix. As previously mentioned, these two ways of measuring value added will result in the same overall net trade for a country, but this will not hold for bilateral relations when trade is between more than two countries (Stehrer, 2012).

For bilateral relations in a multi-country world, trade deficits/surpluses will differ when measured in gross terms and in value added terms. This we can see from the previous calculations leading up to equation (12), where gross exports embody imported intermediates. We recall that when intermediates are imported and used in production of export goods there can be a multiple counting in traditional trade statistics.

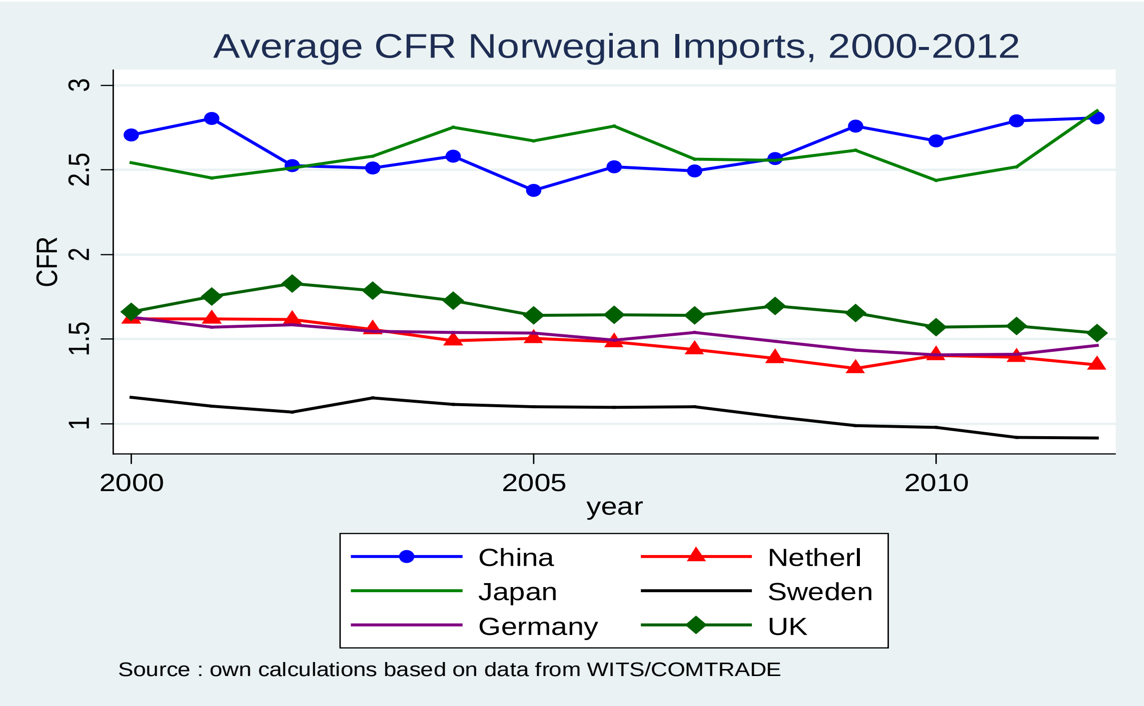
We rely on accurate measures of gross trade in all these steps, from the market clearing condition in equation one, until we have the direct value added coefficients in equation 13. As previously mentioned; *we need a balanced international IO table where imports equal exports.* In the introduction we said that intuitively this should be the case, but then mirror data displayed many examples on large differences between reported values on the same trade flow. In the next chapters we will study mirror data discrepancies and harmonization further.

3 Mirror data, harmonization and TVA

Mirror data analyses are used in the creation of databases and national input-output tables. An example of such a mirror analysis is a comparison of reported imports from China in Norway (CIF) with reported exports to Norway from China (FOB). Since CIF values include transportation, these would intuitively be a little higher than the FOB values. To estimate the differences occurring between reported imports and reported exports we use the ratio of CIF/FOB (abbreviated as CFR). To adjust for higher CIF values the IMF often use the "rule of thumb" that transportation and insurance account for 10%, resulting in an expected CFR of 1.1(Hummels and Lugovskyy, 2006, and IMF web pages).

The introduction had two examples of deviations in mirror data for Norwegian imports, and we find more examples in other countries; in 2010 Chinas average CFR in imports was 1.3 and Japans 1.26 (Melchior, 2012), but CFR for exports can be higher from Asian countries, as seen in figure 7. The same paper also calculates median values of CFR, examples for imports being Canada with 1.4, Germany 1.34 and France just below 1.3.

Figure 7: Average CFR Norwegian Imports, selected countries



We see the higher CFR for the two Asian countries compared to European countries, and it also looks more volatile. In Sweden, some average observations have mirror exports larger than Norway's reported imports, resulting in a CFR<1 for 2011 and 2012. A possible explanation is goods shipped through Sweden on the way to Norway, something that will be discussed in the following section. Most of these observations deviate from the IMF "rule of thumb", but how much would an increase in CFR from 1.1 to 1.5 matter? And how can we explain even larger CFR values?

The following example on transport costs from Hummels and Lugovsky (2006) highlights that even a small change in the mirror data can have a large impact on the CFR: The initial CFR is 1.06 implying a 6% transport cost. Then the importers CIF value increases by 1, 5% combined with a decrease in the exporters FOB value of 1, 5%. These changes results in a new CFR of 1.09 implying as much as 50% increase in transport cost. We can also find examples of CFR values at 2.5 or higher, implying a 150% difference and transport costs exceeding the value of the goods. The dataset Hummels and Lugovsky (2006) use is from IMF DOTS database for the years 1948-97, and one of the main findings is that roughly half of CFR values observed lies outside a range between 1 and 2.When the ratio is this high it we need to look for other explanations than only transport costs. To adjust differences in mirror data we need to know the source of discrepancies, in order to say anything about either the CIF value or the FOB value being a good measure. If higher import price (CIF) is from actual value added from shipping services, it is a better measure than high CIF from wrong information or misreporting to avoid tax. Different explanations matter.

3.1 Explanations of discrepancies in mirror data

The example from Hummels and Lugovsky (2006) looks at explanations for high CFR from increase in transport costs. This answer belongs to one group of explanations, among others. In Melchior et al. (2014, p.48) the following four explanations for the gaps in reported CIF-FOB data are listed:

1- *Cost and price mark ups;* resulting in higher import prices (CIF) because of price mark-ups to middlemen or affiliates of a multinational enterprise (MNE) or higher transportation costs than the 10% assumed. In the introduction we mentioned this explanation as one of two main connections between mirror data discrepancies and measures of value added. When costs increase from services on the way, some of the CIF-FOB difference measures this value added.

2- *Deliberate misreporting;* resulting in higher reported import prices from avoidance of tax or currency restrictions through transfer pricing. As previously mentioned in section 2.3 about policy implications, this is because enterprises operate globally, with incentives to allocate their profit in order to avoid tax, or move funds across borders by adjusting the price. These two actions are often referred to as "profit shifting" or "transfer pricing".

3- *Wrong country of origin or destination, "the Rotterdam effect";* lack of information on where goods are exported from/ imported to, resulting in gaps between CIF-FOB observations. An example of this could be export from China coordinated through the Netherlands before arriving in Norway. In this case, China might report this as exports to the Netherlands, whereas Norway could report this as import from China. This might also explain the excessive mirror exports from Sweden to Norway we saw in the beginning of this chapter. The term "Rotterdam effect" has been used on this phenomenon due to the importance of Rotterdam port in trade.

4- *Deliberate or arbitrary errors in reporting;* resulting in CIF-FOB differences that might not be stable and persistent over time.

In the two first explanations, the gap between CIF-FOB is from price effects. The third, and partly the last will affect volume (Melchior et al., 2014). If the discrepancies causing higher CFR follow explanation 1 in the previous section, these costs reflects value added and should be accounted for rather than zeroed out to harmonize data. The last explanation is directly relevant in measuring TVA, since such errors affect the magnitude of trade.

Again, we need to take out transport costs and adjust these CIF-FOB values to create an international IO table and calculate TVA; so technically, all the four explanations are relevant in this process.

3.2 Mirror data in Norway

Data on Norway's trade is collected by Norwegian customs, reported to Statistics Norway (SSB), and updated every month. Although discrepancies for certain trading partners such as the EU are analyzed, mirror statistics is in general not used in the creation of this monthly data. SSB does not operate under a certain "rule of thumb" on how CIF-FOB values are harmonized, but use total values of export and imports between our partners as they are reported in Norway (Statistics Norway External trade in goods, 2014).

This data on the national level is further reported to OECD, UN or Eurostat. From here, it is one side of bilateral mirror data in the creation of international trade statistics. As mentioned in the previous section, lack of information on destination or different regulations in reporting trade gives rise to discrepancies in these mirror statistics. An example is that values less than 1000 NOK is omitted from statistics on Norwegian imports, and this need not be the case for our partners, resulting in difference due to method of reporting. To harmonize trade statistics, knowledge on our partner countries' regulations is mentioned by SSB as an important tool. Errors affecting quantity due to lack of information on origin and destination country, is also known as a common source to discrepancies in data. Highlighted in SSB's note on External trade in goods (2014), is the importance of comparing Norway's statistics to our major trading partners in the EU, using Eurostat data.

Some exercises on Norwegian mirror statistics have been conducted by Statistics Norway. These mainly take the form on case studies with one partner country, or certain types of goods. One example of this is a mirror exercise from 2007 on Norwegian trade with Ukraine, where the main product traded is frozen fish classified as HS 0303 in the product level data. Interesting here is the finding that discrepancies in value are remarkably large[16], but measured in quantity the scenario is quite different with a deviation of only 3% (Statistics Norway, 2007). Possible reasons for the discrepancies are linked to price effect since quantities do not differ that much. We saw in the previous section that price effect could follow economic incentives causing deliberate misreporting of imports in Ukraine, but the exact reason is hard to reveal without access to the import declarations. For further studies the note suggests the following; potential impact on discrepancies from commodity groups that are suppressed in

[16] When measured in value, the Norwegian export of HS0303 was close to double the amount of Ukrainian imports in 2005 (Statistics Norway, 2007).

the datasets[17], and the problem of transshipment and unknown destination or origin of the goods (“Rotterdam effect”).

Mismatches in data go back in time. A somewhat older mirror exercise between the Nordic countries was published in 1995, also by Statistics Norway, and discrepancies were revealed from trade with our neighbor countries Sweden and Denmark. Some examples are; a CFR of 0.69 on Norwegian imports of medium sized motor cars from Sweden, and for Norway’s total export to Denmark a discrepancy of 25% with HS 03 chapter on fish amounting to half of this (Dahle et al., 1998). In the case of Denmark, the HS chapter 99 representing confidential data is highlighted as an important explanatory factor, since it stood for 9.2 % of Norway’s export to Denmark in 1995. An additional analysis was made on trade with fish between Norway and EU in the same year. Here, some of the discrepancies can be explained by transshipment and re-export between countries such as Germany and France, affecting volumes. The main impression from the analysis between Norway, Sweden and Denmark is that discrepancies arise due to errors in classification, affecting price/values rather than volumes. When the exercise included other European countries, lack of information on destination and origin, due to transshipment, lead to discrepancies explained by volume.

When a good is shipped through EU on its way to Norway, information on country of both shipment and origin is included in the Norwegian customs declaration (Norwegian Customs Tariff, 2014). Only data on country of origin is published in SSB statistics on foreign trade, but data on country of shipment is also registered (Statistics Norway External trade in goods, 2014). Difference in registration might lead to a mismatch between the reported trade flows that could lead to a CFR going in both directions. If only country of origin in Asia is registered in Norway, but exports are shipped through the Netherlands on its way and registered as exports to Norway, this could lead to excessive mirror export from the Netherlands and a CFR<1. If the Norwegian customs register goods from China, shipped through the Netherlands, as imports from the Netherlands, this could lead to excessive imports reported between Norway and the Netherlands.

[17] Some products might fall outside the Harmonized System classification, and not be accounted for.

3.3 Harmonizing mirror data discrepancies

In section 3.1 we discussed four explanations behind deviations in data. Intuitively, different explanations should be accounted for in the adjustment process.

