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The great collapse in value added trade

Arne J. Nagengast
(Deutsche Bundesbank)

Robert Stehrer
(WIIW)

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

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Non-technical summary

Research Question

Trade is generally known to be more volatile than GDP growth even though standard economic models suggest that they move in unison. Nevertheless, the magnitude of the decline in world trade during the global financial crisis still posed a major puzzle to economists and became known as the great trade collapse. Numerous studies have looked into the factors behind the great trade collapse and the consensus that has emerged is that it can be mainly attributed to changes in final expenditure, inventory adjustments and adverse financial conditions. Here we re-examine the issue using a recently available global trade dataset and a structural decomposition analysis.

Contribution

This paper differs from the previous literature in two important aspects. First, we focus on value added trade instead of gross trade flows. Value added trade captures in which country the particular parts of a final good were actually produced. Value added trade flows can differ substantially from gross trade flows due to trade in intermediate goods. Second, the use of yearly global input-output tables from the World Input Output Database (WIOD) allow us to consider changes in the international organisation of production as an additional explanatory factor of the great trade collapse.

Results

First, we show that changes in international production sharing accounted for almost half of the great trade collapse. Furthermore, we demonstrate that changes in international sourcing are common across the business cycle and more pronounced during downturns. Price effects appear to have played an important role for the collapse in value added trade accounting for around one third of the decline, but the relative contribution of changes in international production sharing to the decline in trade volume is the same as for nominal trade values. Applying our decomposition framework to the collapse in gross trade flows we highlight that the importance of changes in international production sharing for the variation in gross exports is even more pronounced than for value added exports due to the presence of foreign value added and double counting terms. Second, the global nature of our dataset and the use of a decomposition framework allow us to quantify the compositional changes in final demand that have been proposed in the previous literature. We find that the drop in the overall level of demand accounted for roughly a quarter of the decline in value added exports while just under one third was due to compositional changes in final demand. Third, we demonstrate that for value added trade all sectors were hit hard by the financial crisis and that the dichotomy between services and manufacturing sectors observed in gross exports is not apparent in value added trade data. This highlights that services sectors that are suppliers of inputs to direct exporters are likely to be much more vulnerable to external shocks than is generally acknowledged.

Nichttechnische Zusammenfassung

Fragestellung

Der Welthandel ist bekanntlich volatiler als das Weltwirtschaftswachstum, obwohl Standard-Wirtschaftsmodelle eine ebenmäßige Entwicklung beider Größen implizieren. Dennoch war die Größenordnung der Kontraktion des Welthandels während der globalen Finanzmarktkrise – welche als der große Handelskollaps bezeichnet wird – eine Überraschung. Zahlreiche Studien haben die Gründe für den großen Handelskollaps erforscht. Gemäß der bisherigen Literatur lässt dieser sich hauptsächlich auf Veränderungen in der Endnachfrage, Anpassung von Lagerbeständen und widrige finanzielle Bedingungen zurückführen. Unsere Studie untersucht den Sachverhalt mit Hilfe eines seit kurzem verfügbaren globalen Handelsdatensatzes sowie einer strukturellen Zerlegungsanalyse.

Beitrag

Unser Papier unterscheidet sich von der bisherigen Literatur in zwei wichtigen Aspekten. Erstens konzentrieren wir uns in unserer Analyse auf den Wertschöpfungshandel anstelle der herkömmlich verwendeten Bruttohandelsströme. Wertschöpfungsbasierte Maße reflektieren, welches Land die Wertschöpfungsanteile eines Endprodukts tatsächlich produziert hat. Wertschöpfungsströme können sich aufgrund des Handels mit Vorleistungsgütern sehr deutlich von Bruttohandelsströmen unterscheiden. Der zweite Aspekt betrifft die Verwendung der globalen Input-Output-Tabellen der World Input-Output Database (WIOD) auf Jahresbasis, die es uns ermöglicht, Veränderungen in der internationalen Arbeitsteilung als zusätzlichen Erklärungsfaktor für den großen Handelskollaps zu berücksichtigen.

Ergebnisse

Erstens zeigen wir, dass Veränderungen in der internationalen Arbeitsteilung annähernd die Hälfte des großen Handelskollapses erklären. Des Weiteren demonstrieren wir, dass Veränderungen in der Beschaffung internationaler Vorleistungsgüter über den Konjunkturzyklus hinweg weit verbreitet und in Rezessionen besonders ausgeprägt sind. Preiseffekte scheinen eine bedeutende Rolle für den Kollaps des Wertschöpfungshandels gespielt zu haben und machen etwa ein Drittel des Rückgangs aus. Zweitens erlaubt uns der globale Charakter des Datensatzes sowie die Verwendung einer Zerlegungsmethode die Quantifizierung von Kompositionseffekten in der Endnachfrage, die in der bisherigen Literatur vorgeschlagen wurden. Unsere Ergebnisse legen nahe, dass etwa ein Viertel des Rückgangs der Wertschöpfungsexporte auf das sinkende Niveau der Endnachfrage zurückzuführen ist, während Kompositionseffekte in der Endnachfrage ungefähr ein Drittel erklären. Drittens dokumentieren wir, dass die Wertschöpfungsexporte aller Sektoren von der Finanzkrise stark betroffen waren und dass der Gegensatz zwischen Dienstleistungssektoren und dem Verarbeitenden Gewerbe, welcher für die Bruttohandelsströme festgestellt wurde, für den Handel mit Wertschöpfung nicht vorliegt. Unsere Ergebnisse verdeutlichen, dass Dienstleistungssektoren, die mit direkten Exporteuren interagieren, deutlich anfälliger gegenüber externen Schocks sind als allgemein bekannt ist.

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Arne J. Nagengast
Deutsche Bundesbank

Robert Stehrer
WIIW

Abstract

This paper studies the great collapse in value added trade using a structural decomposition analysis. We show that changes in vertical specialisation accounted for almost half of the great trade collapse, while the previous literature on gross trade has mainly focused on final expenditure, inventory adjustment and adverse credit supply conditions. The decline in international production sharing during the crisis may partially account for the observed decrease in global trade elasticities in recent years. Second, we find that the drop in the overall level of demand accounted for roughly a quarter of the decline in value added exports while just under one third was due to compositional changes in final demand. Finally, we demonstrate that the dichotomy between services and manufacturing sectors observed in gross exports during the great trade collapse is not apparent in value added trade data.

Keywords: Great trade collapse; Vertical specialisation; Trade in value added; Input-output tables; Structural decomposition analysis

JEL classification: F1, F2, C67, R15

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1 Introduction

The consensus that has emerged on the great trade collapse is that it can be mainly attributed to changes in final expenditure (Bems, Johnson, and Yi, 2011, 2010; Bussière, Callegari, Ghironi, Sestieri, and Yamano, 2013; Eaton, Kortum, Neiman, and Romalis, 2011), inventory adjustment (Alessandria, Kaboski, and Midrigan, 2013, 2011; Altomonte, di Mauro, Ottaviano, Rungi, and Vicard, 2012) and adverse credit supply conditions (Bricongne, Fontagné, Gaulier, Taglioni, and Vicard, 2012; Behrens, Corcos, and Mion, 2013; Chor and Manova, 2012). The literature – reviewed comprehensively by Bems, Johnson, and Yi (2013) – has focused exclusively, with the exception of Bems et al. (2011), on gross trade flows. For gross exports different features of the final demand composition were important determinants of the great trade collapse (Bems et al., 2013), although their exact contributions have not been quantified. Particular attention has been paid to shifts in the demand for different types of exports such as durables and services (Yi, Bems, and Johnson, 2010; Bems et al., 2010, 2011; Eaton et al., 2011) linked to differences in the import intensity of demand components, such as investment and consumption (Bussière et al., 2013) as well as inventories (Alessandria et al., 2011, 2013). Remarkably, services trade proved very resilient during the great trade collapse and in some services sectors trade even continued to increase (Mattoo and Borchert, 2009). Durables were particularly hard hit during the crisis while non-durables were much less affected (Levchenko, Lewis, and Tesar, 2010; Bems et al., 2013). For example, Behrens et al. (2013) find that for the case of Belgian consumer durables exports dropped by 36% while exports of nondurables only decreased by 2%. Vertical specialisation is thought to have contributed to the magnitude of the decline in gross trade only in the sense that demand for sectors with a strong degree of cross-border linkages (and hence trade in intermediate goods) declined most (Bems et al., 2011).

Due to data constraints previous studies suffer from two shortcomings. First, they focus on gross trade instead of value added trade and, second, they assume that the extent of vertical specialisation remained fixed during the crisis. Gross trade figures inflate the volume of trade due to foreign value added and double counting terms (Koopman, Wang, and Wei, 2014). In contrast, value added measures of trade arguably better reflect the existence of bilateral trade imbalances (Nagengast and Stehrer, 2014), the need for relative price adjustment (Bems, 2014) and which countries benefit from trade in terms of income and employment (Foster-McGregor and Stehrer, 2013; Timmer, Los, Stehrer, and de Vries, 2013). Therefore, in order to gauge the overall economic significance of the great trade collapse it seems more appropriate to consider value added instead of gross trade data. Regarding the role of vertical specialisation, assuming a constant organisation of international production sharing implicitly excludes an additional explanatory factor of the great trade collapse. A decline in sourcing from international suppliers to the benefit of national suppliers would provide an amplifying mechanisms of the decline in final demand and reduce the volume of international trade for every dollar spend on final goods and services. This is particularly important in the context of the growth slowdown in global trade relative to GDP growth that has been observed in recent years (Constantinescu, Mattoo, and Ruta, 2015; Ferrantino and Taglioni, 2014). A decline in international production sharing therefore might have played a role both for explaining the great trade collapse as well as partially account for the decrease in global trade elasticities.

In this study, we attempt to fill this gap in the literature by considering value added trade data for the years 1995 to 2011 derived from the World Input Output Database (Dietzenbacher, Los, Stehrer, Timmer, and de Vries, 2013) (WIOD). WIOD is particularly well suited for analysing changes in the international sourcing structure since its global input-output tables are derived mainly from annual supply and use tables and for most countries they are not based on interpolated national input-output tables in reference years. We use a structural decomposition analysis (Miller and Blair, 2009; Dietzenbacher and Los, 1998) which allows us to quantify the contributions of changes in the structure and level of final demand as well as the organisation of international production sharing to changes in world value added trade. Our first contribution is that we show – by relaxing the constancy assumption of vertical specialisation – that changes in (international) production sharing accounted for almost half of the great trade collapse. Furthermore, we demonstrate that changes in international sourcing are common across the business cycle and more pronounced during downturns. Price effects appear to have played an important role for the collapse in value added trade accounting for around one third of the decline, but the relative contribution of changes in international production sharing to the decline in trade volume is the same as for nominal trade values. Applying our decomposition framework to the collapse in gross trade flows we highlight that the importance of changes in international production sharing for the variation in gross exports is even more pronounced than for value added exports due to the presence of foreign value added and double counting terms. Second, we propose a novel decomposition of changes in final demand that renders it possible to estimate the effect of a variety of compositional changes. The global nature of our dataset and the use of a decomposition framework allows us to put a number on the contribution that compositional changes made to the decline in trade during the crisis. We find that the drop in the overall level of demand accounted for roughly a quarter of the decline in value added exports while just under one third was due to compositional changes in final demand. In addition to the well-known goods and component specific demand changes, we identify a third compositional factor of quantitative importance which captures the fact that demand for goods and services of countries with a strong degree of cross-border linkages declined most. Our third contribution is that we demonstrate that the dichotomy between services and manufacturing sectors observed in gross exports during the great trade collapse is not apparent in value added trade data.

The rest of the paper is structured as follows. Section 2 provides a sketch of a simple modeling framework underlying our decomposition analysis as well as the methodological details of the basic structural decomposition analysis and its variants used in the main text. Section 3 presents our empirical results and Section 4 discusses potential explanations of our main findings. Section 5 concludes.

2 Methodology

2.1 Modeling framework

In this section we sketch the basic elements of the economy underlying the subsequent decomposition analysis in order to highlight the potential factors that can affect changes in international trade flows. We extend the framework described in Bems et al. (2010), which considers an exogenously given demand shock, to additionally include an exogenous shock to the input shares in production. In order to simplify the exposition we will refer to the output of different sectors as "goods" even though our data comprise primary commodities, manufactures and services. Let there be C countries with S sectors each producing one differentiated good that is either used as an intermediate input for production or absorbed in final demand. Output in each sector s of country c, y_{cs}, is produced by combining primary inputs or value added, w_{cs}, such as labour and capital with intermediate inputs, $z_{ij,cs}$, sourced from other sectors j at home or abroad (country i):

$$y_{cs} = w_{cs} + \sum_{i,j} z_{ij,cs}.$$

Let $a_{ij,cs} \equiv z_{ij,cs}/y_{cs}$ be the quantity share of sector j in country i used in production of output in sector s in country c and $f_{i,cs}$ be the quantity of final goods from sector s in country c that is absorbed in final demand[1] in destination i. Following Bems et al. (2010) throughout the text we equate quantity shares with value shares as well as quantities of final goods with the the value of final goods. As a robustness test, in Section 3.1.3 we relax this assumption and repeat our analysis holding prices constant. The market clearing condition is then given by

$$y_{cs} = \sum_{i} f_{i,cs} + \sum_{i,j} a_{cs,ij} y_{ij}.$$

At the beginning of each time period, each sector decides on the share of primary inputs in production – taken technology and factor costs as given – as well as the share of intermediate inputs from different suppliers taking factors such as trade costs, non-tariff barriers as well trade financing constraints into account. For the remainder of the time period each sector uses a Leontief production function with inputs in fixed proportions, i.e. inter-industry flows from sector cs to ij depend entirely on the total output of sector ij. We follow Bems et al. (2010) in considering a demand-driven Leontief system which is the most common model used in input-output analysis. This assumption in turn implies that output of every sector is completely pinned down by final demand both at home and abroad. For every time period t, we observe both changes in final demand as well as changes in primary and intermediate inputs using the global input-output table from WIOD. These three variables are the proximate factors that determine production, gross trade as well as value added trade flows in our model while the ultimate causes of their changes are exogenous to our model as in Bems et al. (2010).