Literature does not present any definite way to harmonize data, and this is a developing field. The following methods are listed in Ahmad, Wang and Yamano (2013); Estimation of initial data reliability (Wang, 2011) and use of the standard error of each cell in the global IO tables and comparing the balanced table with initial unbalanced estimates (Lenzen et al. 2012). I will not go into detail on these different approaches, what is of importance here is the common goal to harmonize international trade statistics to a balanced world IO table. Ahmad et al. points out that the use of SUTs as a starting point for creating world IO tables is an important improvement[18]. The reason for this is the link between product based trade statistics with product statistics in SUTs on the one hand, and industry based value added/employment data with industry statistics in SUTs on the other hand (Ahmad et al., 2013).

Timmer et al. (2012) describes the various steps in construction of international SUTs in the World Input-Output database (WIOD)[19]. The supply side is reports the import flows in CIF, and the use tables report exports in FOB. In the international SUT, imports has to be compatible with the use block (exports) from partner countries, hence we need to account for transportation so that imports are converted into FOB terms. For this purpose, product level data from UN COMTRADE is used to develop estimations of bilateral trade margins. In brief, this is done using a gravity model is used with CFR in unit values as dependent variable and distance, landlockedness and dummy variable for the same continent, as explanatory variables (Timmer et al., 2012, p.33). These estimations were restricted to observations where CFR>1. Relevant to our analysis are the many observations found in the Netherlands dataset where CFR<1. Such observations can also contain relevant information, something that will be discussed later in our empirical analyses.

The OECD-WTO international database is derived from OECD IO tables on the national level. To create the IO table, the basic procedure to harmonize mirror data is first to convert the trade flows based CIF import partner shares to FOB. This using total goods exports and

[18] Among the many attempts of creating international IO tables, the WIOD project is the only one where the initial IO tables are derived from SUTs (Streicher and Stehrer ,2012). Recall the explanation of SUT in the introduction.

[19] Public database, founded by the European Comission.

imports in FOB values of National Accounts with IO and SUT as constraints (personal e-mail correspondence 09.03.2014). This description of harmonization is more of a general character.

This brief overview on methods of harmonization leaves the main impression of no single method to harmonize data. Still, some methods are more developed and specific than others; an example follows in the next section.

3.3.1 Reporter reliability in harmonization

A more specific approach to harmonize mirror data uses measures of reporter reliability when transforming CIF-FOB values, analogous to estimation of initial data reliability. A database using reporter reliability is BACI[20], described in Gaulier and Zignago (2010). Like the dataset used in this thesis, the original data in BACI is from the UN COMTRADE database. The authors first motivate this method from the challenge in adjusting CIF-FOB values when we lack detailed information on transport costs. The CIF value is therefore adjusted for transport costs and converted it into FOB by using a gravity equation. Transport costs are accounted for by using the following explanatory variables; bilateral non-linear distance, year fixed effects, world median unit value for each product category, and dummies for congruity and landlockedness (Gaulier and Zignago, 2010).

After transport costs are cleaned out we are left with two FOB-FOB mirror values. Reporter reliability is used to adjust these in the following manner; each country is evaluated from the absolute value of the natural log of the mirror value ratio, and this is decomposed by using a weighted variance analysis (Gaulier and Zignago, 2012, p. 3). The mirror flows are then averaged, using weights from the adjusted measures of reporting qualities.

[20] International Trade Database at the product level, from the French Research Center on International Economics (CEPII).

The results of this method on reporter reliability are divided into quantity and value for both exports and imports, as we see in figure 8:

Figure 8: Examples of reporter reliability ranking, selected countries

Total: 190 countries, i=imports e = exports				
Country	value i	value e	quantity i	quantity e
Norway	60	83	25	75
The Netherlands	132	101	129	106
Germany	110	39	100	57
Sweden	27	71	38	77
Switzerland	1	48	1	54
Denmark	53	91	65	97

Source: BACI database on international trade

Norway does not rank particularly high in reporter reliability of value. When large mirror deviations influence reporter unreliability, one critique is that these might origin from actual services added in shipping and transport, and not from lack of reliability as reporter country. In the reporter reliability method, the question is if this is accounted for when adjusting into CIF-FOB into FOB-FOB. In other words, if high CFR values have a *systematic explanation*, this needs to influence credibility. Such explanations could come from a country's position in trade like in our initial example of differences between Norway and the Netherlands. Periphery countries like Norway are likely to have more indirect trade compared to entrepôt countries. In relation to this critique, three critical issues when using reporter reliability are mentioned in Ahmad et al. (2013)[21]. First, a reliability index for country 1 is based on its reported trade in each product relative to all partners (Ahmad et al., 20013, p.278). But recalling the explanations from section 3.1, country 1's trading partners could misrepresent its trade due to various reasons, and country 1 could be wrongly discredited for this. To deal with this problem, the authors suggest that all reporting countries in the world need to be taken into account when deciding on country 1's reliability as reporter. Second is the possibility of over-penalizing a country's reliability according to the magnitude of the discrepancies. If Norway have large discrepancies in its trade with Asian countries due to misinformation, this does not necessary imply that Norway makes the same mistake for all partners. Finally, the authors

[21] Not specifically addressing the reliability method used in the BACI database.

mention the problem of country specific strengths and weaknesses in its reporting practice for different goods.

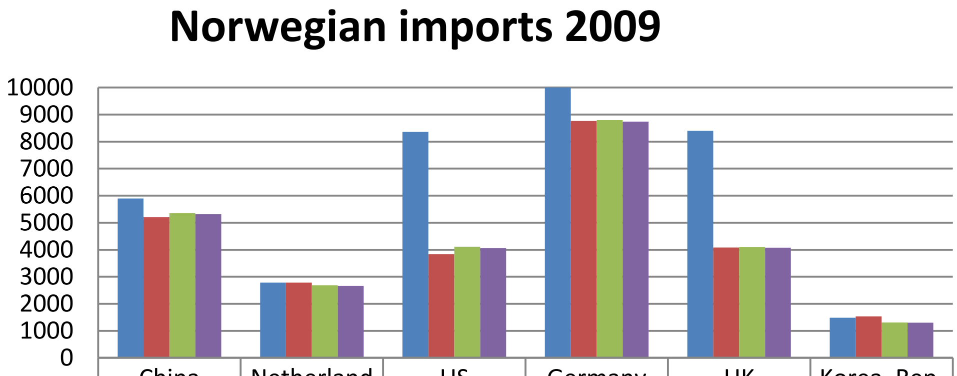
We see that the use of reporter reliability to adjust mirror data is a method still in progress, and systematic errors can discredit a reliable reporter. After looking at some empirical examples of harmonization in the next section, chapters 4 and 5 will analyze how a country's position in trade can affect CFR systematically.

3.3.2 Examples on harmonization of mirror data

Intuitively, the different approaches to harmonize data on trade flows should affect data on gross trade balances between countries. This section presents a comparison on gross Norwegian imports in 2009, from 6 countries in the following 4 databases; The OECD-WTO trade in value added database (TiVA), UN COMTRADE, BACI, and Norwegian Statistics (SSB)[22]. Data on Norwegian reported imports in UN COMTRADE comes from SSB, and except for small deviations due to timing and exchange rates, these values are the same. In figure 9 we can see that for important trade partners such as the US, Germany and UK, the difference in gross value of Norwegian imports vary. We recall that both the OECD TiVA database and the BACI database contain harmonized values, and intuitively these should be a little smaller than CIF reported numbers from SSB and COMTRADE. For all of the selected countries except Korea and the Netherlands, the harmonized values gave different results, especially in the OECD TiVA database, and this is shown in figure 9.

[22] Although this database is on TVA it also provides the gross numbers on international trade. Together with BACI, these two databases have harmonized mirror values.

Figure 9: Norwegian gross imports in USD millions, selected countries

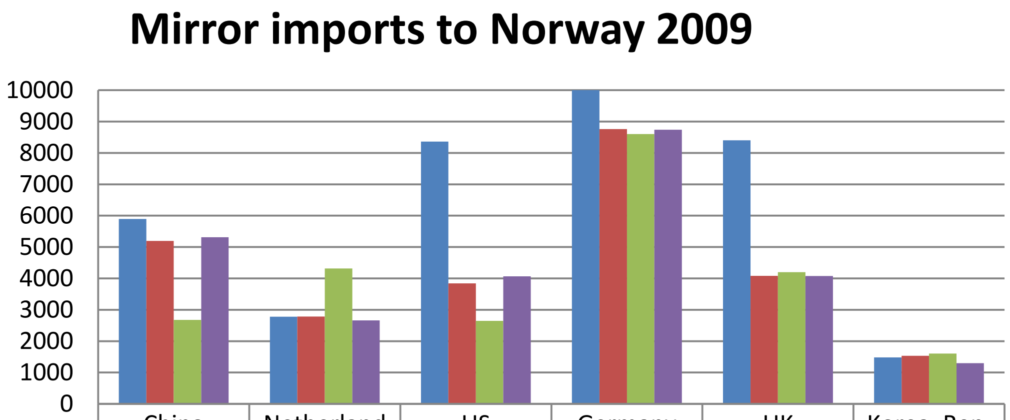


	China	Netherland	US	Germany	UK	Korea, Rep.
OECD TiVA	5894,5	2780,3	8359,9	10028,6	8401,1	1483,9
BACI	5197,61	2785,04	3839,44	8760,86	4082,68	1530,95
UN COMTRADE	5349,2	2679,06	4112,2	8793,8	4103,32	1307,75
SSB	5314,96	2661,94	4064,33	8737,89	4077,07	1299,42

Source: Own calculations

If we look at the mirror data on the same flow, the differences are even greater. To illustrate the deviations from imports in SSB, these numbers are shown again in figure 10:

Figure 10: Mirror data on Norwegian imports (exports to Norway) in USD millions, selected countries



	China	Netherland	US	Germany	UK	Korea, Rep.
OECD TiVA	5894,5	2780,3	8359,9	10028,6	8401,1	1483,9
BACI	5197,61	2785,04	3839,44	8760,86	4082,68	1530,95
UN COMTRADE	2675,3	4314,5	2645,5	8602,5	4200,4	1606,34
SSB IMPORT	5314,96	2661,94	4064,33	8737,89	4077,07	1299,42

Source: Own calculations

Recall that for OECD TiVA and BACI, these numbers are harmonized and the same as in figure 9. We can here see how the mirror exports from UN COMTRADE are adjusted and if these values should be used to measure Norway’s imports, different results would occur depending on which database we take the numbers from.

Together the figures 9 and 10 tell us that;

- Harmonized data on Norwegian imports in the TiVA database have in some cases large deviations from data in other databases.

- Data from the two harmonized databases (OECD TiVA and BACI) sometimes differ in value, and this might be the result of different approaches in harmonizing.

- For the selected countries, the BACI database and SSB display almost the same values, despite deviations in mirror values and Norway’s low rank as a reporter.

The first insight is relevant because Norwegian TVA is calculated from this data, and in this example the numbers from the OECD TiVA database have the largest deviations. The second insight shows us the importance of different methods for harmonization. Finally, we found similar numbers from BACI and SSB, but it still remains to analyze possible systematic explanations behind discrepancies to improve harmonization further.

4 Data and descriptive analysis

We want to know more about explanations behind discrepancies in mirror data, and this motivates our empirical analysis.

The analysis is divided into two parts: the first part is a descriptive analysis from the dataset on Norwegian imports from 2000 to 2012, in this chapter. The second part in chapter 5 is a comparative study with the Netherlands, using data on Netherlands imports and exports from 2000 to 2012. This study is motivated by Norway and the Netherlands having different positions in trade. In addition to this we found large discrepancies in Norwegian imports from the Netherlands, and from this analysis we might get more information to harmonize these.

The next section describes the dataset used for both countries, as the filtering method used in STATA is the same[23].

4.1.1 Description of data

Data on trade in Norway and the Netherlands for the purpose of this thesis is collected from the UN database COMTRADE and downloaded through World Integrated Trade Solution (WITS). To get an overview I start out by using data on yearly aggregated trade flows, but data on the product level is mainly used in both analyses. The product level datasets are classified in the common international 6 digits Harmonized System (HS), which gives the most detailed measure of unit values. For Norwegian imports in the years 2000-2012 this amounts to 1 059 388 observations with Norway as reporter, and 806 881 observations on exports to Norway from the mirror dataset. In the dataset for the Netherlands for the same years we look at both imports and exports. This amounts to 3 954 653 observations with the Netherlands as reporter, and 3 830 057 in the mirror dataset. The datasets are then filtered in the following way: Observations where we don't have mirror data, observations where we have different quantity units, and finally extreme observations where CFR<0.1or >10 are deleted in both datasets and together with observations where unit values deviate more than 5

[23] See table 13 in appendix A for details on filtered data.

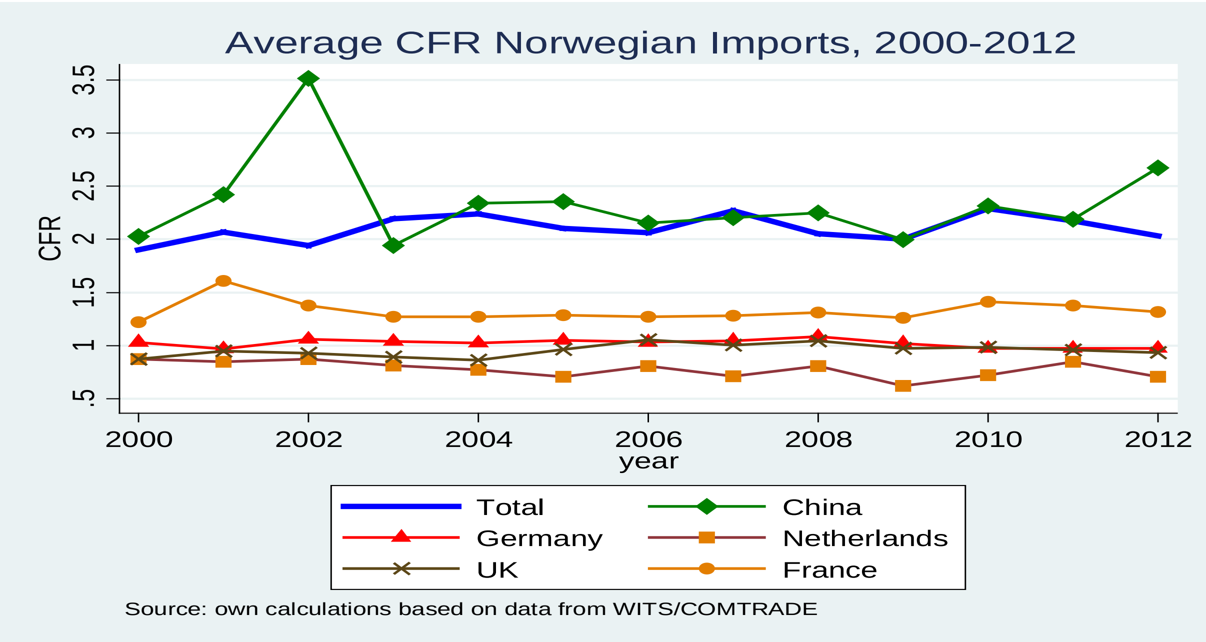
times from the mirror observation[24]. Countries with few observations are not included since CFR is likely to be more erratic when we only have small amounts. This results in a selection of 114 countries for Norway, and 182 for the Netherlands.

From these filtered datasets we can now calculate price indexes in order to decompose the CFR into a price and a quantity effects[25].

4.1.2 Analysis on Norwegian imports

The dataset on Norwegian imports shows us the magnitude of discrepancies, and what drives these related to price or quantity effect. It also shows the relevance of a mirror analysis, as all average values for total import exceeds the previously mentioned IMF "rule of thumb" of CFR at 1.1.

Figure 11: Average CIF-FOB ratios for total Norwegian Imports, selected countries[26]

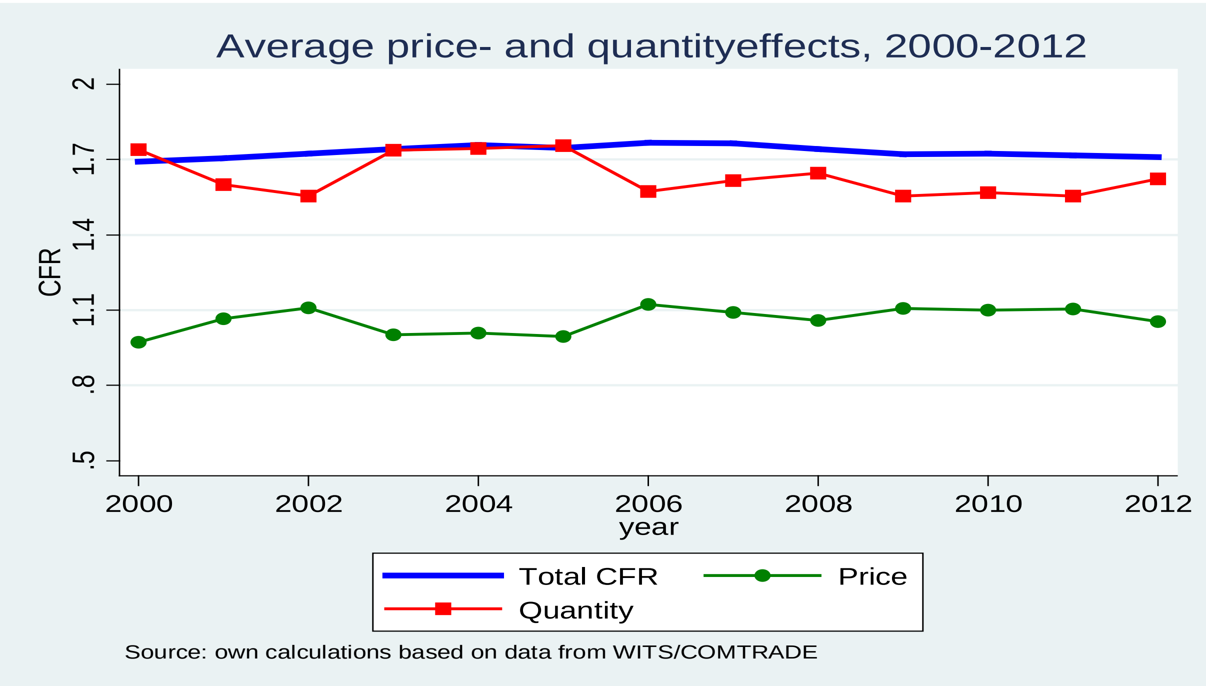


[24] When deviations are so large it can be caused different method of classification, large deliberate errors in reporting, or time lag leading to different year of registration, giving inconclusive results. Analysis of deviations larger than ten times is excluded for the purpose of this thesis.
[25] Using Marshall-Edgeworth price index, see appendix D. The reason to use this index rather than Laspeyre or Paasche, is to neutralize the influence from deviations in quantity on the price index. Quantity effect is calculated by dividing product level CFR on price effect.
[26] Calculated from data on total trade, see table 1 in references.

Like figure 7 in chapter 3, figure 11 shows clearly the high values and volatility of CFR in Norwegian imports from China, and persistent lower values for European countries. For UK, Germany and the Netherlands we have the special case of average values close to and below 1, due to excessive mirror values. Still, most of the observations on total average have a CFR value that exceeds 2, implying that reported imports are twice as big as the reported exports.

What drives these discrepancies in data? Is it only due to high prices from transport costs because Norway is a periphery country, or can we find different explanations related to quantity? To answer such questions we decompose the CFR into a price and a quantity explanation. To do this we calculate price indexes from unit values in the dataset on Norway's imports, and then divide CFR by these to get the quantity effect. In calculation of unit values, we use a detailed dataset on the product level. We then obtain information on the source of discrepancies, and can link the findings from calculating price and quantity indexes to the different explanations in section 3.1.

Figure 12: CFR Norwegian imports on 6 digit level, divided into price and quantity effect[27]



In figure 12, the CFR is decomposed into a price effect, following explanations 1 and 2 in section 3.1, and a quantity effect, following explanations 3 and 4.We see that for all average

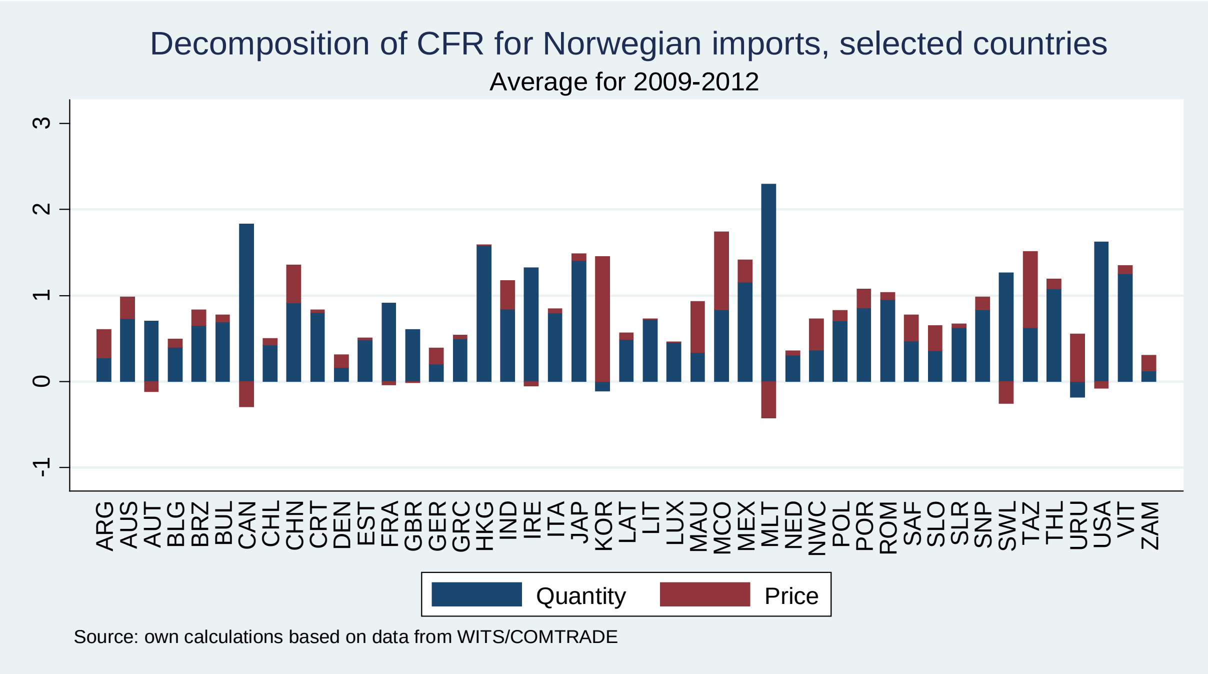
[27] CFR is here calculated from HS 6 digits product level for 115 selected countries where we have mirror observations, resulting in slightly lower discrepancies for total trade than we find in figure 11 because this data is filtered.

observations, the quantity effect is prominent. This might imply a "Rotterdam effect" since Norway is a small and periphery country, with its imports likely to be transported through trading hubs like Rotterdam in the Netherlands. Norway has a high CFR in imports from many Asian countries, and if this is due to such a quantity effect, then it suggests that Norway's import data (CIF-value) is more reliable than Asian export data (FOB-value) (Melchior et al., 2014).

When we sort out the two effects by country, we see that price effect also explains a large part of the discrepancies in some cases. In figure 13, values for price and quantity effect are subtracted by one, and his results in some values below 0. Price effect below 0 is due to FOB>CIF, but transport costs are not likely to be negative so here we need to look for other explanations.

A price effect larger than CFR results in a quantity effect below 0 after subtracting 1. Additionally, the CFR is calculated from product level, and is in some it differs from aggregate, affecting quantity calculated from CFR divided by price index[28].