Of particular interest to our analysis are changes in input shares, which we interpret to be increases in vertical specialisation when the proportion of internationally sourced intermediates increases either to the detriment of domestic inputs or sectoral value added shares. Given that the root causes of the shock to vertical specialisation are important for the interpretation of our results, we briefly discuss the most likely potential candidates for changes in production fragmentation (Hummels, Ishii, and Yi, 2001). A first possibility is that technology shocks lead to changes in vertical specialisation. For example, these shocks may entail changes in production technology that facilitate the separation

[1] Final demand may comprise several different demand components such as investment and consumption. The quantification of compositional effects in final demand are outlined in Section 2.4.1.

of existing stages of production and hence may increase the number of firms and sectors involved in the production of a single good (Deardorff, 2001). In this regard particularly improvements in communication technologies are thought to play a key role as they permit headquarters to coordinate and monitor production in distant locations (Baldwin, 2011). A second factor driving changes in vertical specialisation are variations in the cost of shipping goods. On the one hand these include transportation costs – such as changes in oil prices – and tariffs, which penalise sequential production in multiple countries in particular for two reasons. The first one are multiple border crossings which result in an amplification of tariffs with the number of production stages (Hummels et al., 2001). A second source of amplification comes from the fact that tariffs are levied on gross value rather than on value added (Miroudot and Rouzet, 2013). On the other hand financial development and the availability of trade finance are crucial determinants for the cost of trade and the organisation of global value chains. For example, Manova and Yu (2012) show that credit constraints restrict Chinese firms to low value-added stages of production and preclude them from moving up the value chain. Capital market imperfections are similarly thought to affect multinationals' integration decisions (Antràs, Desai, and Foley, 2009). On a shorter time scale, credit shocks can exert a negative impact on trade by raising the cost of entry as well as by affecting the variable cost of production.[2]

2.2 Value added trade

Value added exports of country i, VAX^i, are defined as value added of country i, which is absorbed in final demand abroad (Johnson and Noguera, 2012), $\text{VAX}^i = (\mathbf{v}^i)'\mathbf{L}\mathbf{f}^{-i}$, where $\mathbf{v}^i$ denotes a vector of value added coefficients with non-negative entries for country i and zeros otherwise, $\mathbf{L}$ denotes the Leontief inverse $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$, $\mathbf{A}$ is the global input-output coefficient matrix, $\mathbf{f}^{-i}$ is a vector of final demand expenditures of all countries except i. In order to arrive at world value added exports, VAX, requires summing over the value added exports of all individual countries. Calculations were performed using global input-output tables from WIOD[3] with $C = 41$ countries and $S = 35$ sectors. The global input-output tables from WIOD are particularly well suited for analysing year-on-year changes in the international sourcing structure since they are derived from annual supply and use tables and not based on interpolation of national input-output tables in reference years.

Value added exports of sector s in country i, VAX^i_s, are computed as

$$\text{VAX}^i_s = \mathbf{v}^{is}\mathbf{L}\mathbf{f}^{-i}$$

where $\mathbf{v}^{is}$ denotes an $1 \times SC$ vector of value added coefficients with a non-negative entry for sector s in country i and zeros otherwise. As before world value added exports of sector s, VAX_s, are calculated by summing value added exports of sector s across all countries

$$\text{VAX}_s = \sum_i^C \text{VAX}^i_s \tag{1}$$

[2]See Section 4 for a detailed discussion of the role of financial constraints.

[3]World Input Output Database (www.wiod.org).

After computing value added exports of individual sectors the results were grouped into 10 different sectoral classes for the sake of brevity.[4]

2.3 Gross trade flows

For comparison we also consider a basic decomposition of gross trade flows. Gross exports of country i, EX^i, are the sum of both final and intermediate goods exports to all of its trade partners j:

$$\mathrm{EX}^i = \sum_{j \neq i} f^{ij} + a^{ij} y^j, \tag{2}$$

where f^{ij} are the entries in $\mathbf{f}$ capturing final goods and services exports from country i to country j, a^{ij} refers to the entries in the global input-output coefficient matrix $\mathbf{A}$ indicating the sourcing of inputs in country j from country i and y^j measures the total output of country j. In order to make the results for gross exports comparable to those for value added exports, we need to express the output of country y^j as a function of demand in other countries as well as introduce value added coefficients. First, note that the gross output of country j is endogenous in a demand-driven Leontief system, i.e. gross output can be expressed as a function of final demand in all other countries

$$y^j = \sum_{m,n} l^{jm} f^{mn}. \tag{3}$$

In a second step, gross exports are broken down by the origin of their value added content. We note that the identity $\mathbf{v}'(\mathbf{I} - \mathbf{A})^{-1} = \mathbf{v}'\mathbf{L} = \iota'$ holds which follows from first principles.[5] and consequently

$$\begin{bmatrix} \sum_k v^k l^{k1} \\ \vdots \\ \sum_k v^k l^{kC} \end{bmatrix} = \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}. \tag{4}$$

[4](1) *Agriculture*: Agriculture, Hunting, Forestry and Fishing; (2) *Mining and utilities*: Mining and Quarrying + Electricity, Gas and Water Supply; (3) *Low tech*: Food, Beverages and Tobacco + Textiles and Textile Products + Leather, Leather and Footwear + Wood and Products of Wood and Cork + Pulp, Paper, Paper , Printing and Publishing + Manufacturing, Nec; Recycling; (4) *Medium-low tech*: Coke, Refined Petroleum and Nuclear Fuel + Rubber and Plastics + Other Non-Metallic Mineral + Basic Metals and Fabricated Metal; (5) *Medium-high and high tech*: Chemicals and Chemical Products + Machinery, Nec + Electrical and Optical Equipment + Transport Equipment; (6) *Construction*: Construction; (7) *Non-tradable market services*: Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel + Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles + Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods + Hotels and Restaurants + Real Estate Activities + Other Community, Social and Personal Services + Private Households with Employed Persons; (8) *Transport and communication*: Inland Transport + Water Transport + Air Transport + Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies + Post and Telecommunications; (9) *Business services*: Financial Intermediation + Renting of M&Eq and Other Business Activities; (10) *Non-market services*: Public Admin and Defence; Compulsory Social Security + Education + Health and Social Work.

[5]See Nagengast and Stehrer (2014) for details.

Substituting y^j in equation (2) by (3) and multiplying the resulting expression by the corresponding entry for country i in equation (4) yields:[6]

$$\mathrm{EX}^i = \sum_{j \neq i} \sum_k v^k l^{ki} f^{ij} + \sum_{j \neq i} \sum_{k,m,n} v^k l^{ki} a^{ij} l^{jm} f^{mn}. \tag{5}$$

Note that after performing the structural decomposition analysis on equation 5 we add the contributions of both $\Delta\mathbf{A}$ and $\Delta\mathbf{L}$ to arrive at our measure of changes in vertical specialisation $\Delta\mathbf{L}$.

2.4 Structural decomposition analysis

The aim of structural decomposition analysis is to provide an additive decomposition of a matrix product $\mathbf{y}$ composed of n-terms into contributions of its individual factors $\mathbf{x}_i$ (Miller and Blair, 2009). Changes in world value added exports can be decomposed into changes in the value added coefficients vector, $\Delta\mathbf{v}$, the Leontief matrix, $\Delta\mathbf{L}$, and final demand vector, $\Delta\mathbf{f}$.[7] The decomposition of the matrix product $\mathbf{y}$ is non-unique and in theory there are $n!$ possible decomposition formulas of which we report the mean as suggested by Dietzenbacher and Los (1998). For additional decompositions of the factors $\mathbf{L}$ and $\mathbf{f}$ we exploit the hierarchical structure of the problem in order to reduce the computational burden and to ensure that the introduction of additional factors at lower levels does not change the contribution of factors at higher levels (Chen and Wu, 2008). See Koller and Stehrer (2009) for a detailed discussion and specifics on the implementation of hierarchical structural decomposition analysis. Figure 1 shows a graphical depiction of all the layers of the hierarchical decompositions which will be described in detail in the subsequent subsections. Decompositions were performed for annual changes for the time period from 1995 to 2011, and the arithmetic mean of annual contributions was calculated where indicated.

2.4.1 Decomposing changes in final demand in global input-output tables

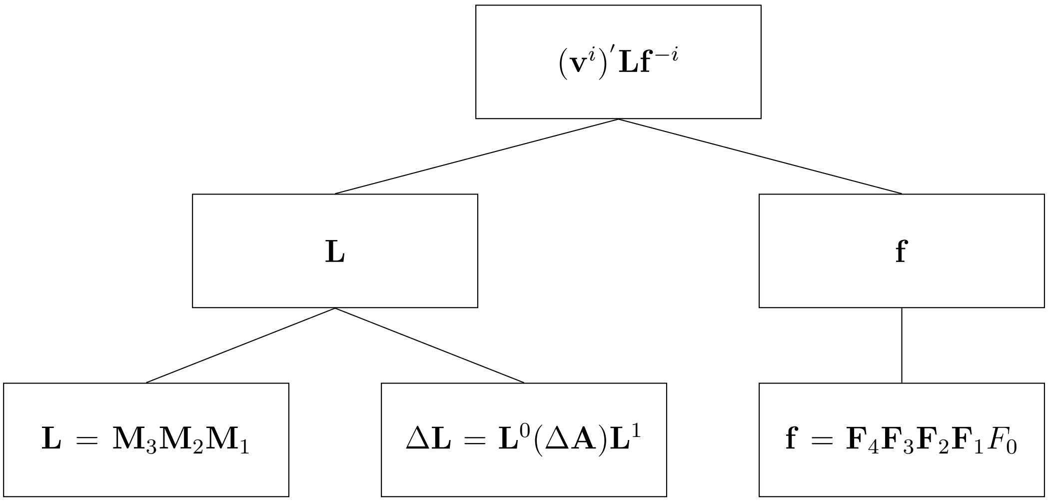
Here, we extend the final demand decomposition for a single country described in Miller and Blair (2009) to a global setting with demand in C countries that in addition can be distributed across goods and services from C different countries. In the one-country case, final demand is disaggregated into the overall *level* of demand, the final demand *mix* across demand categories[8] and the final demand *distribution* across different sectors. In a global setting two additional dimensions need to be considered. First, the overall level of final demand is due to demand in different countries and therefore the final demand *country mix* also needs to be taken into account. Second, once final consumers have

[6]The left-hand side of the expression is unchanged since all entries of the vector in equation (4) are equal to one.

[7]Note that strictly speaking $\Delta\mathbf{v}$ and $\Delta\mathbf{L}$ are not independent, since if a given sector outsources a certain production step to another sector (in the same country or abroad), *ceteris paribus*, this will lead to a decline in the according entry in $\mathbf{v}$ (and an increase of the same magnitude in the according entry in $\mathbf{A}$). See Dietzenbacher and Los (2000) for a detailed exposition of this issue.

[8]The final demand categories specified in WIOD include final consumption expenditure by households, final consumption expenditure by non-profit organisations serving households, final consumption expenditure by the government, gross fixed capital formation and changes in inventories and valuables.

Figure 1: Tree structure showing the different levels of the hierarchical decomposition.



determined which kind of product to acquire (*sectoral distribution*), they also need to decide from which of the C countries a given product should be purchased depending on relative prices and quality. This is captured by the final demand *country market share distribution*.[9]

In a global input-output model with S sectors and C countries differentiating P categories of final demand let f^t_{ipsj} record the amount of expenditure by demand category p in country i on the product of sector s in country j in year t. In the following time superscripts are suppressed for the sake of readability.

$$F_0 = \sum_i \sum_p \sum_s \sum_j f_{ipsj}$$

is a scalar capturing the overall world *level* of final demand.

$$\mathbf{F}_1 = \Big[\sum_p \sum_s \sum_j \frac{f_{1psj}}{\sum_i f_{ipsj}}; \sum_p \sum_s \sum_j \frac{f_{2psj}}{\sum_i f_{ipsj}}; \cdots \sum_p \sum_s \sum_j \frac{f_{Cpsj}}{\sum_i f_{ipsj}} \Big]$$

is the $(C \times 1)$ vector capturing the final demand *country mix*, i.e. how the overall world level of final demand is distributed across countries.

$$\mathbf{F}_2 = \begin{bmatrix} \sum_s \sum_j \frac{f_{11sj}}{\sum_p f_{1psj}} & \sum_s \sum_j \frac{f_{21sj}}{\sum_p f_{2psj}} & \cdots & \sum_s \sum_j \frac{f_{C1sj}}{\sum_p f_{Cpsj}} \\ \sum_s \sum_j \frac{f_{12sj}}{\sum_p f_{1psj}} & \sum_s \sum_j \frac{f_{22sj}}{\sum_p f_{2psj}} & \cdots & \sum_s \sum_j \frac{f_{C2sj}}{\sum_p f_{Cpsj}} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_s \sum_j \frac{f_{1Psj}}{\sum_p f_{1psj}} & \sum_s \sum_j \frac{f_{2Psj}}{\sum_p f_{2psj}} & \cdots & \sum_s \sum_j \frac{f_{CPsj}}{\sum_p f_{Cpsj}} \end{bmatrix}$$

is the $(P \times C)$ matrix capturing the final demand *component mix*, i.e. how the country level of final demand is distributed across individual demand components.