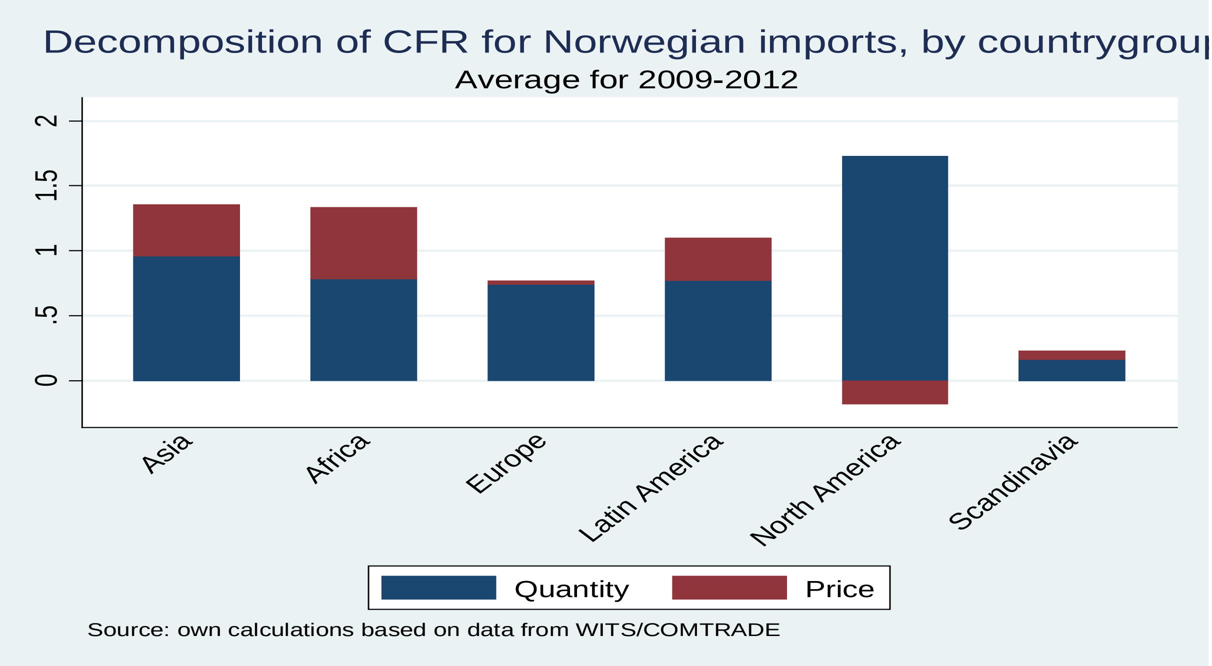
Figure 13: Price- and quantity effect for Norwegian imports 2009-2012[29]



[28] CFR from filtered data can differ from CFR on total trade, and affect quantity effect calculated from CFR/price index.
[29] The two effects are presented with values over 1. Quantity effect is calculated from dividing CFR on price index, and since CFR= (price * quantity)/(mirrorprice * mirror quantity)= (p/pm)*(q/qm)=(1+dp)*(1+dq)= 1+dp+dq+dp*dq and the two effects does not sum up to d(pq), but they are still useful as an illustration.

Intuitively, we would think that transport costs, resulting in higher CIF, will increase with distance. To study the relationship between price effect, distance and high transport costs we divide partner countries into 6 groups.

Figure 14: Price and quantity effect by country group, 2009-2012



In figure 14 the intuition holds when we look at groups of countries, and we have larger price effect in Asia, Africa and Latin America, than in Scandinavia and Europe. This price effect implies an average 34% transport costs for Norwegian imports from Asia. If this increase in CIF from price effect indeed follows explanation 1 with *cost and price mark ups*, some of the difference in CIF-FOB for these countries reflects actual value added.

The other explanation affecting prices came from *deliberate misreporting* and since many developing countries are found in the groups with high price effect, we might link tax avoidance and misreporting to weak institutions in these countries. North America consists of USA and Canada resulting in few observations. Here we also find price effect below 0 and we need other explanations than the apparent negative transport costs.

To sum up our knowledge on mirror data discrepancies in Norwegian imports, these are the main insights;

- Many observations on aggregate imports have a CFR exceeding 2, and we need to look for additional explanations than just transportation, due to the unlikely scenario of average transport costs = 100%[30].

- For individual countries the CFR increases with distance, an example is Norwegian imports from China with the average CFR = 2.3[31]. Intuitively, transport costs are likely to rise with distance, and on average price effect explains a larger part for Asian, African and Latin American countries. This price effect could be explained by services and costs on the way, then the "true" difference between the CIF and FOB measures this actual value added. This does not rule out the possibility that economic incentives such as *transfer pricing* explains some of the price effect.

- Although the CFR vary between countries and price effect explains part of it, the quantity effect is in most observations prominent in explaining the discrepancies.

- Some European partner countries take the special position of having average CFR below 1, giving the unlikely scenario of negative transport costs. Such observations of CFR can be explained by "Rotterdam effect", or deliberate and arbitrary misreporting.

We found many observations of large discrepancies in Norwegian mirror data, explained both by price and quantity. We further want to study possible systematic explanations behind these discrepancies, leading us to the next chapter and the comparative analysis.

[30] Total average CFR from data on total imports is 2.08. See table 1 in Appendix A.
[31] Calculated from data on total imports, 2000-2012, source: data from WITS/COMTRADE.

5 Comparative analysis

Norway and the Netherlands have different positions in trade. Norway is a country in the periphery, likely to have higher transport costs and only small volumes shipped through to other destinations. The Netherlands has a central location, and a large port in trade with large volumes shipped through. These two countries make good candidates when we look for systematic explanations to discrepancies. If countries CIF-FOB deviations differ systematically due to position in trade, this can be included in harmonization of data.

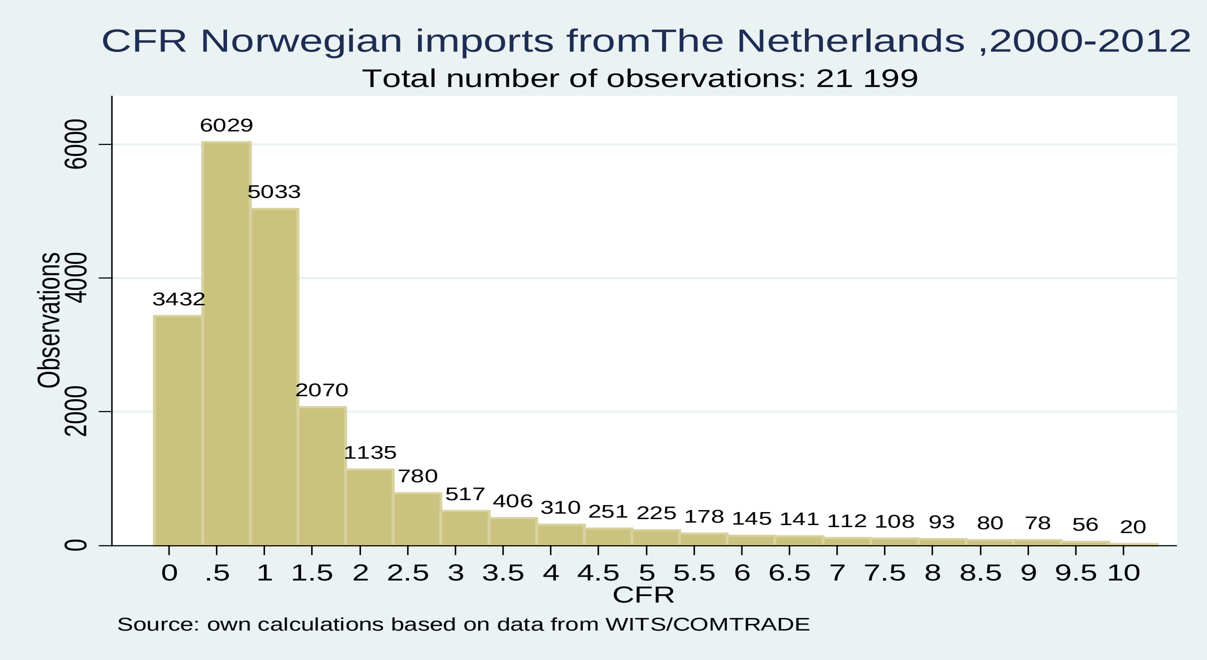
In the next section we will present two hypotheses; the first concerns the comparative study of the Netherlands, and the second connects this analysis to data harmonization and TVA.

5.1 Motivation and hypotheses

Denmark, Sweden and the Netherlands are some of the main countries we import from, and at the same time they share the characteristics of being the three most important entrepôt countries for Norway (Melchior et al., 2012, p. 66). Hence, knowledge from doing an analysis on the Netherlands might also be transferable to countries similar in trade.

Norway's total imports (CIF) from the Netherlands in 2012 amounted to 3,5 million USD. The Netherlands had a share of 3, 9% of our imports, and 12% of our exports in 2012(Source ssb web pages). The problem arise when the Netherlands report the total export to Norway (FOB) for the same year as 4,8 million USD ,implying almost a 30% increase in our trade deficit compared to our numbers in SSB database, and a CFR of 0,73 (source UN COMTRADE database). We see in figure 15 that data on product level gives the same picture. This figure represents all import flows on the product level, in total 21 199 for the years 2000-2012. In the observations, 53% of the CFR values are below one, and 25% below 0, 5, implying that for a quarter of Norway's imports from the Netherlands the CIF value is twice as big. In the other direction, 20% of the observation have a CFR larger than 2.

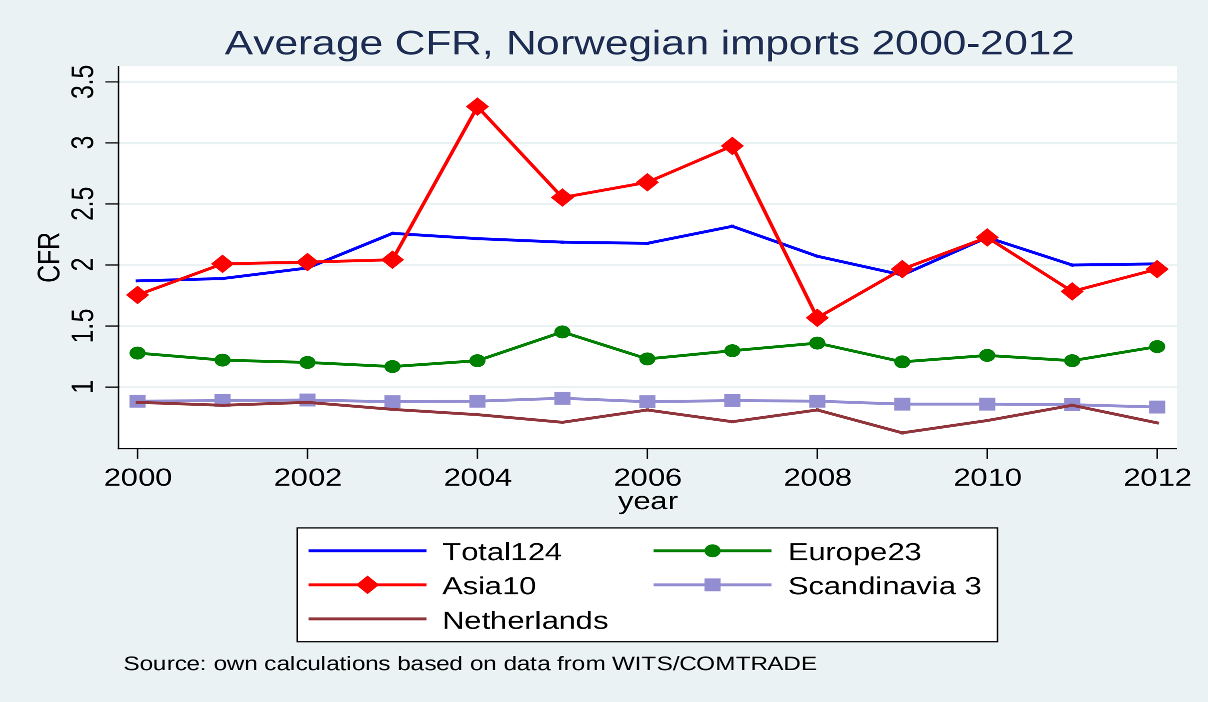
Figure 15: CFR Norwegian imports from The Netherlands, product level, 2000-2012



These findings leave us with the question; how should we weight the Norwegian reported CIF value when harmonizing these discrepancies in data? We recall that data on Norwegian imports reveal average CFR above 1.1, and often much higher, and in the BACI approach to harmonize data this might indicate Norway as an unreliable reporter. Is the FOB value reported by the Netherlands then a better measure of the imports? Although we saw in section 3.3.2 that values for the Netherlands exports in BACI was harmonized like the Norwegian CIF in SSB database, it still remains to investigate if we can find any systematic pattern, implying that the FOB value reported is indeed unreliable. Finding indicators of Netherlands as a “trading hub” and establish a possible “Rotterdam effect”, by doing a comparative analysis, this can indicate unreliable FOB values for its exports to Norway.

In figure 16 we divide Norwegian imports by group of countries, and the special role of the Netherlands is clearer:

Figure 16: Average CFR Norwegian imports, total trade 2000-2012[32]



We see that the Netherlands has a persistent CFR below 1. Although it is located further from Norway than Scandinavia geographically, its CFR is still lower in most cases, violating the intuition of CFR increasing with distance.

These findings in mirror data on Norwegian imports from the Netherlands lead us to the first hypothesis:

Hypothesis 1: a comparative mirror data analysis between Norway and the Netherlands can reveal systematic differences in CIF-FOB discrepancies, providing information useful in data harmonization.

If countries differ systematically due to position in trade, this should influence how data is harmonized. In relation to Norwegian imports from the Netherlands, the result of this hypothesis can affect how FOB values reported from the Netherlands are weighed against Norwegian reported CIF values.

[32] Asia 10: China, Thailand, Korea, Singapore, Vietnam, Japan, India, Bangladesh, Macao, Hong Kong. All values calculated from data on total trade, see table 1 in appendix A.

The second hypothesis is of a general character, and connects results from the comparative analysis to TVA.

Hypothesis 2: mirror data analyses can reveal systematic errors in CIF-FOB discrepancies due to a country's position in trade, and from this contribute to measures TVA from improved harmonization of data.

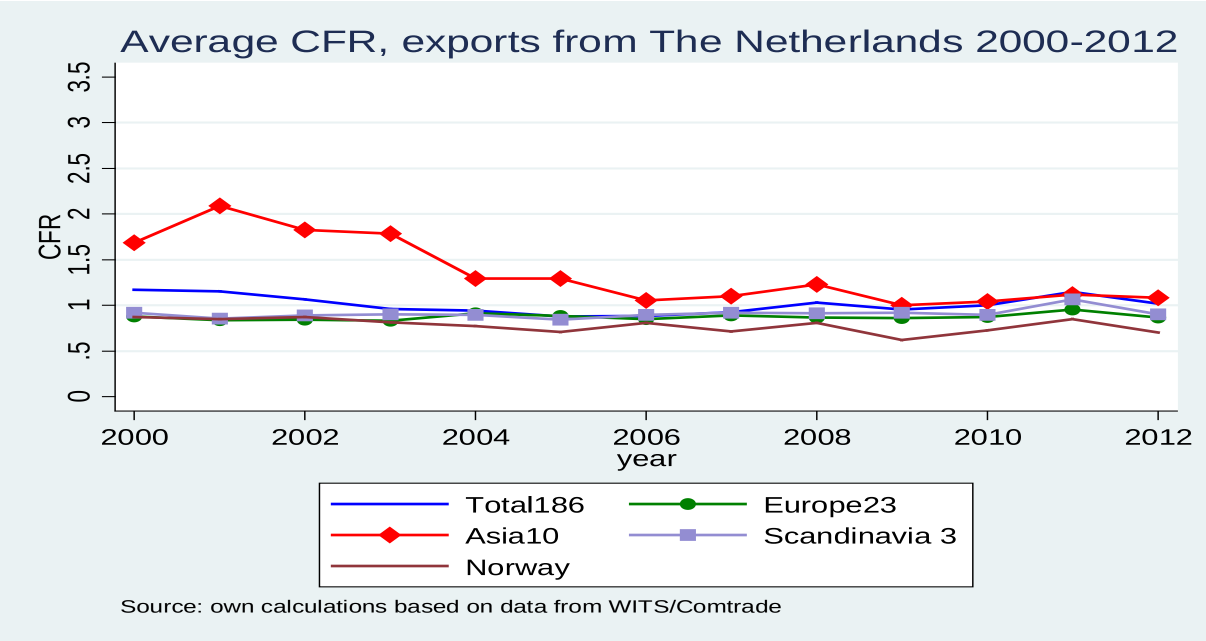
5.2 Comparative analysis

To answer the first hypothesis, we need to list indicators of the Netherlands having systematically differences in CFR, compared to Norway. In an entrepôt country, great volumes are transferred to other destination countries, and this might result in loss of information on origin and destination of the goods. We should find that the following four propositions hold in the dataset of the Netherlands:

- Large mirror data discrepancies, both for imports and exports
- These discrepancies are systematically persistent over time
- Compared to Norway, for imports from Asia the Netherlands as an entrepôt country should have less "missing imports" resulting in an overall lower CFR. It is on the contrary more likely to find observations on Asian over-reporting of exports in mirror data, with the result: $FOB_{export\ from\ China} > CIF_{Netherlands\ import}$
- Quantity effect is prominent in explaining discrepancies in mirror data

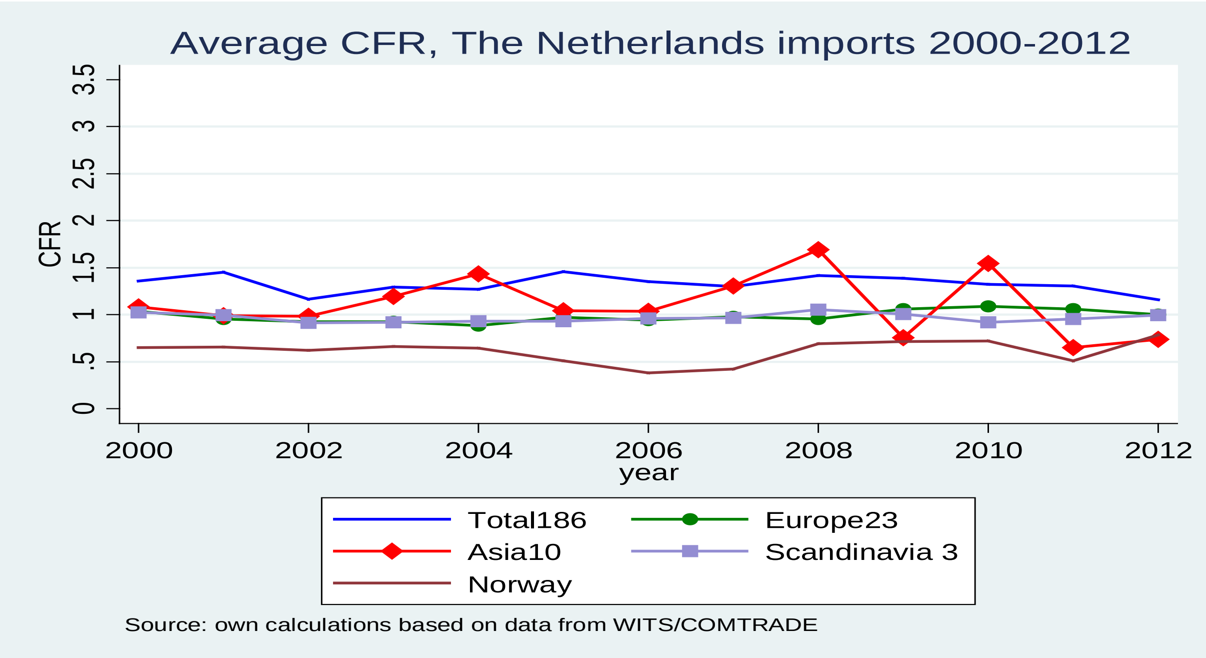
We start out by studying exports. Recall from figure 15 that in mirror data on Norway's imports from the Netherlands, over half of the observations had a CFR<1 with reported exports exceeding imports. Is this the case only for Norway, indicating that our CIF value might be unreliable, or is over-reported FOB-value a systematic pattern in the Netherlands exports?

Figure 17: Average CFR for the Netherlands exports, total trade 2000-2012[33]



We see that for most observations in data for total trade with Scandinavia and Europe, the Netherlands have reported a FOB value higher than its partners CIF value, resulting in a CFR< 1. Low CFR is persistent over time, except for high Asian values for the first years in the dataset.

Figure 18: Average CFR for the Netherlands imports, total trade 2000-2012[34]



[33] Calculated from data on total trade see table 6 in appendix A for detailed numbers.
[34] Calculated from data on total trade see table 7 in appendix A for detailed numbers.

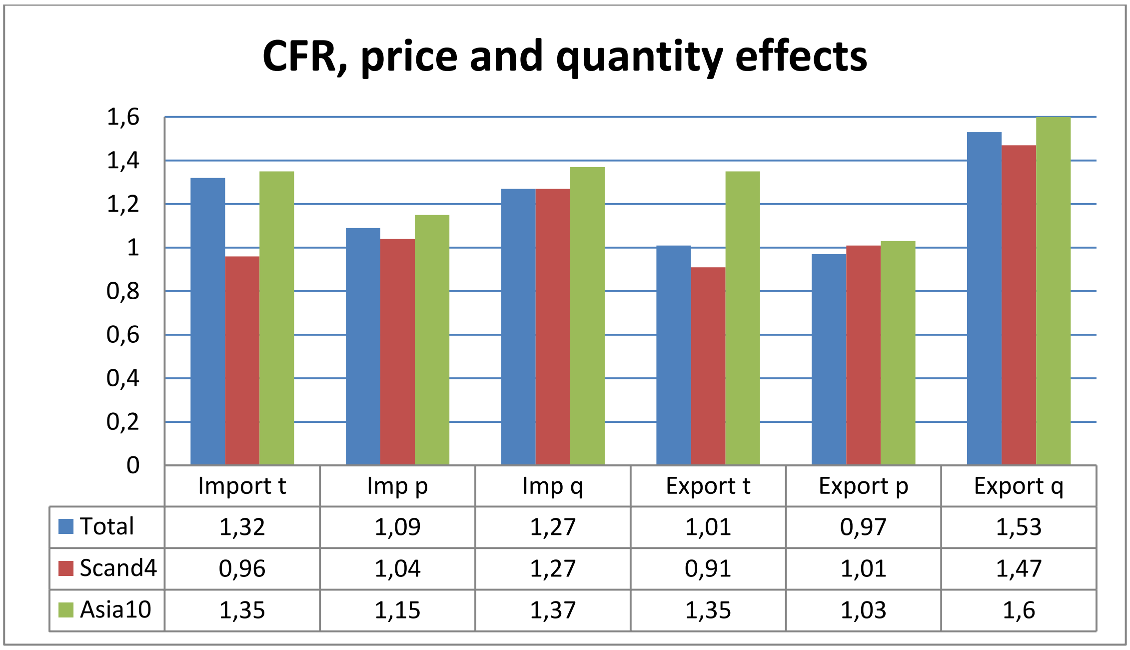
We now compare results in figure 18, with the previous analysis on Norwegian total imports in figure 16, to see how the two countries differ. The average CFR for Norway is much higher, often larger than 2. For the Netherlands, the average CFR is below 1.5 for all observations of total average. We can find the explanation of lower CFR if we study further the median value and the distribution of discrepancies. CFR’s are symmetrically distributed on each side of 1 for the Netherlands trade. Exports has the median value for CFR at 0.97, with 44% of the CFR<0.8, and 32% with the CFR>1.5. The median CFR in imports is 0.88, with 49% of the imports having a CFR<0.8, and 27% with a CFR>1.5. For Norwegian imports the median value is 1.07, with 32% having a CFR<0.8, and 34% a CFR>1.5. This is a skewer distribution with more observations on CFR values above 1in Norway. Since discrepancies are more symmetrically distributed on each side in the Netherlands, they would to some extent cancel out each other. This could give the misleading picture of balanced trade with a CFR around 1, when there actually are both large quantities of exports and imports being reported as too high, supporting out theory of the Netherlands as an entrepôt.

We can also compare CFR values in imports between the Netherlands and Norway from ten selected Asian countries in figures 16 and 18[35]. Norway’s median value is 1.66, and for the Netherlands it is 0.97, with 32% of the CFR values > 1.5, compared to 53% for Norway. Overall CFR for imports from Asia is lower in the Netherlands, and we also see observations from 2009 and onwards of excessive mirror data resulting in CFR<1. In Norway, the lowest value of CFR is as high as 1.5.

To answer the last proposition we need to decompose CFR in product data for the Netherlands into price and quantity effects, like we did for Norwegian imports. The numbers in figure 19 are average values for the years 2000-2012, and the entire value is presented. The first bar for each label is always for total trade flows of imports and exports, the next two are flows for Scandinavia and Asia. The labels t, p and q stands for total average CFR, price effect and quantity effect, respectively.

[35] See tables 7-12 in appendix A for detailed numbers

Figure 19: Average CFR the Netherlands, price and quantity effect



	Import t	Imp p	Imp q	Export t	Export p	Export q
Total	1,32	1,09	1,27	1,01	0,97	1,53
Scand4	0,96	1,04	1,27	0,91	1,01	1,47
Asia10	1,35	1,15	1,37	1,35	1,03	1,6

Source: Own calculations based on data from WITS/COMTRADE

For total trade price effect is about 9% in imports and below 1 in exports. We have previously seen many observations of CFR<1for exports from the Netherlands, implying FOB larger than CIF, and this might explain some of this apparently low transport costs.