[9]Here, we note that our decomposition is not unique and that alternative orders are conceivable. However, the decomposition chosen is, in our opinion, the most intuitive and also naturally leads to an interpretation of competitiveness in terms of market share gains and losses.

$$\mathbf{F}_3 = \begin{bmatrix} \sum_i \sum_j \frac{f_{i11j}}{\sum_s f_{i1sj}} & \sum_i \sum_j \frac{f_{i21j}}{\sum_s f_{i2sj}} & \dots & \sum_i \sum_j \frac{f_{iP1j}}{\sum_s f_{iPsj}} \\ \sum_i \sum_j \frac{f_{i12j}}{\sum_s f_{i1sj}} & \sum_i \sum_j \frac{f_{i22j}}{\sum_s f_{i2sj}} & \dots & \sum_i \sum_j \frac{f_{iP2j}}{\sum_s f_{iPsj}} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_i \sum_j \frac{f_{i1Sj}}{\sum_s f_{i1sj}} & \sum_i \sum_j \frac{f_{i2Sj}}{\sum_s f_{i2sj}} & \dots & \sum_i \sum_j \frac{f_{iPSj}}{\sum_s f_{iPsj}} \end{bmatrix}$$

is the $(S \times P)$ matrix capturing the final demand *sectoral distribution*, i.e. how the final demand of the different demand components is distributed across products of individual sectors.

$$\mathbf{f}_c^{(4)} = \Big[\sum_i \sum_p \frac{f_{ip1c}}{\sum_j f_{ip1j}}; \sum_i \sum_p \frac{f_{ip2c}}{\sum_j f_{ip2j}}; \dots \sum_i \sum_p \frac{f_{ipSc}}{\sum_j f_{ipSj}} \Big]$$

$$\mathbf{F}_4 = \Big[\text{diag}(\mathbf{f}_1^{(4)}); \text{diag}(\mathbf{f}_2^{(4)}); \dots \text{diag}(\mathbf{f}_C^{(4)}) \Big]$$

is the $(SC \times S)$ matrix capturing the final demand *country market share distribution*, i.e. how final demand expenditure on individual sectors is distributed across different countries. With the above definitions, the overall final demand vector $\mathbf{f}$ can be written as the five-factor product

$$\mathbf{f} = \mathbf{F}_4 \mathbf{F}_3 \mathbf{F}_2 \mathbf{F}_1 F_0.$$

2.4.2 Multiplier decomposition of $\Delta\mathbf{L}$

Changes in $\mathbf{L}$ can be due to changes in the national and international sourcing structure of a given sector. In order to take this distinction into account, we decompose $\mathbf{L}$ into three factors $\mathbf{L} = \mathbf{M}_3\mathbf{M}_2\mathbf{M}_1$, where $\mathbf{M}_1$ captures *intra-country* effects, $\mathbf{M}_2$ contains *inter-country* effects and the matrix $\mathbf{M}_3$ records *inter-country* feedback effects capturing the interaction between $\mathbf{M}_1$ and $\mathbf{M}_2$. (Round, 1985; Dietzenbacher, 2002). The first term captures the effect that changes in sourcing within a given economy have on trade, for example, when switching from processing domestic raw materials in-house to purchasing a prefabricated domestic component for production. The second term subsumes the effect of changes in supplier relations between countries, such as procuring car parts from an international supplier instead of a domestic one. In contrast, the inter-country feedback effect considers the full circular effect of changes in $\mathbf{M}_1$ and $\mathbf{M}_2$. This is necessary since the value added embodied in goods and services crosses international borders several times before reaching their final costumer. While the first two terms only capture the first-round effect on trade, higher-order effects measure the interaction of intra-country and inter-country effects. $\mathbf{M}_3$ is therefore also sometimes referred to as the closed-loop effect. The structure of the matrices $\mathbf{M}_1$, $\mathbf{M}_2$ and $\mathbf{M}_3$ is given below following the exposition in Miller and Blair (2009). Changes in intra-country and inter-country elements in $\mathbf{A}$ can be distinguished by noting that

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}^{11} & \mathbf{A}^{12} & \dots & \mathbf{A}^{1C} \\ \mathbf{A}^{21} & \mathbf{A}^{22} & \dots & \mathbf{A}^{2C} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}^{C1} & \mathbf{A}^{C2} & \dots & \mathbf{A}^{CC} \end{bmatrix} = \tilde{\mathbf{A}} + (\mathbf{A} - \tilde{\mathbf{A}}) = \begin{bmatrix} \mathbf{A}^{11} & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & \mathbf{A}^{22} & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & \mathbf{A}^{CC} \end{bmatrix} + \begin{bmatrix} \mathbf{0} & \mathbf{A}^{12} & \dots & \mathbf{A}^{1C} \\ \mathbf{A}^{21} & \mathbf{0} & \dots & \mathbf{A}^{2C} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}^{C1} & \mathbf{A}^{C2} & \dots & 0 \end{bmatrix}$$

$\tilde{\mathbf{A}}$ captures the national sourcing structure of a given sector, while $(\mathbf{A} - \tilde{\mathbf{A}})$ reflects the origin of its internationally sourced inputs. Hence, *intra-country* effects are computed as

$$\mathbf{M}_1 = (\mathbf{I} - \tilde{\mathbf{A}})^{-1} = \begin{bmatrix} (\mathbf{I} - \mathbf{A}^{11})^{-1} & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & (\mathbf{I} - \mathbf{A}^{22})^{-1} & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & (\mathbf{I} - \mathbf{A}^{CC})^{-1} \end{bmatrix}$$

For the other two factors the following definition will be useful.

$$\mathbf{A}^* = (\mathbf{I} - \tilde{\mathbf{A}})^{-1}(\mathbf{A} - \tilde{\mathbf{A}}) = \begin{bmatrix} \mathbf{0} & (\mathbf{I} - \mathbf{A}^{11})^{-1}\mathbf{A}^{12} & \dots & (\mathbf{I} - \mathbf{A}^{11})^{-1}\mathbf{A}^{1C} \\ (\mathbf{I} - \mathbf{A}^{22})^{-1}\mathbf{A}^{21} & \mathbf{0} & \dots & (\mathbf{I} - \mathbf{A}^{22})^{-1}\mathbf{A}^{2C} \\ \vdots & \vdots & \ddots & \vdots \\ (\mathbf{I} - \mathbf{A}^{CC})^{-1}\mathbf{A}^{C1} & (\mathbf{I} - \mathbf{A}^{CC})^{-1}\mathbf{A}^{C2} & \dots & \mathbf{0} \end{bmatrix}$$

Then, *inter-country* effects, $\mathbf{M}_2$, can be calculated as

$$\mathbf{M}_2 = \mathbf{I} + \mathbf{A}^* = \begin{bmatrix} \mathbf{I} & (\mathbf{I} - \mathbf{A}^{11})^{-1}\mathbf{A}^{12} & \dots & (\mathbf{I} - \mathbf{A}^{11})^{-1}\mathbf{A}^{1C} \\ (\mathbf{I} - \mathbf{A}^{22})^{-1}\mathbf{A}^{21} & \mathbf{I} & \dots & (\mathbf{I} - \mathbf{A}^{22})^{-1}\mathbf{A}^{2C} \\ \vdots & \vdots & \ddots & \vdots \\ (\mathbf{I} - \mathbf{A}^{CC})^{-1}\mathbf{A}^{C1} & (\mathbf{I} - \mathbf{A}^{CC})^{-1}\mathbf{A}^{C2} & \dots & \mathbf{I} \end{bmatrix}$$

The interaction between *intra-country* and *inter-country* effects, $\mathbf{M}_3$, is computed as

$$\mathbf{M}_3 = [\mathbf{I} - (\mathbf{A}^*)^2]^{-1}$$

For a derivation and a detailed discussion of the different factors see Miller and Blair (2009) and the references therein.

Two-country two-sector numerical example In this section we describe a simple numerical example in order to build intuition and to illustrate how changes in sourcing decisions are reflected in $\Delta\mathbf{M_1}$, $\Delta\mathbf{M_2}$ and $\Delta\mathbf{M_3}$. Consider a two-country two-sector world. At time $t = 0$ both countries are identical and in autarky:

$$\mathbf{v_0} = \begin{bmatrix} 0.2 & 1 & 0.2 & 1 \end{bmatrix}; \mathbf{A_0} = \begin{bmatrix} 0.4 & 0 & 0 & 0 \\ 0.4 & 0 & 0 & 0 \\ 0 & 0 & 0.4 & 0 \\ 0 & 0 & 0.4 & 0 \end{bmatrix}; \mathbf{f_0} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix}.$$

Sector 2 is akin to a services sector whose output is produced only using primary inputs and no intermediates. Sector 1 can be thought of as a manufacturing sector which uses both capital and labour as well as intermediate inputs from both sectors. Final consumers in both countries buy one unit of the domestic manufacturing good so there is no trade. In the following, we will consider three different scenarios for time period $t = 1$. In all three the value added shares as well as final demand will be held constant, i.e. $\mathbf{v_1} = \mathbf{v_0}$ and $\mathbf{f_1} = \mathbf{f_0}$. The only factor that changes are the input shares in $\mathbf{A}$ and we compute the resulting changes in value added trade, $\Delta\mathbf{VAX}$, as well as the contributions deriving from changes in the intra-country effect, $\Delta\mathbf{M}_1$, the inter-country effect, $\Delta\mathbf{M}_2$, and the inter-country feedback effect, $\Delta\mathbf{M}_3$.[10]

$$\mathbf{A_1^I} = \begin{bmatrix} 0.4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0.4 & 0 \\ 0.4 & 0 & 0.4 & 0 \end{bmatrix}; \mathbf{\Delta VAX^I} = \begin{bmatrix} 0 \\ 2/3 \end{bmatrix};$$

$$\mathbf{\Delta M_1^I} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}; \mathbf{\Delta M_2^I} = \begin{bmatrix} 0 \\ 2/3 \end{bmatrix}; \mathbf{\Delta M_3^I} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

In scenario I the manufacturing sector in country 1 starts to source its services inputs exclusively from country 2 instead of the domestic supplier. As a result country 2 benefits and its value added trade with country 1 grows from zero to 2/3. The increase is entirely due to the changes in the inter-country effect, $\Delta\mathbf{M}_2$, whereas both $\Delta\mathbf{M}_1$ and $\Delta\mathbf{M}_3$ are zero. In order to understand why the contribution from changes in the intra-country effect is zero, let us consider a second way of opening up from autarky.

$$\mathbf{A_1^{II}} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0.4 & 0 & 0.4 & 0 \\ 0.4 & 0 & 0.4 & 0 \end{bmatrix}; \mathbf{\Delta VAX^{II}} = \begin{bmatrix} 0 \\ 4/5 \end{bmatrix};$$

$$\mathbf{\Delta M_1^{II}} = \begin{bmatrix} 0 \\ -4/15 \end{bmatrix}; \mathbf{\Delta M_2^{II}} = \begin{bmatrix} 0 \\ 16/15 \end{bmatrix}; \mathbf{\Delta M_3^{II}} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

In scenario II the manufacturing sector in country 1 starts to source both its services and manufacturing inputs exclusively from country 2 and no longer purchases any intermediates from the domestic economy. As a consequence country 2 benefits even more than in the previous example and its value added trade with country 1 increases from zero to 4/5. Since now all domestic suppliers are replaced by international suppliers, changes in the inter-country effect, $\Delta\mathbf{M}_2$, are also larger than in scenario I. Changes in the intra-country effect, $\Delta\mathbf{M}_1$, are now slightly negative. This is due to the fact that in scenario I the manufacturing sector in country 1 used some of its output as intermediate inputs in its own production process. Since the services sector in country 2 provided inputs to the production of the manufacturing sector in country 1, this self-sourcing was beneficial for services value added trade of country 2. In our simple two-country example, however, the loss is more than compensated for by manufacturing value added trade of country 2 –whose increase is attributed to changes in the inter-country effect – but it is obvious that this no longer needs to be the case with more than two countries. In order to elicit a non-negative contribution from the inter-country feedback effect, $\Delta\mathbf{M}_3$, we will consider a third scenario.

$$\mathbf{A_1^{III}} = \begin{bmatrix} 0 & 0 & 0.4 & 0 \\ 0 & 0 & 0.4 & 0 \\ 0.4 & 0 & 0 & 0 \\ 0.4 & 0 & 0 & 0 \end{bmatrix}; \mathbf{\Delta VAX^{III}} \approx \begin{bmatrix} 0.5714 \\ 0.5714 \end{bmatrix};$$

[10]Note that since value added shares as well as final demand are held constant in all three scenarios neither contributes to growth in value added trade.

$$\mathbf{\Delta M_1^{III}} \approx \begin{bmatrix} -0.1803 \\ -0.1803 \end{bmatrix}; \mathbf{\Delta M_2^{III}} \approx \begin{bmatrix} 0.6959 \\ 0.6959 \end{bmatrix}; \mathbf{\Delta M_3^{III}} \approx \begin{bmatrix} 0.0559 \\ 0.0559 \end{bmatrix}.$$

In scenario III the manufacturing sectors in the two countries start to source both its services and manufacturing inputs exclusively from abroad. As a result both countries begin to export. Taken together world value added trade is largest in this scenario while value added trade of country 2 is smaller than in the previous examples. Changes in the intra-country effect are negative and changes in the inter-country effect positive for the same reasons as discussed above. However, now changes in the inter-country feedback effect, $\mathbf{\Delta M_3}$, also contribute positively to value added trade growth. Accordingly, a precondition for a non-negative contribution of $\mathbf{\Delta M_3}$ is two-way trade in intermediates. $\Delta \mathbf{M}_3$ involves second-round and higher-order effects that involve both the domestic economy as well as all other countries. The interaction between the sourcing structure at home and abroad in the infinite geometric series that defines the Leontief inverse eventually determines the exact value added contribution originating from the different sectors in the domestic economy and its trade partners.

Regional decomposition of $\Delta \mathbf{M}_2$ The aim of this additional analysis is to further decompose $\mathbf{M}_2$ into contributions from intra- versus inter-regional production sharing, which will allow us to answer the question whether shifts in production sharing across trade blocks are more pronounced than within them. Let $\mathbf{A}^{*(ij)}$ denote the ith row jth column entry of the block matrix $\mathbf{A}^*$ such that

$$\mathbf{A}^{*(ij)} = \begin{bmatrix} \mathbf{0} & (\mathbf{I}-\mathbf{A}^{ii})^{-1}\mathbf{A}^{ij} & \dots & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & \mathbf{0} \end{bmatrix}$$

Similarly let

$$\mathbf{M}_2^{(ij)} = \mathbf{I} + \mathbf{A}^{*(ij)} = \begin{bmatrix} \mathbf{I} & (\mathbf{I}-\mathbf{A}^{ii})^{-1}\mathbf{A}^{ij} & \dots & \mathbf{0} \\ \mathbf{0} & \mathbf{I} & \dots & \mathbf{0} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & \mathbf{0} & \dots & \mathbf{I} \end{bmatrix} \tag{6}$$

which captures the part of the *inter-country* spillovers due to sourcing of country j from country i. Likewise, $\Delta \mathbf{M}_2^{(ij)}$ describes changes in *inter-country* spillovers due to changes in sourcing of country j from country i. For simplicity, we group countries into three geographic regions: EU, NAFTA and Asia.[11]

2.4.3 Decomposition of ∆L - the sectoral and country dimension

An alternative decomposition of $\mathbf{L}$ considers the sectoral and country dimension of the international sourcing structure. It splits $\mathbf{A}$ into contributions of individual sectors in

[11] EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Sweden. NAFTA: Canada, Mexico, United States. Asia: China, Indonesia, India, Japan, Korea, Taiwan.

different countries, i.e. it captures from which sector and country a given sector s obtains its intermediate inputs. In this manner the contribution of sourcing changes in individual sectors to the economy-wide sourcing changes can be determined. Note the difference between this decomposition and the analysis of sectoral value added exports described in equation (1). Sectoral value added exports of sector s describe the monetary amount of value added of sector s, which is absorbed in final demand in countries other than the country of production. They are affected by changes in the sourcing structure of *all* sectors, since value added of sector s can enter into the production of intermediate and final goods of any sector. In turn, changes in the sourcing structure of sector s can in theory have an impact on sectoral value added exports of *all* sectors.