Quantity effect is prominent in explaining the discrepancies, especially in exports. We recall the two explanations from section 3.1 that will affect quantity/volume; wrong country of origin or destination, “the Rotterdam effect” or deliberate or arbitrary errors in reporting. If discrepancies are due to the former, we are more likely to find a *systematic pattern* in the distribution of CFR. In the latter explanation, these might vary more over time and not follow a particular pattern. The former explanation is more likely in the Netherlands, as the price and quantity effects are persistent over time[36].

[36] See tables 8-12 in appendix A for details.

5.3 Results

When studying trade in the Netherlands, we kept four propositions in mind to find an answer to the first hypothesis.

First we saw that although trade seemed more harmonized with average CFR closer to 1 in both the total trade and product level dataset, discrepancies in product flows are still large with many observations where either exports or imports are reported as too big. But these are distributed more symmetrically on each side of 1resulting in an average CFR closer to 1. We could also see in the figures 17 and 18 that the mirror data discrepancies were persistent over time. Since discrepancies are persistent over time, they are likely to follow the explanation of a "Rotterdam effect" with wrong country of origin and destination, rather than arbitrary or deliberate errors resulting in discrepancies that might be unstable over time.

In data on total imports from Asia, the CFR in the Netherlands imports was much lower with only a few observations over 1.5, compared to the average value of CFR at 2.21 in Norway. These findings might indicate some of Norway's "missing imports" from Asia (high CFR); the FOB value is wrongly registered as exports to trading hubs like the Netherlands, and not as exports to Norway due to "Rotterdam effect". This effect might also explain some of the observations of CFR<1 in Norwegian imports from the Netherlands when we might have found some of Norway's "missing imports" from Asia here, if we investigated further.

Finally we saw that for both in imports and exports the quantity effect is prominent for all average observations from the Netherlands.

In answer to hypothesis one, analysis of data show us that the four propositions to establish the Netherlands as an entrepôt country hold. We further found systematic differences in CFR between Norway and the Netherlands, both in distribution and magnitude of CFR. These differences were especially prominent in imports from Asia.

In answer to hypothesis two, the comparative mirror data analysis established the two countries' different position in trade, providing knowledge useful in evaluation of reported values. This is in addition to factors like distance and magnitude of discrepancies.

6 Conclusions

World trade today is increasingly fragmented, and compared to conventional statistics, trade in value added provides a better measure on the value created from trade. This thesis considered the relationship between trade in value added, and challenges from the quality of international trade statistics. We have seen that an international IO table is needed to calculate TVA. Such an international IO table is created from; national IO tables and SUT's, combined with international data on bilateral trade. The challenge occurs when we find large deviations in this bilateral mirror data. We then need to adjust for transport costs and harmonize the CIF-FOB deviations. Because some explanations are quantity-related and some price-related, we decomposed the overall CFR's into a quantity and price component. For this purpose we used detailed product data to calculate unit values and construct price indexes.

We described two ways mirror data discrepancies affect measures of trade in value added; first, CIF-FOB values are harmonized to create an international IO table and calculate TVA. Second, increased costs from value added in transportation services are reflected in some of the deviations, and these should be accounted for as part of the value chain.

Our comparative analysis between Norway and the Netherlands was motivated by a possible connection between systematic explanations behind CFR and different positions in trade. In answer to our first hypothesis we found evidence in data that CFR in Norway and the Netherlands differ systematically.

We start out by looking at results for imports in both countries. Since Norway is a periphery country some of the high CIF values should come from high transport costs, something that was made clearer when we compared the datasets. Although overall price effect is similar, imports from Asian countries imply a 34% transport cost in Norway compared to 15% in the Netherlands, supporting intuition that distances matters. The price effect also increased for the Netherlands import from Asian countries, further supporting that part of CFR is explained by transport services added. These findings does not rule out the possibility that part of the price effects are explained by deliberate misreporting such as transfer pricing. Together with the large difference between Norway and the Netherlands in CFR for Asia, these results support out hypothesis that discrepancies are systematically affected by a country's position in trade.

Figure 20: Average CFR, price and quantity effects, 2000-2012

CFR, Price, Quantity	Norway Imp.	The Netherlands Imp.	The Netherlands Export
Total average	2,08	1,32	1,01
Price	1,07	1,09	0,97
Quantity	1,60	1,27	1,53
Total Asia	2,21	1,35	1,35
Asia price	1,34	1,15	1,03
Asia quantity	1,84	1,37	1,6
Total Europe	1,26	0,98	0,87
Europe price	1,04	0,96	0,97
Europe quantity	1,61	1,29	1,54
Total Scandinavia	0,87	0,96	0,91
Scandinavia price	1,08	1,04	1,01
Scandinavia quantity	1,16	1,27	1,47

Source: Own calculations based on data from WITS/COMTRADE

Further, we see in figure 20 that total CFR is lower in the Netherlands, and average CFR<1 are found in total imports from Europe and Scandinavia implying reported exports as larger than the reported imports in the Netherlands. Also interesting is the result of price effect at 0, 96 for imports from Europe, implying the unlikely case of average negative transport costs. These findings for imports from Europe can be explained by the expected “Rotterdam effect”, resulting in lack of information on origin and destination of goods. “Rotterdam effect” can also be an explanation for deviations in Norwegian imports, since quantity effect prominent and persistent over time. We mentioned that Denmark and Sweden are entrepôt countries for Norway, something that is supported by average CFR at 0, 87 for Norwegian imports from Scandinavia.

Results from the dataset on exports in the Netherlands state its position as an entrepôt clearer, examples being average low CFR and high quantity effects. To address the specific example in the beginning of chapter 5 where CFR<1 for Norwegian imports, we recall that for most observations in data for total exports the Netherlands have reported a FOB value higher than its partners CIF value. The finding of such systematic discrepancies in data for the Netherlands, leads us to recommend Norwegian reported CIF value as a better measure. These findings can also explain some of the difference between Norway’s gross and value added trade balance with the Netherlands, illustrated in figure 6, section 2.4. If we look at gross numbers, it gives a misleading picture when large parts of our imports and exports to the Netherlands is only shipped through the country, with the value added coming from other countries of destination and origin.

Our second hypothesis in chapter 5 connected our results from the comparative analysis to TVA. These results from the comparative analysis establish that magnitude and distribution of CFR's are affected by a country's position in trade.

Harmonizing CIF-FOB values in international trade statistics is a developing field. This thesis main finding is that a country's position in trade can systematically influence discrepancies in mirror data. Together with other methods, harmonization can benefit from including a country's position in trade, and from here further improve calculations of trade in value added.

References

Ahmad, N., Wang Z., & Yamano, N. (2013). A Three-Stage Reconciliation Method to Construct a Time Series International Input–Output Database. In Matoo, A., Wang, Z. & We, Z. (edit.) *Trade in Value Added* (p.253-289). Available at: https://openknowledge.worldbank.org/bitstream/handle/10986/15809/786210PUB0Trad0Box0377348B00PUBLIC0.pdf?sequence=1

Cernat, L., & Kutlina-Dimitrova,Z. (2014). Thinking in a box: A 'Mode 5' Approach to Service Trade. *Chief Economist Note, the European Commission.* Available at: http://trade.ec.europa.eu/doclib/html/152237.htm

Contessi, S., & Weinberger, A. (2009). Foreign direct investment, productivity, and country growth: an overview. *Federal Reserve Bank of St. Louis Review, 91*. Available at: http://research.stlouisfed.org/publications/review/09/03/Contessi.pdf

Dahle, A. B., Thomasen, J. & Østereng, H.K. (1998). The Mirror Statistics Exercise between the Nordic Countries .Oslo. Statistics Norway.

Dedrick, J., Kraemer, K. L., & Linden, G. (2010). Who profits from innovation in global value chains?: a study of the iPod and notebook PCs. *Industrial and Corporate Change*, *19*(1), 81-116. Available at: http://icc.oxfordjournals.org/content/19/1/81.full.pdf+html

Dee, P. (2001). Trade in services. *Australian Productivity Commission*. Available at: http://www.cepii.fr/%5C/anglaisgraph/communications/pdf/2001/washington/dee.pdf

Guillaume, G., & Zignago, S. (2010). BACI: International Trade Database at the Product-Level. The 1994-2007 Version. *Working Papers 2010-23, CEPII research center*. Available at: http://mpra.ub.uni-muenchen.de/36348/1/MPRA_paper_36348.pdf

Hummels, D., & Lugovskyy, V. (2006). Are Matched Partner Trade Statistics a Usable Measure of Transportation Costs?*. *Review of International Economics*, *14*(1), 69-86. doi: 10.1111/j.1467-9396.2006.00561.x

Hummels, D., Ishii, J., & Yi, K. M. (2001). The nature and growth of vertical specialization in world trade. *Journal of international Economics*, *54*(1), 75-96. doi: http://dx.doi.org/10.1016/S0022-1996(00)00093-3

International Monetary Fund (IMF) web pages. Available at: http://www.imf.org/external/data.htm

Johnson, R. C., & Noguera, G. (2012). Accounting for intermediates: Production sharing and trade in value added. *Journal of International Economics*, *86*(2), 224-236. doi: http://dx.doi.org/10.1016/j.jinteco.2011.10.003

Johnson, R. C., & Noguera, G. (2012). Fragmentation and trade in value added over four decades (No. w18186). *National Bureau of Economic Research*. Available at: http://www.nber.org/papers/w18186.pdf?new_window=1

Koopman, R., Powers, W., Wang, Z., & Wei, S. J. (2010). Give credit where credit is due: Tracing value added in global production chains (No. w16426). *National Bureau of Economic Research*. Available at: http://www.nber.org/papers/w16426.pdf?new_window=1

Kommerskollegium (2007). Adding Value to the European Economy. Kommerskollegium National Board of Trade. Stockholm. Available at: http://www.kommers.se/upload/Analysarkiv/Arbetsomr%C3%A5den/EUs%20yttre%20handelspolitik/AddingvaluetotheEuropeaneconomy.pdf

Lenzen, M., K. Kanemoto, D. Moran & A. Geschke (2012). Mapping the structure of the world economy. *Environmental Science and Technology 46(15),* 8374–8381. Available at: http://pubs.acs.org/doi/pdf/10.1021/es300171x

Leontief, W., & Strout, A. (1963).Multiregional Input-Output Analysis. *Input-output economics* p. 223-257. New York: Oxford University Press.

Melchior, A., Rich, K., & Perry, B. (2012). Norsk handel med de fattigste –mellom profitt og utviklingspolitikk . (In Norwegian, Norway's trade with the least developed –between profit and development politics). *Norwegian Institute of International Affairs*. Available at: http://www.nupi.no/content/download/269529/946000/version/3/file/NUPI-rapport-Melchior-Perry-Rich.pdf

Melchior, A. (2012): International Trade, Trade Costs and Middlemen: A New Look at Mirror Data. *Norwegian Institute of International Affairs*. Oslo

Melchior, A., Lind, J. T., & Lie, C. M. (2014). Norway, Asia and the Global Value Chains. *Norwegian Institute of International Affairs*. Available at: http://www.nupi.no/content/download/494691/1644338/version/2/file/NUPI+report+Asia+Final.pdf

Miroudot, S., Lanz, R., & Ragoussis, A. (2009). Trade in intermediate goods and services (No. 93). *OECD Publishing*. doi: 10.1787/5kmlcxtdlk8r-en

Miroudot, S., & Yamano,N. (2013). Towards the Measurement of Trade in Value-Added Terms: Policy Rationale and Methodological Challenges. In Matoo, A., Wang, Z. & We, Z. (edit.) *Trade in Value Added*(p. 17-41). Available at: https://openknowledge.worldbank.com/bitstream/handle/10986/15809/786210PUB0Trad0Box0377348B00PUBLIC0.pdf?sequence=1#page=42

Norwegian Customs Tariff (2014). Available at: http://toll.no/templates_TAD/Tolltariffen/StartPage.aspx?id=267887&epslanguage=en

OECD-WTO preliminary results. (2013) *OECD-WTO trade in value added database publishing.* Available at: http://www.wto.org/english/res_e/statis_e/miwi_e/tradedataday13_e/oecdbrochurejanv13_e.pdf

OECD-WTO Joint note (2013). Trade in Value Added: Concepts, Methodologies and Challenges. *OECD-WTO trade in value added database publishing.* Available at: http://www.oecd.org/sti/ind/49894138.pdf

OECD–WTO. (2012) Measuring Trade in Value-Added: An OECD-WTO Joint Initiative. *OECD-WTO trade in value added database publishing*. Available at: http://www.oecd.org/sti/industryandglobalisation/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm

OECD-WTO(2013) TiVA Indicators, country note for Norway. *OECD-WTO trade in value added database publishing.* Available at: http://www.oecd.org/sti/ind/TiVA_NORWAY_MAY_2013.pdf

Sanyal, K. K., & Jones, R. W. (1982). The theory of trade in middle products. *The American Economic Review*, 16-31. Available at: http://www.jstor.org/stable/1808572

Schneider, H. 2013. "U.S.-China Deficit May be Lower than Thought. *The Washington Post*, January 16. Available at: http://www.washingtonpost.com/business/economy/us-china-deficit-may-be-lower-than-thought/2013/01/16/d474122a-5f5f-11e2-9940-6fc488f3fecd_story.html

Statistics Norway (2007). Preliminary results: Trade between Ukraine and Norway: A Mirror Exercise. *Statistics Norway*. Oslo.