The sectoral decomposition of $\Delta\mathbf{L}$ follows the exposition by Miller and Blair (2009). As a first step, note that $\Delta\mathbf{L}$ is related to changes in the global input-output coefficient matrix $\mathbf{A}$ in the following way

$$\Delta\mathbf{L} = \mathbf{L}^1 - \mathbf{L}^0 = \mathbf{L}^0\mathbf{A}^1\mathbf{L}^1 - \mathbf{L}^0\mathbf{A}^0\mathbf{L}^1 = \mathbf{L}^0(\Delta\mathbf{A})\mathbf{L}^1$$

$\Delta\mathbf{A}$ can then simply be disaggregated into changes in individual sectors of different countries

$$\Delta\mathbf{A} = \sum_{c=1}^{C}\sum_{s=1}^{S}\Delta\mathbf{A}^{sc}$$

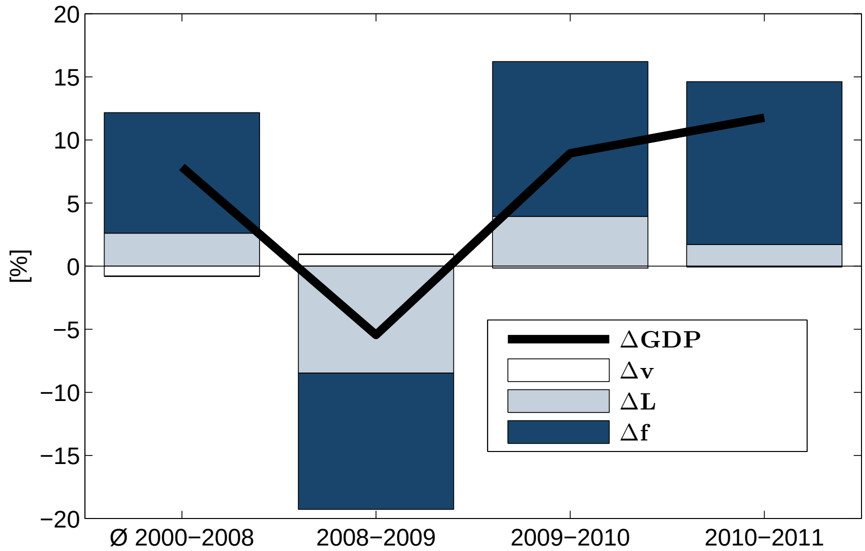
where $\Delta\mathbf{A}^{(sc)} = \begin{bmatrix} 0 & \dots & \Delta a_{11sc} & \dots & 0 \\ \vdots & & \vdots & & \vdots \\ 0 & \dots & \Delta a_{SCsc} & \dots & 0 \end{bmatrix}$ represents the technology change of sector s in country c and a_{ijsc} is the technical coefficient capturing the value of sector i in country j that enters production of sector s in country c necessary to produce 1 unit of output. In order to assess contributions to $\mathbf{L}$ from changes in sector s irrespective of the country or changes in country c irrespective of the sector the appropriate sums of $\mathbf{A}^{(sc)}$ were computed.

3 Decomposing the great trade collapse

3.1 The importance of (international) production sharing

First, note that the great trade collapse, i.e. a more than proportional decline of trade in comparison to changes in GDP, is a phenomenon not limited to gross trade, but is also apparent in value added trade data. While world GDP declined by 5.4% in nominal terms, value added trade collapsed by 18.3% in 2009. Overall the evolution of value added trade mirrors the changes in gross trade figures. Between 2000 and 2008 nominal value added exports grew on average by 11.4% a year. During the great trade collapse value added exports saw a very strong decline and fell by almost one fifth. The two years after the crisis saw a cyclical rebound of value added exports with exceptionally high growth rates in comparison to pre-crisis years (16.1% and 14.6%). In a first step, we use a structural decomposition analysis to assess which of its three basic building blocks contributed to the overall change in value added trade: $\Delta\mathbf{v}$ captures changes in the value added content of production, $\Delta\mathbf{L}$ represents changes in the structure of international production sharing

Figure 2: Decomposition of change in world value added trade.



and $\Delta\mathbf{f}$ records changes in final demand. Figure 2 shows that in an average year before the crisis growth in value added trade (11.4%) was to a large extent driven by changes in final demand (9.6pp). Increased (international) production sharing[12] contributed substantially less (2.6pp), while the decline in the sectoral value added content – corresponding to outsourcing of value creation to other sectors – put a drag on the growth of value added trade (−0.8pp). In stark contrast, changes in (international) production sharing explained just under half (−8.5pp) of the decline in value added exports in 2009 (−18.3%). Demand factors were still the most important (−10.8pp) although their relative significance was smaller than in previous years (59% vs. 84% of the change in value added trade). During the crisis, the share of value added generated within a given sector increased slightly (from 48% to 49%). During the recovery years the relative contribution of all three factors was similar to pre-crisis years. While the drop in final demand was almost completely compensated for in the first year after the crisis, the degree of (international) production sharing had still not regained its pre-crisis level by 2011. Our focus on value added trade, which precludes the influence of double counting terms, demonstrates that *changes* in vertical specialisation have played a substantial role during the great trade collapse over and above demand effects (Bems et al., 2011).

3.1.1 Contribution to changes in international production sharing ($\Delta\mathbf{M}_1$, $\Delta\mathbf{M}_2$ and $\Delta\mathbf{M}_3$)

In general, changes in international production sharing, $\Delta\mathbf{L}$, can be due to changes in both the national and international sourcing structure of a given sector. In order to disentangle these two effects, we perform an additional decomposition of $\Delta\mathbf{L}$ into three factors $\Delta\mathbf{M}_1$, $\Delta\mathbf{M}_2$ and $\Delta\mathbf{M}_3$. $\Delta\mathbf{M}_1$ captures changes in the *intra-country* sourcing structure of sectors, $\Delta\mathbf{M}_2$ reflects changes in the *inter-country* sourcing structure and

[12]Strictly speaking $\Delta\mathbf{L}$ includes both changes in intra-country and inter-country production sharing. In Section 3.1.1, we show that changes in international production sharing and its interaction terms were the main drivers of $\Delta\mathbf{L}$.

$\Delta\mathbf{M}_3$ records *inter-country* feedback effects due to the interaction between the first two factors.

Table 1: Decomposition of $\Delta\mathbf{L}$ into intra-country ($\Delta\mathbf{M}_1$) and inter-country components ($\Delta\mathbf{M}_2$) as well as their interaction effect ($\Delta\mathbf{M}_3$). Contribution to total change in world value added exports.

	⌀ 2000-2008	2008-2009	2009-2010	2010-2011
bn USD				
$\Delta\mathbf{L}$	185	-1041	395	199
$\Delta\mathbf{M_1}$	7	203	-116	-34
$\Delta\mathbf{M_2}$	112	-798	328	165
$\Delta\mathbf{M_3}$	65	-445	182	68
contribution to ΔVAX [pp]				
$\Delta\mathbf{L}$	2.6	-8.5	3.9	1.7
$\Delta\mathbf{M_1}$	-0.0	1.7	-1.2	-0.3
$\Delta\mathbf{M_2}$	1.7	-6.5	3.3	1.4
$\Delta\mathbf{M_3}$	0.9	-3.6	1.8	0.6

NOTE: Deviations from totals are due to rounding.

Table 1 shows that before the crisis the biggest contribution to changes in international production sharing came from the inter-country effect ($\Delta\mathbf{M}_2 = 1.7$pp) and the interaction term ($\Delta\mathbf{M}_3 = 0.9$pp). This suggests that the relocation of production abroad and the consolidation of cross-border production chains was a significant factor for the growth in value added trade before the crisis (Baldwin, 2011). The reorganisation of production within countries played a negligible role for explaining changes in value added trade. During the great trade collapse inter-country linkages were strongly reduced ($\Delta\mathbf{M}_2 = -6.5$pp) while the intra-country effect somewhat cushioned the drop in value added trade ($\Delta\mathbf{M}_1 = 1.7$pp). This means that on average sectors increased the relative share of intermediate inputs sourced from national suppliers at the expense of intermediates purchased from international suppliers. The interaction effect also shows a strong negative contribution ($\Delta\mathbf{M}_3 = -3.6$pp) during the crisis indicating that in the aggregate the negative inter-country effect prevailed over the positive intra-country effect. Overall this suggests that the negative contribution of $\Delta\mathbf{L}$ during the great trade collapse was mainly driven by changes in *international* production sharing.

Changes within or between trade blocks? Another question worthwhile considering is whether the shift in international production sharing was more pronounced within or between trade blocks. For example, there has been some evidence that during the crisis period EU manufacturing sectors may have increasingly sourced their inputs from non-EU countries (far-shoring) at the expense of choosing suppliers from within the European Union (near-shoring) (Foster-McGregor, Stehrer, and Timmer, 2013). In order to disentangle regional changes in production sharing we partition the inter-country effect, $\mathbf{M}_2$, by off-shoring origin and destination region. For simplicity, we only consider two off-shoring destinations: either the same region as the off-shoring origin (near-shoring) or any other region (far-shoring). For example, EU countries off-shoring production to other EU countries would be considered near-shoring while off-shoring by EU countries to Asia would be considered far-shoring. Table 2 shows the regional contribution to the overall change in $\mathbf{M}_2$ by off-shoring origin (EU, NAFTA and Asia)[13] and off-shoring destination (near-shoring vs. far-shoring).

Table 2: Decomposition of $\Delta\mathbf{M}_2$ into intra-region (*near-shoring*) and inter-region components (*far-shoring*). Contribution to total change in world value added exports.

	from		∅ 2000-2008	2008-2009	2009-2010	2010-2011
bn USD						
	EU	*near-shoring*	13	-67	-48	45
		far-shoring	24	-73	154	20
		ratio	0.53	0.92	-0.31	2.26
	NAFTA	*near-shoring*	3	-35	28	26
		far-shoring	29	-94	72	54
		ratio	0.09	0.37	0.39	0.47
	Asia	*near-shoring*	3	-31	37	25
		far-shoring	23	-189	77	122
		ratio	0.11	0.16	0.48	0.21

Before the crisis off-shoring to more distant destinations played a more pronounced role than to proximate ones for all regions. For NAFTA and Asian countries in particular far-shoring was about ten times more important than near-shoring, and near-shoring was even reduced in some years before the crisis in favour of more remote production locations. In contrast, in the European Union near-shoring was much more important in particular due to the integration of Central and Eastern European countries into regional production chains. During the great trade collapse both components of off-shoring were negatively impacted. However, near-shoring declined relatively more during the crisis than it had grown in previous years. For example, near-shoring in the EU fell by almost the same as far-shoring (-67 vs. -73 billion USD) while before the crisis it usually increased only by half as much. One possible explanation for this observation is that arms-length trade declines more with distance than intra-firm trade (Bombarda, 2011) while arms-length trade is at the same time typically more affected by economic crises (Bernard, Jensen, Redding, and Schott, 2009). In the two years after the crisis a strong recovery is observed for both components of off-shoring, and near-shoring grew relatively more than before the crisis. The only exception was the EU where near-shoring continued to decline for an additional year after the crisis before starting to recover in 2011 in line with the findings by Foster-McGregor et al. (2013). Overall, while near-shoring was affected more heavily during the financial crisis, we do not find evidence for a general shift from near-shoring to far-shoring.

3.1.2 Production changes in which sector and which country?

Since modifications in global value chains were such an important factor for the great trade collapse, the question arises whether altered sourcing decisions were a widespread

[13] Note that the remaining countries have been omitted since they do not correspond to a contiguous geographic region.

phenomenon or a characteristic of specific economic sectors or countries only.

Table 3 details the contribution of sourcing changes in ten sectoral aggregates to the overall change in value added trade in percentage points. During the crisis changes in production sharing in all sectoral aggregates reduced world value added trade. The absolute magnitude of the changes were larger than in an average year before the crisis suggesting that the crisis impacted sourcing decisions of firms in all sectors to a large extent. While it is true that certain sectors such as medium-low technology and medium-high and high technology contributed relatively more to changes than others, these sectors also showed greater sourcing dynamics before the crisis.

Table 3: Contribution of changes in the sectoral sourcing structure, $\Delta\mathbf{A}^{(s)}$, to the overall change in world value added trade in percentage points.

	∅ 2000-2008	2008-2009	2009-2010	2010-2011
Agriculture etc.	0.1	-0.2	0.0	0.1
Mining and utilities	0.3	-0.5	0.2	0.3
Low technology	0.2	-0.7	0.4	0.1
Medium-low technology	0.6	-1.7	0.7	0.4
Medium-high and high technology	0.6	-1.7	0.7	0.2
Construction	0.1	-0.9	0.3	0.1
Non-tradable market services	0.2	-1.1	0.9	0.1
Transport and communication	0.2	-0.7	0.3	0.1
Business services	0.1	-0.4	-0.0	0.1
Non-market services	0.2	-0.6	0.5	0.2

NOTE: Deviations from totals are due to rounding.

Table 4 lists the contribution of changes in vertical specialisation to the overall change in world value added trade in percentage points. During the great trade collapse changes in the input mix in all countries except Ireland reduced world value added trade. Some countries such as the United States, Japan, China and Germany showed substantially higher contributions to changes in vertical specialisation. However, these are also the countries with the highest world market share in value added trade and hence changes in their sourcing structure are expected to have a relatively larger impact on world value added trade.

Overall, this suggests that changes in the input mix of production were a widespread phenomenon not limited to particular sectors or economies.

3.1.3 On the (un)importance of prices changes

Most of the literature on trade in value added considers nominal flows since global input-output tables have until recently only been available in current prices. This implies that changes in the relative prices of different sectors (e.g. commodities versus manufactures)

Table 4: Contribution of changes in individual countries' sourcing structure, $\Delta\mathbf{A}^{(c)}$, to the overall change in world value added trade in percentage points.

	∅ 2000-2008	2008-2009	2009-2010	2010-2011
AUS	0.0	-0.1	-0.0	0.1
AUT	0.0	-0.0	0.0	0.0
BEL	0.0	-0.1	0.1	0.1
BGR	0.0	-0.0	0.0	0.0
BRA	0.0	-0.2	0.1	0.1
CAN	0.0	-0.0	-0.0	0.0
CHN	0.2	-0.7	0.7	0.4
CYP	0.0	-0.0	0.0	-0.0
CZE	0.0	-0.1	0.0	0.0
DEU	0.2	-0.5	0.3	0.1
DNK	0.0	-0.0	-0.0	0.0
ESP	0.1	-0.2	0.1	0.0
EST	-0.0	-0.0	-0.0	0.0
FIN	0.0	-0.0	0.0	0.0
FRA	0.1	-0.2	0.2	0.1
GBR	0.1	-0.1	0.0	0.0
GRC	0.0	-0.1	0.0	0.0
HUN	0.0	-0.0	0.0	0.0
IDN	0.0	-0.1	0.0	0.1
IND	0.0	-0.2	-0.0	0.0
IRL	0.0	0.0	-0.0	-0.0
ITA	0.1	-0.3	0.3	0.1
JPN	0.4	-1.1	0.3	0.4
KOR	0.1	-0.2	0.1	0.1
LTU	0.0	-0.0	0.0	0.0
LUX	0.0	-0.0	0.0	0.0
LVA	0.0	-0.0	0.0	0.0
MEX	0.0	-0.0	0.1	0.1
MLT	0.0	-0.0	0.0	0.0
NLD	0.0	-0.0	0.0	0.0
POL	0.0	-0.1	0.1	0.0
PRT	0.0	-0.0	0.0	0.0
ROU	0.0	-0.0	0.0	-0.0
RUS	0.0	-0.1	0.0	0.1
SVK	-0.0	-0.0	0.0	0.0
SVN	0.0	-0.0	-0.0	0.0
SWE	0.0	-0.0	-0.0	0.0
TUR	0.0	-0.1	0.0	0.1
TWN	0.1	-0.1	0.1	0.0
USA	0.5	-2.7	1.6	0.5
RoW	0.3	-1.2	-0.2	-0.9

NOTE: Deviations from totals are due to rounding.

may potentially have a bearing on our results. For example, the literature on the great trade collapse has documented that the price of manufactured goods increased (Haddad, Harrison, and Hausman, 2010) or remained broadly stable (Gopinath, Itskhoki, and Neiman, 2012) while the prices of other goods declined substantially in the crisis year. The expenditure on sectors whose prices increased relative to those of other sectors mechanically gains weight relative to the rest, which may erroneously lead us to conclude that vertical specialisation has changed even though in constant prices the Leontief inverse matrix would have remained constant.

In order to rule out any effects resulting from changes in prices we draw on the December 2014 release of global input-output tables from WIOD in previous years' prices which are available from 1996 to 2009.[14] Subtracting value added trade in year $t-1$ in current prices from value added trade in year t in previous year's prices allows us to obtain the change in constant prices of value added trade since all entries in the two global input-output tables are expressed in prices of year $t-1$.[15] Subsequently, we express value added trade in current prices and previous years' prices as a product of the corresponding vector of value added coefficients, the Leontief inverse and the vector of final demand expenditures (see Section 2.2 for details on the definitions of the three factors):

$$\begin{aligned}\Delta \text{VAX}^i_{real}(t) &= \text{VAX}^i_{pyp}(t) - \text{VAX}^i_{cur}(t-1) \\ &= [\mathbf{v}^i_{pyp}(t)]' \mathbf{L}_{pyp}(t)\mathbf{f}^{-i}_{pyp}(t) - [\mathbf{v}^i_{cur}(t-1)]' \mathbf{L}_{cur}(t-1)\mathbf{f}^{-i}_{cur}(t-1), \end{aligned} \tag{7}$$

where the subscript *cur* refers to current prices and *pyp* to previous years' prices. The structural decomposition analysis used above is then directly applied to Equation 7. Note that we define changes in vertical specialisation as changes in the entries of the Leontief inverse matrix as in the remainder of the text.

The middle panel of Table 5 shows the results of the structural decomposition analysis of world value added trade growth in constant prices. We first note that the dynamics of changes in value added trade for both current and constant price data are relatively similar and show a correlation of $\rho = 0.759$ across the sample period whereas their level usually differs. Before 2002 the data suggests that real changes in value added trade outpaced those in current prices. In the years before the trade collapse real changes were markedly lower than changes in nominal terms implying that price increases accounted partially for the rise in value added trade figures. Similarly, during the great trade collapse value added trade in real terms decreased by "only" 11.2% in contrast to 18.3% in nominal terms as prices fell sharply in response to the global crisis of 2008. Therefore, differentiating between real and nominal data is important since current price data inflates value added trade growth in most normal years as well as overstates the drop in value added trade in constant prices by a little more than a third. Similarly, in the literature on the great trade collapse Levchenko et al. (2010) report that roughly one third of the decline in gross trade values was due to changes in prices whereas many others have found that price movements played a negligible role in explaining the phenomenon (Gopinath et al., 2012; Haddad et al., 2010; Behrens et al., 2013; Bricongne et al., 2012).

Now that we have established the level differences in the trade collapse in current and constant prices, we can turn our attention to comparing the relative contribution of the underlying factors. The crucial question is whether changes in international production sharing contributed relatively less to the decline in constant prices than to the decrease in current prices. A difference would support the notion that changes in the Leontief inverse matrix were driven by movements in prices instead of volume. For constant price data we find that changes in vertical specialisation account for -5.2 percentage points of the 11.2% decline in value added trade between 2008 and 2009 (44% of the total change). In nominal terms reduced international production sharing contributed -8.5 percentage points out of the 18.3% collapse in value added trade (46% of the total change). Therefore,

[14] The current vintage of the global input-output tables from WIOD in previous years' prices is based on a RAS approach proposed by Dietzenbacher and Hoen (1998). The previously used double-deflation method was abandoned to ensure comparability of value added data with other data sources.

[15] See also Xu and Dietzenbacher (2014) for a similar analysis in a different context.

Table 5: Decomposition of change in world value added trade in current prices, world value added trade in constant prices and world gross trade in current prices.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Change in world value added trade in current prices																
bn USD																
ΔVAX	202	38	-36	208	443	-101	252	845	1161	906	1062	1506	1474	-2251	1609	1694
Δ**v**	-5	-13	-5	-19	-78	-32	52	-28	-24	-99	-81	-99	-177	115	-15	-6
Δ**L**	39	52	-29	84	325	-11	-56	97	268	259	244	173	365	-1041	395	199
Δ**f**	167	-1	-2	143	196	-57	256	775	917	746	900	1433	1286	-1325	1229	1501
% change / contribution to ΔVAX [pp]																
ΔVAX	4.7	0.8	-0.8	4.6	9.4	-2.0	5.0	15.9	18.8	12.4	12.9	16.2	13.6	-18.3	16.1	14.6
Δ**v**	-0.1	-0.3	-0.1	-0.4	-1.7	-0.6	1.0	-0.5	-0.4	-1.3	-1.0	-1.1	-1.6	0.9	-0.1	-0.1
Δ**L**	0.9	1.2	-0.6	1.8	6.9	-0.2	-1.1	1.8	4.3	3.5	3.0	1.9	3.4	-8.5	3.9	1.7
Δ**f**	3.9	-0.0	-0.0	3.2	4.2	-1.1	5.1	14.6	14.9	10.2	10.9	15.4	11.9	-10.8	12.3	12.9
Change in world value added trade in constant prices (based on previous year prices)																
bn USD																
ΔVAX	240	280	293	352	527	62	151	268	530	463	643	625	362	-1446	-	-
Δ**v**	-10	18	-22	-5	-4	-13	35	-5	-9	-10	-47	-80	-15	-38	-	-
Δ**L**	60	35	52	72	194	-3	-13	57	202	88	165	160	69	-640	-	-
Δ**f**	190	226	262	284	337	78	129	215	338	385	525	545	309	-768	-	-
% change / contribution to ΔVAX [pp]																
ΔVAX	5.6	6.2	6.4	7.8	11.2	1.2	3.0	5.0	8.6	6.3	7.8	6.7	3.4	-11.8	-	-
Δ**v**	-0.2	0.4	-0.5	-0.1	-0.1	-0.3	0.7	-0.1	-0.2	-0.1	-0.6	-0.9	-0.1	-0.3	-	-
Δ**L**	1.4	0.8	1.1	1.6	4.1	-0.1	-0.3	1.1	3.3	1.2	2.0	1.7	0.6	-5.2	-	-
Δ**f**	4.4	5.0	5.8	6.3	7.1	1.5	2.5	4.0	5.5	5.3	6.4	5.9	2.9	-6.3	-	-
Change in world gross trade in current prices																
bn USD																
ΔEX	271	56	-9	330	762	-159	307	1181	1753	1346	1644	2192	2216	-3873	2482	2391
Δ**v**	-7	-17	-6	-25	-101	-43	73	-38	-28	-137	-111	-143	-246	152	-18	-6
Δ**L**	58	83	-29	150	591	-46	-108	191	552	462	500	317	642	-2138	828	329
Δ**f**	221	-10	26	206	272	-69	342	1029	1229	1022	1254	2017	1821	-1887	1672	2068
% change / contribution to ΔEX [pp]																
ΔEX	4.9	1.0	-0.2	5.7	12.4	-2.3	4.5	16.7	21.3	13.5	14.5	16.9	14.6	-22.3	18.4	14.9
Δ**v**	-0.1	-0.3	-0.1	-0.4	-1.6	-0.6	1.1	-0.5	-0.3	-1.4	-1.0	-1.1	-1.6	0.9	-0.1	-0.0
Δ**L**	1.0	1.4	-0.5	2.6	9.6	-0.7	-1.6	2.7	6.7	4.6	4.4	2.4	4.2	-12.3	6.1	2.1
Δ**f**	4.0	-0.2	0.4	3.5	4.4	-1.0	5.1	14.6	14.9	10.2	11.1	15.5	12.0	-10.8	12.4	12.9

NOTE: Deviations from totals are due to rounding.

these results are not consistent with price changes accounting for the bulk of the observed changes in vertical specialisation. A similar conclusion can be drawn for the increase in vertical integration before the crisis. Between 1995 and 2007 deepened international production sharing accounted for roughly one quarter of the growth in world value added trade in both current and constant prices. Hence, the observed emergence of cross-border production networks since 1995 in nominal terms is not an epiphenomenon of differential price inflation across different sectors and countries.

In summary, price changes are important in the sense that they account for about one third of the decline in value added trade during the trade crisis in 2009. However, they are unimportant regarding the relative contribution of the decline in international production sharing, which account for a little less than half of the collapse in both constant and current prices.

3.1.4 Comparison with gross trade flows

While the focus of this article is on value added trade, the question naturally arises what the decomposition results look like for gross trade flows. Koopman et al. (2014) show that gross exports can be decomposed into value added exports along with a number of different components that appear at least twice in international trade statistics. First, there is domestic value added that eventually returns to the domestic economy for absorption in final demand and therefore does not qualify as a value added export. Second, there are foreign value added terms which only appear in the gross concept. These terms are, of course, (partially) counted towards the value added exports of the country from which the value added originates, but not towards those of the re-exporting country. Third, there are so-called double counting terms for both domestic and foreign value added, which capture the phenomenon that due to multiple border crossings "the same" value added may appear several times in international trade statistics.

The lower panel of Table 5 details the results of this additional decomposition exercise. First, note that the dynamics of gross and value added trade are extremely similar ($\rho = 0.9964$) which is to be expected given that value added exports account for the bulk of gross exports (Koopman et al., 2014). In general, however, gross trade is slightly more volatile than value added trade, i.e. it has larger positive growth rates in upswings (on average +1.0pp) and larger negative growth rates in downturns (on average −1.2pp). The results of the structural decomposition analysis provide a clue as to what determines the difference between the two concepts. It turns out that the contribution from changes in the value added shares (the difference ranges from −0.1 to 0.1pp) and final demand ($[-0.1\text{pp}, 0.5\text{pp}]$) are very similar in the two cases. What is mainly driving the wedge between the growth rates of gross and value added trade are changes in production sharing ($[-3.8\text{pp}, 2.7\text{pp}]$) which consequently contribute a larger share to the overall growth rate of gross exports. This is in agreement with the fact that the difference between value added and gross trade is made up of double counting terms and foreign value added, which cross international borders more than once and as a result are disproportionally affected by changes in the international organisation of production. A similar result holds also true for the great trade collapse during which gross trade (−22.3%) declined slightly more than value added trade (−18.3%). While $\Delta \mathbf{v}$ and $\Delta \mathbf{f}$ both contributed about the same (in percentage points) in both cases, $\Delta \mathbf{L}$ accounted for −3.8pp more in gross terms, and hence the relative contribution of changes in international production sharing to the overall collapse goes up from 46.2% in the case of value added trade to 55.2% for gross trade. Hence, our main conclusion also applies to the case of gross exports, for which changes in vertical specialisation were even more important in explaining the great trade collapse due to the presence of double counting terms which are particularly sensitive to changes international production sharing.

3.1.5 Cyclicality and asymmetry of changes in production sharing

So far we have focused exclusively on the great trade collapse and compared annual changes and contributions from 2008 to 2011 to the average of those from previous years. In the following we address the question of how common changes in international production sharing are from year-to-year, whether they are more important during trade declines than in normal times and whether there are any systematic differences in the volatility of sourcing changes across sectors.

The top panel of Table 5 lists the annual changes in value added trade from 1995 to 2011 along with the contribution from changes in value added shares, international production sharing and final demand. The mean of the growth rate of value added trade including all years before the crisis (1995 to 2007) is 7.5% and therefore similar to the results for the shorter time period (2000 to 2008) depicted in Figure 2. The decline in value added shares contributed −0.6pp (−7.4% of the total), increased international production sharing +1.8pp (24.1% of the total) and growth in final demand +6.3pp (83.3% of the total). There is substantial variation in the annual growth rates of value added trade across time. For example, world value added trade declined in 1998 after the Asian financial crisis as well as in 2001 after the burst of the dot-com bubble in the US and a recession in the Eurozone. International production sharing also decreased during these two trade contractions and in 2002 albeit substantially less so in absolute terms than during the great trade collapse. In general $\Delta\mathbf{L}$ shows a strong positive correlation with $\Delta\mathbf{f}$ ($\rho = 0.7612$) and world value added trade growth ($\rho = 0.8729$).[16] This means that international production sharing tends to intensify more when final demand and hence value added trade growth is strong rather than weak, and that international production sharing can even decline during macroeconomic downturns. Hence, changes in vertical specialisation are to a certain extent cyclical, which suggests that it may be misleading to think of vertical linkages between countries as being fixed or alternatively to think of vertical specialisation as expanding at a constant rate (at least when considering annual frequencies).

Our analysis in Section 3.1 suggests that the relation between value added trade growth and changes in production sharing may be potentially asymmetric in the sense that the latter may be relatively more important when trade declines. In order to assess whether this finding is limited to the great trade collapse, we consider changes in value added exports of individual countries as well as the production sharing contribution for episodes of positive and negative trade growth separately.[17] The arithmetic mean (weighted by the total change in value added exports) of the production sharing contribution is 28.1% when trade growth was positive ($N = 517$). During these episodes value added trade grew on average by 11.3%. In contrast, the relative contribution stands at 44.3% ($N = 139$) in all downturns with an average growth rate of −9.7%. When we exclude the great trade collapse from the sample ($N = 98$) the decline in value added trade is not as pronounced (−5.3%), but the relative contribution of changes in production sharing still stands at 54.3%. This provides some suggestive evidence that the hysteresis in production sharing changes might be a more general phenomenon not limited to the great trade collapse. Increases in demand were the main driver of value added trade growth in normal times whereas during downturns the decline in international production sharing contributed almost as much as contractions in final demand. However, while the relative contribution of sourcing changes during the financial crisis were similar to previous trade declines, the overall magnitude of the effect was clearly most pronounced during the great trade collapse as was the lack of immediate recovery in production sharing in the years after the crisis.