Statistics Norway (2014). External trade in goods. *Statistics Norway.* Available at: http://ssb.no/en/utenriksokonomi/statistikker/muh/maaned/2014-04-16?fane=om#content

Statistics Norway (2014). External trade in services. *Statistics Norway.* Available at: http://ssb.no/en/utenriksokonomi/statistikker/uhtjenester/kvartal/2014-03-20?fane=om#content

Stehrer, R. (2012). Trade in value added and the value added in trade. *WIOD WPN, 8*. Available at: http://www.iioa.org/conferences/20th/papers/files/1022_20120515111_wiod8.pdf

Stehrer, R. (2013). Accounting relations in bilateral value added trade. *Constraints.* Available at: http://ideas.repec.org/p/wii/wpaper/101.html

Streicher, G. and R. Stehrer (2012) Wither Panama? Constructing a Consistent and Balanced World SUT System Including International Trade and Transport Margins. *WIOD Working Paper Nr. 13*, available at: http://ideas.repec.org/p/wii/wpaper/94.html

Timmer, M., Erumban, A. A., Francois, J., Genty, A., Gouma, R., Los, B., ... & d Vries, G. J. (2012). The World Input-Output Database (WIOD): Contents, Sources and Methods.

WIOD Background document. Available at: http://www.wiod.org/publications/source_docs/WIOD_sources.pdf

UNCTAD (2013). Global Value Chains and Development: Investment and Value Added Trade in the Global Economy. *United Nations Publications*. Available at: http://unctad.org/en/PublicationsLibrary/diae2013d1_en.pdf

Wang, Z. (2011). A Model to Construct Time Series Databases for Global Trade, Production, and Consumption Linkages. Paper presented at World Bank Workshop on Fragmentation of Global Production and Trade in Value Added: Developing New Measures of Cross Border Trade, 9–10 June 2011, Washington DC.

Appendix A: Tables

Table 1. CFR Norwegian imports, data on total trade

CFR Imp	Total124	Europe23	Asia10	Scand3	Netherlands	UK	China	Germany	France
2000	1,87	1,28	1,75	0,88	0,87	0,87	2,03	1,03	1,22
2001	1,89	1,22	2,01	0,89	0,85	0,95	2,42	0,97	1,61
2002	1,97	1,20	2,02	0,89	0,87	0,93	3,51	1,06	1,38
2003	2,26	1,17	2,04	0,88	0,81	0,89	1,94	1,04	1,27
2004	2,21	1,21	3,30	0,88	0,77	0,86	2,34	1,03	1,27
2005	2,19	1,45	2,55	0,91	0,71	0,97	2,35	1,05	1,29
2006	2,18	1,23	2,68	0,88	0,81	1,05	2,15	1,03	1,27
2007	2,32	1,30	2,97	0,89	0,72	1,00	2,20	1,05	1,28
2008	2,07	1,36	1,56	0,88	0,81	1,04	2,25	1,08	1,31
2009	1,92	1,20	1,96	0,86	0,62	0,98	2,00	1,02	1,26
2010	2,22	1,26	2,23	0,86	0,73	0,99	2,31	0,98	1,41
2011	2,00	1,22	1,78	0,86	0,85	0,96	2,19	0,97	1,38
2012	2,01	1,33	1,97	0,83	0,71	0,93	2,67	0,97	1,32

Table 2. CFR Norwegian imports, product level data, 114 countries

All values on *product level data* are from the filtered dataset for 114 countries. Differences from data on total trade are due to the filtering process.

CFR imp	China	U.S	Netherlands	Japan	Germany	Sweden	Spain	Korea Rep	UK	France	India
2000	2,71	2,44	1,62	2,54	1,63	1,16	1,65	1,83	1,66	1,81	2,23
2001	2,81	2,36	1,62	2,45	1,57	1,11	1,86	2,07	1,75	1,78	2,36
2002	2,53	2,44	1,62	2,51	1,59	1,07	1,72	2,02	1,83	1,81	2,48
2003	2,51	2,42	1,56	2,58	1,55	1,15	1,78	1,98	1,79	1,84	2,33
2004	2,58	2,41	1,49	2,75	1,54	1,12	1,86	2,05	1,73	1,91	2,60
2005	2,38	2,40	1,51	2,67	1,54	1,10	1,98	2,10	1,64	1,96	2,39
2006	2,52	2,37	1,48	2,76	1,50	1,10	1,88	2,13	1,64	1,99	2,43
2007	2,50	2,40	1,44	2,56	1,54	1,10	1,80	2,41	1,64	1,98	2,35
2008	2,57	2,46	1,39	2,56	1,49	1,04	1,84	2,18	1,70	2,07	2,43
2009	2,76	2,48	1,33	2,62	1,44	0,99	1,82	2,09	1,66	1,87	2,37
2010	2,67	2,42	1,41	2,44	1,41	0,98	1,83	2,14	1,57	1,90	2,72
2011	2,79	2,48	1,39	2,52	1,41	0,92	1,83	2,37	1,58	1,79	2,32
2012	2,81	2,28	1,35	2,85	1,46	0,92	1,85	2,10	1,54	1,78	2,45

Table 3. CFR Norwegian imports price effect, product level data

CFR imp p	China	U.S	Netherlands	Japan	Germany	Sweden	Spain	Korea Rep	UK	France	India
2000	1,09	1,07	0,95	0,90	0,93	0,99	1,20	1,00	0,91	1,01	1,12
2001	1,31	0,96	1,00	1,05	1,10	1,11	1,21	1,05	1,01	1,00	1,14
2002	1,38	1,08	1,14	1,03	1,15	1,16	1,15	1,08	0,98	0,98	1,35
2003	1,03	1,27	1,24	0,94	0,97	1,01	1,11	1,10	0,97	0,90	1,19
2004	1,73	1,15	1,16	1,03	1,01	1,00	0,94	1,04	0,91	0,87	1,35
2005	1,62	1,09	0,97	1,00	1,02	0,96	0,94	1,04	0,86	0,83	1,38
2006	1,45	1,15	1,05	1,16	1,24	1,14	1,25	1,24	1,00	0,94	1,29
2007	1,49	0,94	1,07	1,22	1,28	1,12	1,14	1,35	0,98	0,98	1,28
2008	1,46	1,07	1,03	1,11	1,24	1,11	1,11	1,41	1,00	0,95	1,32
2009	1,26	0,91	1,11	1,02	1,14	1,14	1,17	3,53	0,97	0,96	1,37
2010	1,49	0,96	1,06	1,09	1,23	1,10	1,19	1,06	1,01	0,93	0,84
2011	1,49	0,90	1,05	1,12	1,31	1,11	1,11	1,07	1,03	0,94	1,46
2012	1,49	0,94	0,99	1,05	1,00	1,05	1,11	0,98	0,94	1,01	1,65

Table 4. CFR Norwegian imports quantity effect, product level data

CFR imp q	China	U.S	Netherlands	Japan	Germany	Sweden	Spain	Korea Rep	UK	France	India
2000	2,48	2,29	1,70	2,81	1,75	1,16	1,38	1,83	1,83	1,80	1,98
2001	2,14	2,44	1,62	2,33	1,43	0,99	1,54	1,98	1,74	1,79	2,07
2002	1,83	2,27	1,42	2,43	1,38	0,92	1,49	1,87	1,86	1,85	1,85
2003	2,43	1,91	1,25	2,75	1,59	1,14	1,60	1,80	1,84	2,05	1,96
2004	1,49	2,11	1,28	2,67	1,53	1,11	1,97	1,98	1,91	2,20	1,92
2005	1,47	2,21	1,54	2,68	1,51	1,14	2,10	2,02	1,92	2,36	1,74
2006	1,74	2,07	1,41	2,37	1,21	0,96	1,51	1,71	1,65	2,12	1,88
2007	1,68	2,56	1,35	2,11	1,20	0,98	1,58	1,78	1,68	2,02	1,84
2008	1,75	2,31	1,35	2,29	1,20	0,94	1,66	1,55	1,69	2,17	1,84
2009	2,20	2,72	1,20	2,57	1,26	0,87	1,55	0,59	1,70	1,95	1,73
2010	1,79	2,54	1,32	2,24	1,14	0,89	1,53	2,01	1,56	2,05	3,22
2011	1,87	2,76	1,32	2,24	1,08	0,83	1,65	2,22	1,53	1,90	1,59
2012	1,89	2,42	1,36	2,71	1,47	0,87	1,66	2,15	1,63	1,77	1,49

Table 5. CFR the Netherlands imports, data on total trade

CFR Imp	Total186	Europe23	Asia10	Scand4	Norway
2000	1,36	1,04	1,08	1,02	0,65
2001	1,45	0,96	0,99	1,00	0,66
2002	1,16	0,93	0,98	0,91	0,62
2003	1,29	0,92	1,19	0,92	0,66
2004	1,27	0,89	1,44	0,93	0,65
2005	1,46	0,97	1,04	0,93	0,51
2006	1,35	0,94	1,03	0,96	0,38
2007	1,30	0,98	1,31	0,97	0,42
2008	1,42	0,95	1,69	1,06	0,69
2009	1,39	1,06	0,76	1,01	0,72
2010	1,32	1,09	1,55	0,92	0,72
2011	1,30	1,06	0,65	0,96	0,51
2012	1,16	1,00	0,74	0,99	0,78

Table 6. CFR the Netherlands exports, data on total trade

CFR ex	Total186	Europe23	Asia10	Scand4	Norway
2000	1,17	0,88	1,68	0,92	0,87
2001	1,15	0,84	2,09	0,86	0,85
2002	1,07	0,85	1,83	0,89	0,87
2003	0,96	0,83	1,78	0,90	0,81
2004	0,94	0,91	1,30	0,90	0,77
2005	0,88	0,88	1,29	0,85	0,71
2006	0,89	0,85	1,05	0,90	0,81
2007	0,93	0,89	1,10	0,92	0,72
2008	1,03	0,87	1,23	0,91	0,81
2009	0,96	0,86	1,00	0,92	0,62
2010	1,00	0,88	1,04	0,90	0,73
2011	1,15	0,96	1,12	1,07	0,85
2012	1,02	0,87	1,09	0,91	0,71

Table 7. CFR the Netherlands import, product level data

All values on *product level data* are from the filtered dataset for 182 countries.