While our analysis in Section 3.1.2 highlights that sourcing changes in all sectors contributed to the great trade collapse, Table 3 also indicates that some sectors may be more volatile in terms of changes in their sourcing structure than others. Table 6

[16] Similar results are obtained when correlating the growth rate of individual countries' production sharing contributions and $\Delta\mathbf{f}$ ($\rho = 0.4448$) or value added exports ($\rho = 0.7640$), respectively.

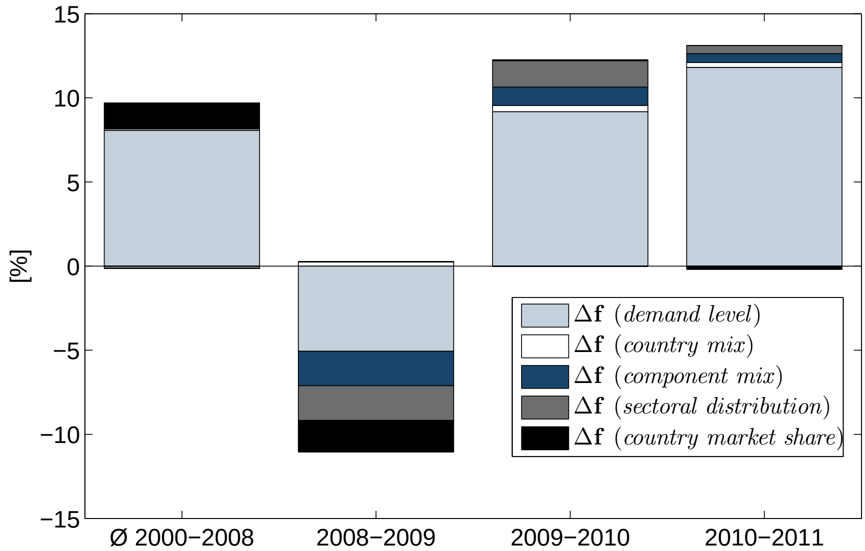
[17] Considering *world* value added trade growth would limit this analysis to only two observations for downturns.

Table 6: Volatility of changes in the sectoral sourcing structure, $\Delta\mathbf{A}^{(s)}$.

	σ [*bn USD*]	rank(σ)	rank(σ_{real})	rank(σ_{adj})
Coke, Refined Petroleum and Nuclear Fuel *mean share in world output: 1.7%*	35.1	1	1	1
Electricity, Gas and Water Supply *mean share in world output: 2.4%*	31.2	2	9	2
Construction *mean share in world output: 7.1%*	31.2	3	7	12
Basic Metals and Fabricated Metal *mean share in world output: 3.9%*	30.1	4	5	6
Chemicals and Chemical Products *mean share in world output: 2.9%*	23.8	5	11	4
Transport Equipment *mean share in world output: 3.6%*	21.7	6	10	7
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles *mean share in world output: 5.0%*	19.3	7	4	16
Food, Beverages and Tobacco *mean share in world output: 4.4%*	16.4	8	13	18
Electrical and Optical Equipment *mean share in world output: 3.7%*	16.3	9	3	13
Public Admin and Defence; Compulsory Social Security *mean share in world output: 6.1%*	14.0	10	15	28
...				
Rubber and Plastics *mean share in world output: 1.2%*	5.1	26	23	14
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies *mean share in world output: 1.2%*	4.5	27	29	15
Textiles and Textile Products *mean share in world output: 1.4%*	3.8	28	18	23
Education *mean share in world output: 2.2%*	3.5	29	32	32
Water Transport *mean share in world output: 0.4%*	3.3	30	22	5
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel *mean share in world output: 1.1%*	2.6	31	27	24
Manufacturing, Nec; Recycling *mean share in world output: 0.8%*	2.6	32	30	21
Wood and Products of Wood and Cork *mean share in world output: 0.6%*	2.1	33	33	19
Leather, Leather and Footwear *mean share in world output: 0.3%*	0.8	34	34	20
Private Households with Employed Persons *mean share in world output: 0.1%*	0.0	35	35	35

NOTE: σ_{real} corresponds to the standard deviation on the basis of the decomposition in previous-years' prices. σ_{adj} is defined as the standard deviation of $\Delta\mathbf{A}^{(s)}$ divided by the mean share of the sector in world output between 1995 and 2011. σ and σ_{adj} are based on data from 1995 to 2011, while due to data availability σ_{real} is limited to the years 1995 to 2009.

Figure 3: Final demand contribution to change in world value added trade.



analyses the question of systematic differences in sourcing volatility across sectors by using a more detailed sectoral breakdown. It shows how sectors rank in terms of their volatility of sourcing changes as measured by their standard deviation for the decomposition in current prices, σ, the decomposition in previous-years' prices, σ_{real}, and after adjusting for the sectors' mean share in total output, σ_{adj}. The sectors that display the highest volatility of sourcing changes in the standard decomposition are those whose inputs are rather homogeneous and hence relatively substitutable such as "Coke, Refined Petroleum, and Nuclear Fuel", "Electricity, Gas and Water Supply", "Construction" and "Basic Metals and Fabricated Metal". In the top ten are also sectors with high shares of foreign value added which have experienced particularly pronounced outsourcing dynamics in order to benefit from differences in factor costs such as "Transport Equipment" and "Electrical and Optical Equipment". When price dynamics are discounted the ranking of individual sectors changes appreciably, but our previous conclusions remain unaltered. The top sectors are either those with homogeneous inputs or high shares of foreign value added.[18] Finally, some sectors may simply contribute substantially to the aggregate changes in production sharing by virtue of their size rather than due to particularly pronounced sourcing dynamics. Once we control for size effects some sectors, such as "Construction", "Wholesale Trade" and "Public Administration and Defense", become considerably less important, while the overall picture remains the same.

3.2 The role of level and composition of final demand

For gross exports it has been shown that changes in the composition of final expenditure were an important determinant of the great trade collapse although its exact contribution has not been quantified (Bems et al., 2011). Using a global input-output framework allows us to estimate the share of the great trade collapse due to changes in the structure and level of final demand. Here we present the results of a novel decomposition that splits

[18]The sector which ranks second according to σ_{real} is "Mining and Quarrying".

final demand into the five subsequent factors: (1) the overall *level* of final demand, (2) the mix of countries that contribute to the overall level of demand (*country mix*), (3) the mix of final demand across different demand components such as investment and private consumption (*component mix*), (4) the distribution of goods and services across different demand components (*sectoral distribution*) and (5) the distribution of country market shares by sector (*country market share distribution*). (1) represents pure changes in the level of final demand, while (2)-(5) record compositional changes. Category (2) and (3) represent the demand side – i.e. which demand component in which country (e.g. investment in the United States) – and (4) and (5) capture the value added source – i.e. from which sector in which country (e.g. automobiles from Germany). The aggregate results of the decomposition are presented in Figure 3. In addition, we delineate i) which demand components were behind changes in the *component mix* (Table 7), ii) for which goods and services demand declined most (Table 8) and iii) which countries contributed to changes in the *country market share distribution* (Table 9).

Table 7: Contribution of $\Delta\mathbf{f}(component\ mix)$ by demand component to change in value added trade in percentage points.

	∅ 2000-2008	2008-2009	2009-2010	2010-2011
Consumption Households	-0.2	1.0	-0.5	-0.0
Consumption Non-profit Organisations	-0.0	0.0	0.0	0.0
Consumption Government	0.0	0.5	-0.1	-0.2
Investment	0.1	-1.5	-0.5	0.2
Inventory changes	0.1	-2.1	2.2	0.5

NOTE: Deviations from totals are due to rounding.

Table 8: Contribution of $\Delta\mathbf{f}(sectoral\ distribution)$ by sector to change in value added trade in percentage points.

	∅ 2000-2008	2008-2009	2009-2010	2010-2011
Agriculture etc.	-0.0	0.0	0.1	0.2
Mining and utilities	0.0	-0.2	0.1	0.0
Low technology	-0.0	-0.2	0.2	0.3
Medium-low technology	-0.1	-0.8	0.3	0.4
Medium-high and high technology	-0.0	-1.3	1.3	-0.3
Construction	-0.0	0.4	-0.2	0.1
Non-tradable market services	-0.0	-0.0	-0.0	-0.0
Transport and communication	0.2	-0.2	0.1	0.0
Business services	-0.0	0.1	-0.1	-0.0
Non-market services	-0.0	0.2	-0.1	-0.1

NOTE: Deviations from totals are due to rounding.

In an average year before the crisis almost the entire final demand contribution to growth in value added trade derived from increases in the overall level of final demand in parallel with strong world economic growth (Figure 3). The only other significant contribution came from the country market share distribution (1.5pp), which reflects gains in export market shares of countries such as China and other emerging countries

Table 9: Contribution of $\Delta\mathbf{f}$(*country market share distribution*) by country to change in value added trade in percentage points.

	∅ 2000-2008	2008-2009	2009-2010	2010-2011
AUS	0.0	0.1	0.1	0.1
AUT	0.0	-0.1	-0.1	-0.0
BEL	0.0	-0.1	-0.2	-0.0
BGR	0.0	-0.0	-0.0	-0.0
BRA	0.1	-0.0	0.2	0.1
CAN	-0.0	-0.0	0.2	-0.1
CHN	0.9	1.2	1.0	1.0
CYP	0.0	-0.0	-0.0	-0.0
CZE	0.1	-0.1	-0.0	0.0
DEU	0.1	-0.5	-0.6	-0.1
DNK	0.0	-0.1	-0.1	-0.0
ESP	0.1	-0.1	-0.3	-0.1
EST	0.0	-0.0	-0.0	0.0
FIN	0.0	-0.1	-0.1	-0.0
FRA	0.0	-0.1	-0.4	-0.2
GBR	-0.1	-0.5	-0.1	-0.1
GRC	0.0	-0.0	-0.1	-0.0
HUN	0.0	-0.1	-0.0	-0.0
IDN	0.0	0.1	0.2	0.1
IND	0.1	0.3	0.3	-0.0
IRL	0.0	-0.1	-0.2	-0.0
ITA	0.0	-0.3	-0.4	-0.2
JPN	-0.3	-0.2	0.5	-0.3
KOR	0.0	-0.1	0.3	0.0
LTU	0.0	-0.0	-0.0	0.0
LUX	0.0	-0.0	-0.0	-0.0
LVA	0.0	-0.0	-0.0	-0.0
MEX	-0.0	-0.2	0.1	0.0
MLT	0.0	-0.0	-0.0	-0.0
NLD	0.0	-0.1	-0.2	-0.1
POL	0.1	-0.1	-0.0	0.0
PRT	0.0	-0.0	-0.1	-0.0
ROU	0.0	-0.0	-0.0	0.0
RUS	0.1	-0.2	0.1	0.1
SVK	0.0	-0.0	-0.0	-0.0
SVN	0.0	-0.0	-0.0	-0.0
SWE	0.0	-0.2	0.0	0.0
TUR	0.0	-0.1	0.0	-0.0
TWN	-0.1	-0.1	0.1	-0.1
USA	-0.4	-0.1	-0.4	-0.6
RoW	0.5	0.2	0.4	0.3

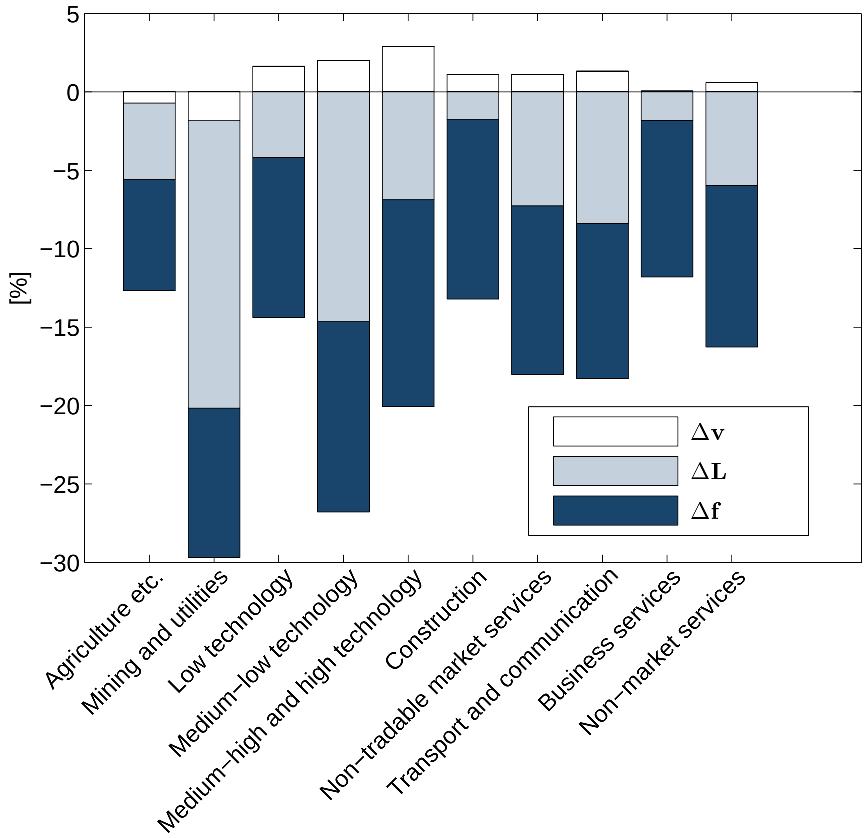
NOTE: Deviations from totals are due to rounding.

to the detriment of Japan and the United States which are less strongly integrated in global value chains (Table 9). During the great trade collapse the drop in the overall level of demand accounted for roughly a quarter of the decline in value added exports (-5.1pp) while just under one third (-5.7pp) was due to compositional changes in final demand. Changes in the component mix (-2.0pp) and the sectoral distribution (-2.1pp) played an important role. With regard to the component mix, the share of investment and inventory demand declined substantially relative to that of household and government consumption during the crisis (Table 7). This led to a decline in world value added trade since the latter have a lower import content than the former. The sectoral distribution of demand also changed markedly during the trade collapse as the share of demand declined in all sectoral aggregates relative to demand in construction, non-market services and business services (Table 8). Demand for medium-low technology as well as medium-high and high technology goods dropped strongly both of which have a very high import content. Overall, our results on the importance of the strong decline in investment and inventories as well as the large decrease in the demand for durable goods in explaining the collapse in value added trade mirror the findings from the literature on gross trade (Bems et al., 2013). A new important compositional factor that emerges is the country market share distribution which contributed about one tenth (-1.9pp) to the great trade collapse. This reflects the fact that the crisis particularly affected demand for goods and services of economies that are highly integrated in cross-border production chains such as EU countries (Table 9). The year after the crisis saw an immediate rebound of the overall demand level that more than offset the drop during the great trade collapse. The sectoral distribution and component mix recovered much more slowly and in 2011 still had not reached their respective pre-crisis level. The share of inventory demand rebounded completely in the year after the crisis, while investment demand continued to decline and only started to recover weakly in 2011 (Table 7). The prolonged crisis was also reflected in the country market share distribution which did not recuperate in the year after the crisis and even showed a further decline in 2011. This was mainly due to a continuing decrease in the demand share of many European Union countries in 2010 and even 2011 reflecting the reverberations of the sovereign debt crises in the euro area.

3.3 Sectoral value added exports

Another question that needs to be addressed is how value added exports of different sectors fared during the financial crisis. For gross exports, the consensus that has emerged is that exports of durables were particularly hard hit while non-durables and services were much less affected (Levchenko et al., 2010; Bems et al., 2013). Bems et al. (2011) arrive at the same conclusion for value added trade based on a global input-output table constructed from national input-output tables and bilateral trade data from 2004. However, in the light of our results on the changes in international production sharing a constant input-output structure does not appear to be an innocuous assumption. Table 13 shows the percentage changes in sectoral value added exports and the corresponding contribution of changes in value added content, international production sharing and final demand factors as a percentage of the total change. In an average year before the crisis nominal value added exports of almost all sectors grew with two-digit figures while the mining and utilities sector – likely also due to price increases – even reached growth rates of almost 22%. In contrast to the findings on gross exports, all sectors were hard hit by the financial crisis and in no sector did value added exports decline by less than 11.8% (Figure 5). While value added exports fell particularly strongly in the medium-low technology sector (-24.8%), the dichotomy between services and manufacturing sectors observed in

Figure 4: Decomposition of change in world value added exports between 2008 and 2009 by sector.



gross exports is not apparent in value added trade data.[19]

Regarding the relative contribution of final demand and vertical specialisation to sectoral value added export growth prior to the crisis there are no strong disparities between sectors and the overall picture is very much in line with the figures of aggregate value added exports.[20] During the crisis year sourcing changes became a major factor for the decline in value added exports of almost all sectors. Changes in international production sharing for most services sectors (non-market services, non-tradable market services, transport and communication) accounted for 38% to almost 50% of the drop in value added exports. Manufacturing sectors (low technology, medium-low technology, medium-high and high technology) were likewise hard hit by sourcing changes (between 33% and 59%). This is a remarkable result which highlights that focusing on final demand changes falls short of accounting for the great trade collapse in value added exports in very much every sector.[21] In the year after the crisis most sectors saw above average contributions of

[19] Our results are qualitatively in line with the numbers from the OECD Trade in Value Added database.

[20] The mining and utilities as well as the medium-low technology sector are the only exception. Mining and utilities value added exports show a big contribution of changes in international production sharing, but given the high dependence on natural resource inputs in this sector price effects are difficult to rule out. The medium-low technology sector has a large negative contribution of $\Delta \mathbf{v}$ and a big positive contribution of $\Delta \mathbf{L}$ presumably reflecting the pronounced outsourcing and off-shoring dynamics in this sector.

[21] The results remain qualitatively unchanged when the sectoral analysis is conducted in constant

sourcing changes compensating for some but not all of the decline during the crisis. What is striking is that the growth of value added exports of some sectors, in particular services, was hampered by changes in sourcing decisions. This was particularly true for value added exports of the construction and business services sector which includes financial intermediation suggesting that firms may have reduced or postponed these "non-essential" services expenditures in the aftermath of the crisis.

While our results contradict the findings by Bems et al. (2011), they are consistent with what we know about the structural differences between gross and value added trade. Johnson and Noguera (2012) show that the share of services value added in total value added exports is substantially higher than the share of direct services exports in total gross exports of a country. This is due to the fact that services sectors often provide intermediate inputs to goods exporters whereas direct services exports are hampered, for example, due to linguistic and legal barriers. As a consequence services sectors indirectly benefit from and contribute to the export success of goods exporters. In turn, our findings highlight that demand shocks hitting direct goods exporters are transmitted to service input providers further upstream in line with theoretical models on the origins of aggregate fluctuations (Horvath, 2000; Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi, 2012).

3.4 Robustness

In this section we consider the robustness of our results with respect to intra-sectoral composition effects (Section 3.4.1), regarding their variation across the $n!$ possible decomposition formulas (Section 3.4.2) as well as regarding our choice of a hierarchical structural decomposition framework (Section 3.4.3).

3.4.1 Intra-sectoral composition effects

In theory, changes in the sourcing structure of a given sector could be either due to changes in the vertical specialisation of individual firms or due to changes in the sectoral composition of firms differing in the degree of intermediate inputs sourced from domestic and foreign suppliers. If an intra-sectoral composition effect were to account for the observed contribution of $\Delta\mathbf{L}$, we would expect output of firms with a relatively higher import content to decline more than output of those with a relatively lower import content.

Firms with a low (or zero) import content tend to be either small exporters or less productive firms that sell their output exclusively to domestic clients (Bernard, Jensen, and Schott, 2009). In contrast, firms with a high import content are usually more productive, with better access to credit and also more likely to export than firms that import fewer of their intermediate inputs (Andersson and Lööf, 2009; Kasahara and Lapham, 2013; Silva, 2011). For example, Alfaro and Chen (2012) show that multinational affiliates, which strongly participate in intra-firm trade with their parent companies, maintained higher sales during the crisis than domestic establishments. Furthermore, evidence from various studies (Görg and Spaliara, 2014; Behrens et al., 2013; Bricongne et al., 2012) suggests that particularly large firms weathered the crisis better than others, i.e. the opposite of what a compositional account would predict.

instead of current prices. See the Appendix for details.

Table 10: Decomposition of change in world value added exports by sector (% change / contribution to ΔVAX in percentage points).

		⌀ 2000-2008	2008-2009	2009-2010	2010-2011
Agriculture etc.					
share in world trade: 4.4% (2011)	ΔVAX	19.1	-12.7	18.8	20.9
	Δv	-0.5	-0.7	1.6	-0.3
	ΔL	1.9	-4.9	4.8	3.3
	Δf	9.8	-7.1	12.4	14.6
Mining and utilities					
share in world trade: 15.2% (2011)	ΔVAX	24.2	-29.7	24.3	29.0
	Δv	-0.7	-1.8	0.8	0.1
	ΔL	10.9	-18.4	10.6	9.1
	Δf	10.6	-9.5	13.0	14.1
Low technology					
share in world trade: 8.8% (2011)	ΔVAX	16.2	-12.7	12.8	14.8
	Δv	-0.9	1.6	-0.8	-0.2
	ΔL	0.3	-4.2	3.3	-0.4
	Δf	9.4	-10.2	10.3	13.7
Medium-low technology					
share in world trade: 10.6% (2011)	ΔVAX	18.0	-24.8	21.3	20.8
	Δv	-2.1	2.0	-0.8	0.1
	ΔL	4.0	-14.7	8.4	3.5
	Δf	10.0	-12.1	13.7	13.6
Medium-high and high technology					
share in world trade: 19.9% (2011)	ΔVAX	15.3	-17.1	18.2	14.5
	Δv	-1.3	2.9	-0.3	-0.2
	ΔL	1.0	-6.9	4.3	1.0
	Δf	9.3	-13.2	14.3	11.5
Construction					
share in world trade: 0.7% (2011)	ΔVAX	19.2	-12.1	9.8	11.2
	Δv	-0.4	1.1	0.7	-0.1
	ΔL	1.6	-1.7	-0.6	-2.4
	Δf	9.9	-11.5	9.7	12.6
Non-tradable market services					
share in world trade: 15.3% (2011)	ΔVAX	17.0	-16.9	13.7	15.2
	Δv	-0.1	1.1	-1.4	-0.0
	ΔL	1.1	-7.3	2.5	0.1
	Δf	9.4	-10.7	12.6	13.3
Transport and communication					
share in world trade: 7.9% (2011)	ΔVAX	17.0	-17.0	12.7	14.1
	Δv	-0.7	1.3	0.0	-0.1
	ΔL	2.1	-8.4	1.8	-0.8
	Δf	9.7	-9.9	10.8	13.4
Business services					
share in world trade: 16.0% (2011)	ΔVAX	17.3	-11.8	10.0	11.7
	Δv	-0.1	0.0	0.7	-0.0
	ΔL	2.1	-1.8	-0.8	-1.1
	Δf	9.2	-10.0	10.1	11.7
Non-market services					
share in world trade: 1.1% (2011)	ΔVAX	18.0	-15.7	7.8	16.0
	Δv	-0.4	0.6	-0.1	0.0
	ΔL	3.4	-6.0	-2.9	1.1
	Δf	9.5	-10.3	10.9	13.7

NOTE: Deviations from totals are due to rounding.

However, it is conceivable that firms that are only domestically active might have outperformed exporters in 2009 since domestic demand continued to grow in some countries during the crisis period. This account predicts that sectors whose export content – a proxy of how much exporters were affected relative to domestically active firms – declined more strongly should also show more pronounced changes in production sharing. In order to test this more formally, we regress changes in the ratio of final goods exports over total output of all 35 sectors included in WIOD between 2008 and 2009 on sectoral changes in production sharing, $\Delta\mathbf{A}^{(s)}$, from Section 3.1.2. We find that the coefficient from this regression is slightly positive (0.228), but not statistically different from zero (robust standard error: 0.159). In addition, we run a panel regression with the same variables for the period 1996-2011 using a full set of year and sector fixed effects. Again the coefficient on the sectoral changes in export content is slightly positive (0.113), but not significantly different from zero (robust standard error: 0.119). Altogether, this suggests that intra-sectoral composition effects are unlikely to account for the observed changes in $\mathbf{L}$ in this paper.

3.4.2 Variation across different decomposition formulas

As discussed in Section 2.4 the decomposition of a matrix product is non-unique and in theory there are $n!$ possible decomposition formulas of which we report the mean throughout the text. In order to provide an estimate of the variation of the results across different specifications, we review the result of our main decomposition which has three factors resulting in six different decomposition formulas. Table 11 shows the mean results of the decomposition of value added trade along with their range and standard deviation. While for all factors and years the six decompositions result in different values, their standard deviation is actually small relative to the mean. In none of the cases and in particularly not during the crisis episodes do the decomposition formulas have a substantial bearing on the relative importance of the factors. In summary, our basic results are robust to the particular ordering of the factors in the decomposition formula.

Table 11: Robustness to variation across different decomposition formulas.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
bn USD																
$\Delta\mathbf{v}$																
μ	-5	-13	-5	-19	-78	-32	52	-28	-24	-99	-81	-99	-177	115	-15	-6
min	-6	-13	-6	-20	-81	-34	49	-31	-26	-108	-89	-110	-189	102	-17	-6
max	-4	-13	-4	-18	-76	-31	54	-24	-21	-90	-73	-89	-165	127	-13	-6
σ	1	0	1	1	2	1	2	3	3	8	7	10	12	11	1	0
$\Delta\mathbf{L}$																
μ	39	52	-29	84	325	-11	-56	97	268	259	244	173	365	-1041	395	199
min	35	49	-36	78	321	-15	-60	92	250	246	234	160	355	-1074	381	193
max	44	56	-23	89	328	-8	-52	102	286	272	254	186	375	-1007	409	205
σ	4	4	7	5	2	3	4	4	18	9	8	10	8	30	14	7
$\Delta\mathbf{f}$																
μ	167	-1	-2	143	196	-57	256	775	917	746	900	1433	1286	-1325	1229	1501
min	164	-5	-8	138	193	-61	252	770	898	732	888	1416	1268	-1362	1216	1494
max	170	2	4	148	199	-53	260	781	935	761	913	1451	1304	-1289	1242	1507
σ	3	4	6	5	2	3	3	4	18	10	8	11	12	30	14	6

NOTE: Deviations from totals are due to rounding.

3.4.3 Hierarchical framework versus polar decompositions

In order to reduce computational burden our paper adopts the hierarchical structural decomposition framework outlined in Section 2.4. As a robustness check we compare our results to an additional decomposition including all sub-components simultaneously. In particular, we consider a specification in which changes in value added trade are split into contributions of the following nine components

$$\text{VAX}^i = \mathbf{v}^i\mathbf{L}\mathbf{f}^{-i} = \mathbf{v}^i\mathbf{M}_3\mathbf{M}_2\mathbf{M}_1\mathbf{F}_4^{-i}\mathbf{F}_3^{-i}\mathbf{F}_2^{-i}\mathbf{F}_1^{-i}F_0^{-i}, \tag{8}$$

i.e. considering changes in intra-country and inter-country production sharing as well as the full set of final demand components. To speed up computation, we take the mean of the two so-called polar decompositions, which in general is fairly close to the average of the full set of decompositions (Dietzenbacher and Los, 2000). Table 12 displays the results of this additional decomposition ("polar") along with those of the hierarchical structural decomposition analysis ("HSDA"). In contrast to the rest of the paper the results are displayed in million USD instead of billion USD to emphasise that the results of the two decompositions do indeed differ from each other. However, a few exceptions aside, the two sets of results are essentially identical in billion USD, which indicates that the conclusions of this paper are not sensitive to our choice of a hierarchical decomposition framework.

Table 12: Comparison between hierarchical (HSDA) and simultaneous polar decompositions (polar).