CFR imp	Total182	Asia10	Scand4	Europe23	Norway
2000	1,35	1,61	1,26	1,17	1,41
2001	1,32	1,71	1,23	1,12	1,35
2002	1,36	1,67	1,32	1,16	1,39
2003	1,38	1,64	1,32	1,22	1,23
2004	1,38	1,67	1,30	1,21	1,30
2005	1,37	1,59	1,27	1,20	1,12
2006	1,39	1,60	1,31	1,23	1,14
2007	1,40	1,60	1,34	1,26	1,23
2008	1,39	1,55	1,30	1,26	1,17
2009	1,43	1,57	1,34	1,30	1,25
2010	1,39	1,50	1,33	1,26	1,20
2011	1,46	1,47	1,48	1,41	1,12
2012	1,46	1,47	1,49	1,42	1,13

Table 8. CFR Netherlands imports price effect, product level data

CFR imp p	Total182	Asia10	Scand4	Europe23	Norway
2000	1,08	1,11	1,03	1,04	0,97
2001	1,10	1,10	1,02	1,08	1,01
2002	1,12	1,09	1,03	1,10	1,02
2003	1,12	1,20	1,04	1,10	0,96
2004	1,08	1,15	1,02	1,03	1,05
2005	1,08	1,14	1,01	1,02	1,03
2006	1,05	1,16	1,01	0,99	1,03
2007	1,03	1,11	1,00	0,99	1,01
2008	1,04	1,12	1,03	0,99	1,04
2009	1,45	1,56	1,38	1,28	1,63
2010	1,05	1,10	1,01	1,00	1,03
2011	1,04	1,07	1,00	1,00	1,03
2012	1,02	1,05	0,97	0,97	1,03

Table 9. CFR Netherlands imports quantity effect, product level data

CFR imp q	Total182	Asia10	Scand4	Europe23	Norway
2000	1,24	1,44	1,23	1,13	1,46
2001	1,21	1,55	1,21	1,03	1,33
2002	1,22	1,53	1,29	1,05	1,37
2003	1,23	1,37	1,27	1,11	1,27
2004	1,27	1,45	1,27	1,18	1,24
2005	1,28	1,39	1,26	1,17	1,09
2006	1,32	1,38	1,31	1,24	1,11
2007	1,36	1,43	1,34	1,27	1,22
2008	1,33	1,39	1,27	1,28	1,12
2009	0,98	1,01	0,98	1,02	0,77
2010	1,33	1,36	1,32	1,26	1,17
2011	1,41	1,37	1,48	1,41	1,09
2012	1,44	1,40	1,54	1,46	1,10

Table 10. CFR the Netherlands exports, product level data

CFR ex	Asia10	Total182	Scand4	Europe23	Norway
2000	1,79	1,59	1,61	1,58	1,62
2001	1,79	1,62	1,68	1,63	1,62
2002	1,70	1,57	1,62	1,58	1,62
2003	1,68	1,51	1,56	1,52	1,56
2004	1,65	1,51	1,53	1,53	1,49
2005	1,67	1,54	1,51	1,56	1,51
2006	1,59	1,50	1,50	1,51	1,48
2007	1,59	1,49	1,51	1,52	1,44
2008	1,62	1,46	1,47	1,48	1,39
2009	1,64	1,47	1,44	1,46	1,33
2010	1,58	1,43	1,39	1,44	1,41
2011	1,62	1,42	1,34	1,35	1,39
2012	1,61	1,40	1,34	1,30	1,35

Table 11. CFR the Netherlands exports price effect, product level data

CFR ex p	Asia10	Total182	Scand4	Europe23	Norway
2000	1,07	1,03	1,02	1,03	0,95
2001	1,03	1,00	1,03	0,99	1,00
2002	1,05	0,97	0,99	0,97	1,14
2003	1,07	0,95	1,02	0,94	1,24
2004	1,07	0,99	1,00	0,99	1,16
2005	1,00	0,98	0,95	0,98	0,97
2006	1,06	0,97	1,04	0,97	1,05
2007	1,00	0,98	1,02	0,97	1,06
2008	1,03	0,97	1,04	0,96	1,03
2009	0,96	0,85	1,00	0,81	1,11
2010	1,07	1,01	1,07	1,01	1,06
2011	1,02	0,99	1,04	0,99	1,05
2012	1,03	1,02	1,02	1,02	0,99

Table 12. CFR the Netherlands exports quantity effect, product level data

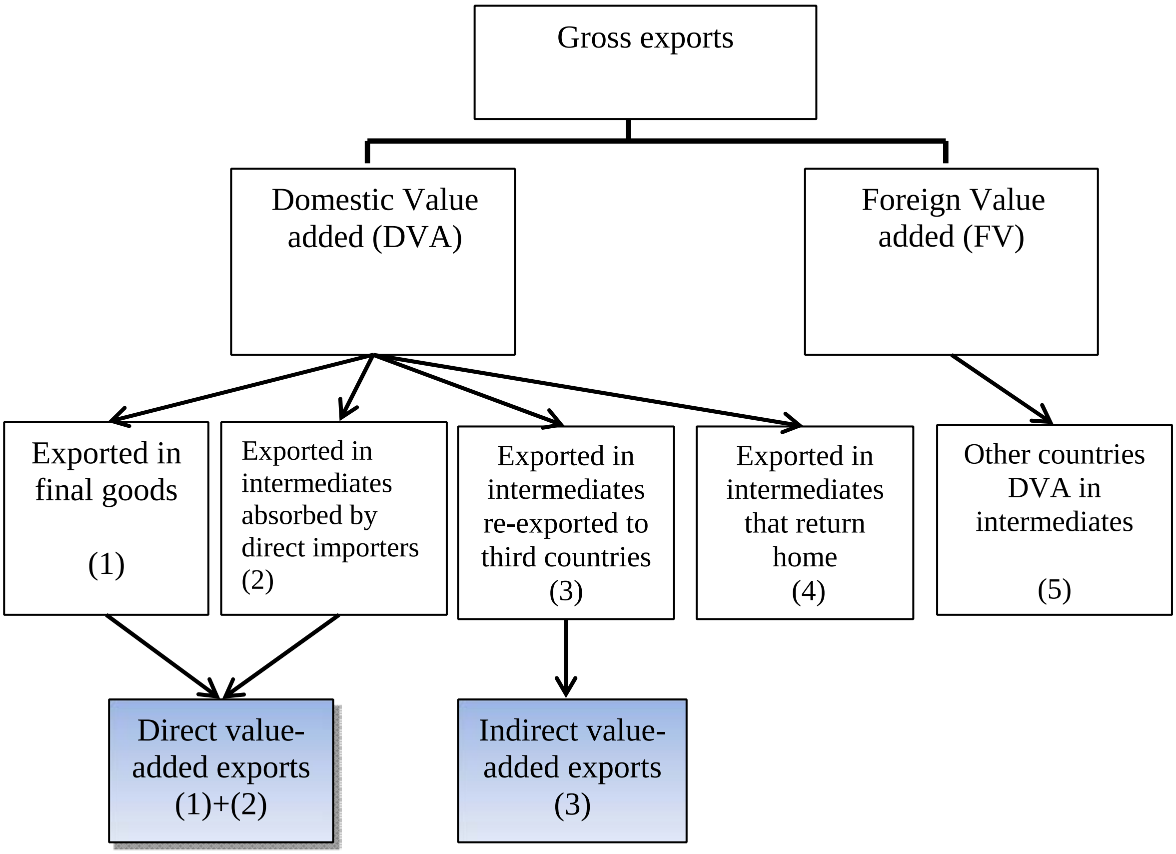
CFR ex q	Asia10	Total182	Scand4	Europe23	Norway
2000	1,68	1,53	1,58	1,54	1,70
2001	1,74	1,63	1,63	1,65	1,62
2002	1,62	1,62	1,64	1,63	1,42
2003	1,57	1,59	1,53	1,62	1,25
2004	1,54	1,53	1,53	1,55	1,28
2005	1,67	1,56	1,60	1,59	1,54
2006	1,50	1,55	1,44	1,56	1,41
2007	1,60	1,53	1,48	1,56	1,35
2008	1,57	1,52	1,41	1,54	1,35
2009	1,70	1,73	1,43	1,79	1,20
2010	1,48	1,41	1,31	1,42	1,32
2011	1,58	1,43	1,29	1,36	1,32
2012	1,56	1,38	1,31	1,27	1,36

Table 13. Dropped observations

Dropped observations for dataset on product level, 2000-2012

	Norway	The Netherlands
Initial dataset	1 685 765	3 954 653
No mirror value	829 191	1 542 779
%	49 %	39 %
Filtering	276 618	809 490
%	16 %	21 %
Total dropped	1 105 809	2 352 269
%	65 %	60 %
Variables left	579 956	1 602 384
%	35 %	40 %
Import	373 523	541 647
%	65 %	34 %
Export	206 433	1 060 737
%	35 %	66 %

Appendix B: Decomposition of gross exports



Source: Koopman et al. (2010)

(4) and (5) are sources of multiple counting in traditional trade statistics, as these involve value added that crosses national boarders at least twice.

The domestic share of value added in exports equals (1)+(2)+(3)+(4), and the VAX ratio for each country's export to the world from Johnson and Noguera (2012), is (1)+(2)+(3) divided by gross exports (Koopman et al., 2010).

Appendix C: Countries

Latin America				**Other countries**	
Nepal	NEP	Bulgaria	BUL	Australia	AUS
Brazil	BRZ	Lithuania	LIT	Azerbaijan	AZE
Argentina	ARG	Austria	AUT	Bahrain	BAH
El Salvador	ELS	**Asia**		Belarus	BLR
Madagascar	MAD	Vietnam	VIT	Bosnia and Herzegovina	BOH
Mexico	MEX	Macao	MCO	Cambodia	CMB
Colombia	COL	Japan	JAP	Cameroon	CMR
Dominican Republic	DOR	Hong Kong, China	HKG	Cyprus	CRP
Costa Rica	CSR	Singapore	SNP	Czech Republic	CZE
Peru	PER	India	IND	Faeroe Islands	FAI
Ecuador	ECU	Korea, Rep.	KOR	Georgia	GRA
Uruguay	URU	China	CHN	Greenland	GRN
Guatemala	GUA	Thailand	THL	Hungary	HUG
Venezuela	VEZ	Bangladesh	BAN	Iceland	ICL
Bolivia	BOL	**North America**		Indonesia	IDO
Chile	CHL	Canada	CAN	Iran, Islamic Rep.	IRN
Europe		United States	USA	Israel	ISR
Luxembourg	LUX	**Scandinavia**		Jamaica	JAM
Slovak Republic	SLR	Finland	FIN	Jordan	JOR
Portugal	POR	Denmark	DEN	Kazakhstan	KZS
Greece	GRC	Sweden	SWE	Lebanon	LEB
United Kingdom	GBR	**Africa**		Macedonia, FYR	MAC
France	FRA	Namibia	NAM	Malaysia	MAL
Germany	GER	Egypt, Arab Rep.	EGY	Moldova	MOL
Latvia	LAT	Cote d'Ivoire	CIV	Morocco	MRC
Belgium	BLG	Mauritius	MAU	New Zealand	NWC
Slovenia	SLO	Uganda	UGA	Oman	OMN
Malta	MLT	Kenya	KEN	Other Asia, nes	OAN
Poland	POL	Ethiopia(excludes Eritrea)	ETH	Pakistan	PAK
Netherlands	NED	South Africa	SAF	Philippines	PHL
Italy	ITA	Ghana	GHN	Qatar	QTR
Ireland	IRE	Zambia	ZAM	Russian Federation	RUS
Romania	ROM	Gambia, The	GAM	Sri Lanka	SLA
Estonia	EST	Tanzania	TAZ	Syrian Arab Republic	SYR
Croatia	CRT	Tunisia	TUN	Turkey	TUR
Spain	SPA	Gabon	GAB	Ukraine	UKR
Switzerland	SWL	Nigeria	NIG	Yugoslavia	YOG

Appendix D: Mathematical appendix

Marshall- Edgeworth index:

$$P = \frac{\sum_k p_k \times (q_k + q_{k-mirror})}{\sum_k p_{k-mirror} \times (q_k + q_{k-mirror})}$$

Input-Ouput Table, a numerical example:

The economy has *n* sectors, each one producing x_i units of a single homogenous good. Assume that the ith sector, in order to produce 1 unit, must use a_{ij}units from sector j. Furthermore, assume that each sector sells some of its output to other sectors (intermediate output) and some of its output to consumers (final output, or final demand). Call final demand in the ith sector d_i. Then we might write:

$$x_i = a_{1i}x_1 + a_{2i}x_2 + \cdots + a_{ni}x_n + d_i$$

Total output equals intermediate output plus final output, simplified into an expression for the economy: $x = Ax + d$, A being the coefficient matrix from the a_{ij} vectors of total output, and d is the vector of final demand. This can be rewritten into$(I - A)x = d$, and if values in the coefficient matrix and final demand vector are known, we can calculate the output needed when $I - A$ is invertible and the linear system of equations yields a unique solution.

The economy produces two goods; A and B. Further, we know that:

$A = \begin{pmatrix} 0.5 & 0.2 \\ 0.4 & 0.1 \end{pmatrix}$ and $d = \begin{pmatrix} 7 \\ 4 \end{pmatrix}$ we see from this that demand for good A is 7, and good B is 4, yielding the two equations: $0.5x_1 - 0.2x_2 = 7$ and $-0.4x_1 + 0.9x_2 = 4$

What does the output x have to be in order to satisfy demand in this case? The solution to this linear system of equations is: $x = (I - A)^{-1}d = \begin{pmatrix} 19.19 \\ 12.97 \end{pmatrix}$ And we can think of $(I - A)^{-1}$ as the N x N block Leontief inverse matrix in the calculation of TVA.