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
million USD													
ΔVAX		442577	-101039	251651	844955	1160716	906166	1062467	1506291	1473815	-2250981	1608740	1693773
$\Delta\mathbf{v}$	HSDA	-78457	-32496	51514	-27702	-23712	-98756	-81261	-99166	-177224	114594	-14980	-5978
	polar	-78454	-32494	51498	-27773	-23742	-98862	-81340	-99289	-177227	114769	-15016	-5977
$\Delta\mathbf{M_1}$	HSDA	-25381	23288	-46243	-15709	-70534	56659	16141	29045	97888	202824	-115520	-33968
	polar	-25349	23128	-46094	-15579	-70147	56915	16427	29310	98317	201874	-115141	-33254
$\Delta\mathbf{M_2}$	HSDA	238116	-26484	1244	71640	217668	124985	132890	88664	162070	-797863	328448	165328
	polar	238089	-26378	1157	71626	217385	124925	132785	88634	161776	-797152	328189	164657
$\Delta\mathbf{M_3}$	HSDA	112093	-8080	-10929	41302	120763	76970	94524	54918	104678	-445473	181915	67798
	polar	112082	-8030	-10958	41327	120720	76986	94502	54928	104549	-445584	181867	67750
ΔF_0	HSDA	142342	-43248	221914	667398	797613	612207	696089	1211692	1156071	-621329	920202	1373772
	polar	142280	-43243	221752	668162	797065	612010	695827	1211529	1155638	-621329	920107	1373453
$\Delta\mathbf{F_1}$	HSDA	7886	2148	-811	-4437	2254	9181	9830	13379	25576	31790	36806	32601
	polar	7873	2167	-747	-4473	2398	9153	9819	13252	25306	31701	36726	32701
$\Delta\mathbf{F_2}$	HSDA	13651	-54689	-29058	-2446	65839	8668	44336	17552	-26328	-251687	109463	61958
	polar	13690	-54960	-29046	-3958	66571	8761	44371	17706	-26108	-250663	109077	62112
$\Delta\mathbf{F_3}$	HSDA	9189	-66873	-45551	7816	-23920	15438	12997	43360	10131	-252812	156743	55650
	polar	9164	-66419	-45355	8231	-24117	15300	12997	43239	9973	-252433	156572	55455
$\Delta\mathbf{F_4}$	HSDA	23138	105395	109571	107092	74746	100813	136921	146846	120953	-231026	5663	-23386
	polar	23202	105189	109445	107391	74582	100979	137078	146981	121590	-232165	6358	-23124

NOTE: Deviations from totals are due to rounding.

4 Discussion

What ultimately lies at the heart of the changes in international production sharing is the most pressing question that comes out of our study. In principle, all of the factors affecting the sourcing decisions of firms outlined in Section 2.1 may have played a role.

Previous studies have investigated whether a rise in protectionism resulting in an increase in trade costs may have contributed to the great trade collapse. At first sight our finding that on average sectors increased the relative share of intermediate inputs sourced from national suppliers at the expense of intermediates purchased from international suppliers may be interpreted to be evidence in favour of the protectionism hypothesis. However, previous studies document that the effect of an increase in protectionism appears to have been relatively minor quantitatively. For example, Kee, Neagu, and Nicita (2013) find that changes in protectionism account for only 2% of the great trade collapse. This suggests that the reorganisation of production is unlikely to be related to a rise in protectionist policies.

Alternatively, changes in inventories have been proposed to have played an amplifying role during the great trade collapse (Alessandria et al., 2013, 2011). In input-output tables final demand changes already include inventory adjustments and the more than proportional decline of inventory demand accounted for a sizeable share of the *component mix* in the final demand composition (Table 7). Inventory adjustments may also have additionally affected the international sourcing structure, **L**, during the crisis by firms drawing on their inventories rather than purchasing intermediates from their suppliers. However, two points speak against the hypothesis that $\Delta\mathbf{L}$ can be fully accounted for by inventory adjustments. First, while the inventory adjustment component in final demand rebounded rapidly in the year after the crisis (Table 7), the observed changes in **L** were of a more persistent nature and had not reached their pre-crisis level by 2011. Second, an inventory account predicts the absence of an effect of $\Delta\mathbf{L}$ on services value added due to their non-stockable nature. On the contrary, services value added was also strongly affected by changes in **L** during the crisis (Table 13).

One potential explanation of the observed changes in international production sharing is related to firms' unfavourable financing conditions during the crisis and its ramifications on the sourcing of intermediate inputs. There is by now ample empirical evidence on the role of capital market imperfections on international trade during financial crises in general and during the great trade collapse in particular. Using high-frequency import data for the US, Chor and Manova (2012) show that countries with tighter credit markets reduced their exports to the US relatively more during the great trade collapse while this effect was particularly pronounced for sectors more dependent on external financing. Berman, de Sousa, Martin, and Mayer (2013) provide evidence for a negative impact of financial crises on trade which is magnified for destinations with longer shipping times using aggregate trade data from 1950 to 2009. At the firm-level, Bricongne et al. (2012) demonstrate that the 2008-2009 crisis affected borrowing restricted French exporters disproportionally. Behrens et al. (2013) obtain similar results for Belgian firms' exports using balance sheet proxies for financial health. Amiti and Weinstein (2011) identify a causal link between the health of banks providing trade finance to firms and the latter's export performance in a bank-firm matched dataset for Japan covering several financial crises. Using a similar dataset for Peru, Paravisini, Rappoport, Schnabl, and Wolfenzon (2015) establish that exporters lowered their sales more if their banks experienced bigger liquidity shocks.

In theory, credit shocks can exert their negative impact on trade by raising the cost of entry as well as by affecting the variable cost of production, which vary in their impact on the different margins of trade (Bernard et al., 2009; Carballo, Ottaviano, and Martincus, 2013). Financing shocks negatively influence only the entry decision but not the intensive margin of exports in models in which credit is used to pay exclusively for the fixed cost of exporting (Chaney, 2013) or a fixed capital investment (Brooks and Dovis, 2013). In models in which credit shocks have an impact on the variable cost of production external finance is needed to pay inputs in advance before receiving payments from clients abroad for the output of production (Ahn, 2011; Manova, 2013; Feenstra, Li, and Yu, 2014). As a consequence both the intensive and the extensive margin are affected since a deterioration in credit conditions lowers both the equilibrium size as well as profitability of each export flow. Empirical evidence suggests that trade financing costs increased substantially during the great trade collapse (Auboin, 2009; Asmundson, Dorsey, Khachatryan, Niculcea, and Saito, 2011) and that this may have resulted in an increase in import prices of manufactured goods particularly in sectors highly dependent on external financing (Haddad et al., 2010). This implies that the price of intermediates sourced from abroad increased relative to the one of inputs from domestic suppliers and hence made the former relatively less attractive during the financial crisis. At the margin firms may have decided to reduce their inputs sourced from abroad or to switch to domestic suppliers resulting in the exit of some firms from international trade (Kramarz, Mejean, and Martin, 2014). As long as the intensive margin of trade is exclusively affected or financial conditions improve rapidly the effect of credit shocks on vertical specialisation will be only temporary as firms re-establish their pre-crisis business activity (Altomonte et al., 2012). This cyclical pattern is consistent with the relatively rapid recovery of international production sharing after the decline in world value added trade in 1998 and in 2001. However, the fact that firms need to pay a fixed cost in order to enter export markets (Roberts and Tybout, 1997) and that they lose the bulk of destination-specific knowledge rapidly after exit (Berman, Rebeyrol, and Vicard, 2015) translate into a more permanent effect of financial shocks on vertical specialisation if the extensive margin of trade is adversely affected. This is in line with the slow and incomplete recovery of international production sharing after the great trade collapse that we observe in our dataset. Furthermore, Iacovone and Zavacka (2009) document using a large cross-country dataset that banking crises inhibit export growth in the three years following the initial credit shock. Hence, both the nature and magnitude of the credit shock during the Great Recession may have contributed to the dent in vertical specialisation during and after the great trade collapse. Looking to the future, additional studies on the determinants of the sourcing of intermediate inputs as well as outsourcing decisions at the firm-level during economic crises would be highly desirable in order to better understand the variation in production sharing at the global level.

The (international) macroeconomics literature has increasingly recognised the importance of input-output linkages and trade in intermediate inputs for the transmission of (international) business cycle comovements. One of the main conclusions that can be drawn from our paper is that the assumption of a constant input-output structure – either using data for individual years or sample period averages – in both empirical and theoretical work may not always be appropriate. On the empirical side, di Giovanni and Levchenko (2010) document that sector pairs that trade relatively more with each other display stronger output comovements. Similarly, Ng (2010) demonstrate that country pairs with stronger bilateral production sharing tend to have more correlated business cycles using a range of different measures of production fragmentation. On the theoretical side, recent contributions in closed economy models have studied the role of sector-level shocks in generating aggregate fluctuations. For example, Horvath (2000) show that a multi-sector dynamic general equilibrium model can match empirical macroeconomic fluctuations as well as standard one-sector business cycle models without relying on aggregate shocks. Acemoglu et al. (2012) highlight the importance of the network structure of production in the transmission of idiosyncratic shocks across sectors. In the international macroeconomics literature, Johnson (2014) examines the transmission of productivity shocks across countries in a multi-sector model. Bems (2014) investigates the link between external rebalancing and relative price adjustment in a model with intermediates trade. Going beyond the fixed input-output structure of the models outlined above will be a challenge since it requires endogenising the structure of international production sharing or at least its changes over time, which comes at the cost of increased model complexity. However, disregarding the mutability of international production sharing potentially shuts down an important channel in the transmission of international business cycles as well as the adjustment of trade imbalances. Relaxing the assumption of a constant input-output structure in both closed economy as well as international macroeconomics models may therefore provide a promising avenue for future research.

5 Concluding remarks

This paper provides a nuanced view of the great trade collapse and quantifies the contribution of the proximate factors that led to the changes in value added trade in the last two decades. Our first contribution is that we are the first to show that changes in (international) production sharing accounted for almost half of the great trade collapse while previous studies have mainly emphasised the importance of final demand. The decline in vertical specialisation during the crisis may also partially account for the observed decrease in global trade elasticities in recent years. Furthermore, we demonstrate that changes in international sourcing are common across the business cycle and more pronounced during downturns. Price effects appear to have played an important role for the collapse in value added trade accounting for around one third of the decline, but they do not reduce the contribution of changes in international production sharing any more than that of changes in final demand. We find that the importance of changes in international production sharing for the variation in gross exports is even more pronounced than for value added exports due to the presence of foreign value added and double counting terms. Second, we propose a novel decomposition of changes in final demand that allows us to quantify the effect of a variety of compositional changes. In addition to the well-known goods and component specific demand changes, we identify a third compositional factor of quantitative importance which captures the fact that demand for goods and services of countries with a strong degree of cross-border linkages declined most. Finally, we show that the dichotomy between services and manufacturing sectors observed in gross exports during the great trade collapse is not apparent in value added trade data. This highlights that services sectors that are suppliers of inputs to direct exporters are likely to be much more vulnerable to external shocks than is generally acknowledged.

A Appendix

A.1 Sectoral value added exports in constant prices

Figure 5: Decomposition of change in world value added exports in constant prices between 2008 and 2009 by sector.

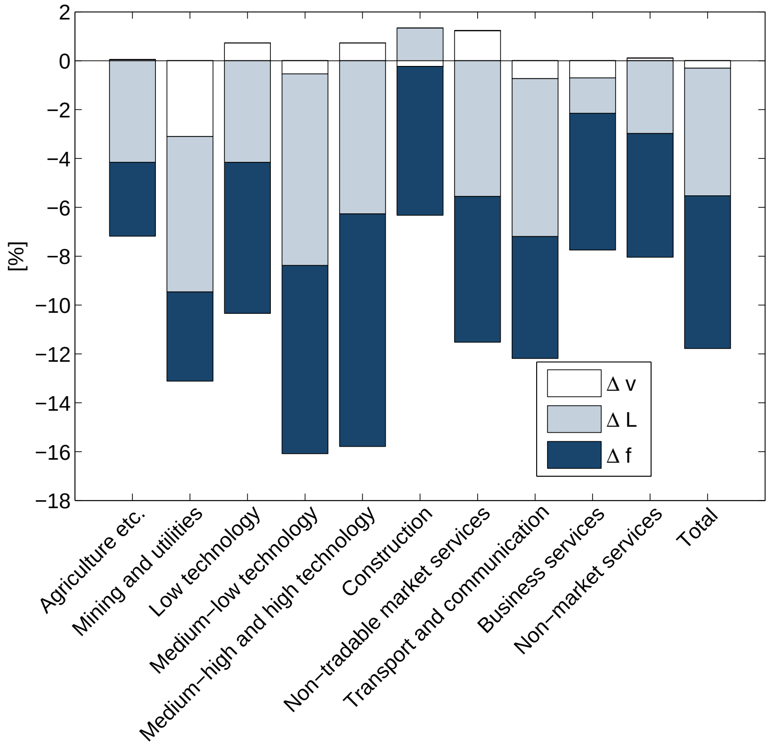


Table 13: Decomposition of change in world value added exports in constant prices by sector (% change / contribution to ΔVAX in percentage points).

		∅ 2000-2008	2008-2009	2009-2010	2010-2011
Agriculture etc.					
share in world trade: 4.1% (2009)	ΔVAX	5.9	-7.1	-	-
	Δ**v**	0.1	0.1	-	-
	Δ**L**	1.1	-4.2	-	-
	Δ**f**	4.5	-3.0	-	-
Mining and utilities					
share in world trade: 15.0% (2009)	ΔVAX	6.0	-13.1	-	-
	Δ**v**	0.5	-3.1	-	-
	Δ**L**	2.2	-6.4	-	-
	Δ**f**	4.0	-3.6	-	-
Low technology					
share in world trade: 8.8% (2009)	ΔVAX	4.4	-9.6	-	-
	Δ**v**	-0.8	0.7	-	-
	Δ**L**	0.6	-4.2	-	-
	Δ**f**	4.6	-6.2	-	-
Medium-low technology					
share in world trade: 10.3% (2009)	ΔVAX	5.3	-16.1	-	-
	Δ**v**	-0.7	-0.5	-	-
	Δ**L**	1.6	-7.8	-	-
	Δ**f**	4.7	-7.7	-	-
Medium-high and high technology					
share in world trade: 18.9% (2009)	ΔVAX	6.9	-15.1	-	-
	Δ**v**	-0.2	0.7	-	-
	Δ**L**	2.2	-6.3	-	-
	Δ**f**	5.4	-9.5	-	-
Construction					
share in world trade: 0.8% (2009)	ΔVAX	3.2	-5.0	-	-
	Δ**v**	-0.8	-0.2	-	-
	Δ**L**	-0.6	1.3	-	-
	Δ**f**	4.0	-6.1	-	-
Non-tradable market services					
share in world trade: 15.7% (2009)	ΔVAX	4.7	-10.3	-	-
	Δ**v**	0.1	1.2	-	-
	Δ**L**	0.7	-5.6	-	-
	Δ**f**	4.2	-6.0	-	-
Transport and communication					
share in world trade: 8.1% (2009)	ΔVAX	6.0	-12.2	-	-
	Δ**v**	0.3	-0.7	-	-
	Δ**L**	1.6	-6.5	-	-
	Δ**f**	4.3	-5.0	-	-
Business services					
share in world trade: 17.0% (2009)	ΔVAX	6.0	-7.8	-	-
	Δ**v**	-0.3	-0.7	-	-
	Δ**L**	1.9	-1.5	-	-
	Δ**f**	4.2	-5.6	-	-
Non-market services					
share in world trade: 1.2% (2009)	ΔVAX	4.8	-7.9	-	-
	Δ**v**	-0.6	0.1	-	-
	Δ**L**	1.4	-3.0	-	-
	Δ**f**	4.0	-5.1	-	-

NOTE: Deviations from totals are due to rounding.

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