EUROPEAN CENTRAL BANK
EUROSYSTEM

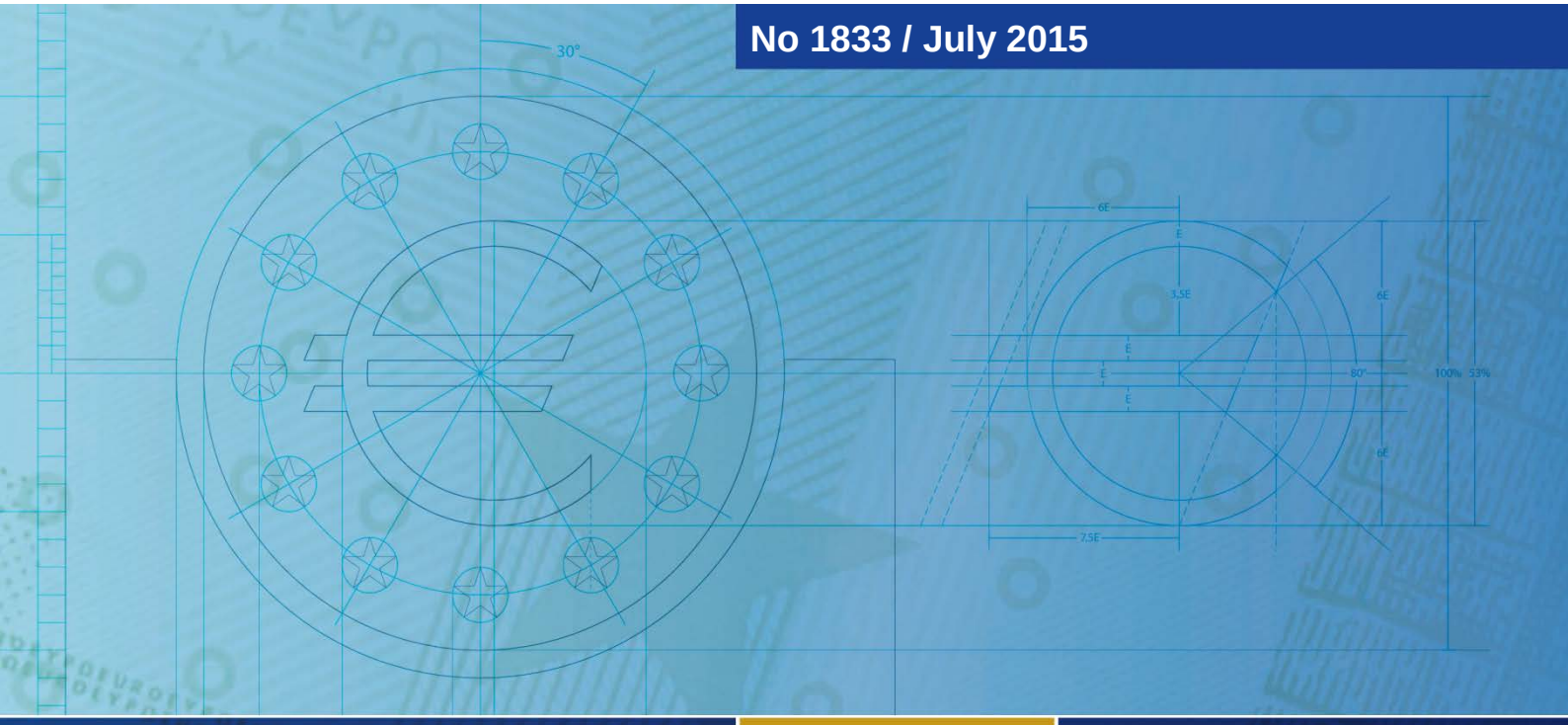
Working Paper Series

Arne J. Nagengast and
Robert Stehrer

The great collapse in value added trade

CompNet The Competitiveness Research Network

No 1833 / July 2015



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 specialization; Trade in value added; Input-output tables; Structural decomposition analysis
JEL classification: F1, F2, C67, R15

Non-technical summary

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 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. 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 which are used as inputs to produce final goods. This is because an intermediate good, such as a subcomponent of a car engine, might cross several international borders until the final good, such as a car, is purchased by a client abroad. 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. An increase in sourcing from domestic suppliers to the detriment of international suppliers would provide an amplifying mechanism of the decline in final demand and reduce the volume of international trade for every dollar spent on final goods and services.

Our first contribution is to show that changes in international production sharing accounted for almost half of the great trade collapse. While the level of final expenditure almost completely recovered in the first year after the crisis, the degree of international production sharing had still not regained its pre-crisis level by 2011. Additional analyses indicate that changes in the input mix were a widespread phenomenon not limited to particular sectors or economies. We argue that price changes, inventory adjustments, intra-sectoral composition effects and increases in protectionism were unlikely to be the main driver for the observed alteration in international production sharing in 2009. 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. We identify a novel 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 to highlight a strong discrepancy in the changes of services and manufacturing trade between gross and value added trade flows. For gross exports, the consensus that has emerged is that exports of durables were particularly affected while services trade proved very resilient during the great trade collapse. In contrast to the findings on gross exports, 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.

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 et al., 2011, 2010; Bussière et al., 2013; Eaton et al., 2011), inventory adjustment (Alessandria et al., 2013, 2011; Altomonte et al., 2012) and adverse credit supply conditions (Bricongne et al., 2012; Behrens et al., 2013; Chor and Manova, 2012). The literature – reviewed comprehensively by Bems et al. (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 et al., 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 et al., 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 et al., 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 et al., 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. In order to separate the contributions of potential explanatory factors, our paper contributes to the literature on the methodological side by using a detailed structural decomposition analysis framework. An increase in sourcing from domestic suppliers to the detriment of international suppliers would provide an amplifying mechanism of the decline in final demand and reduce the volume of international trade for every dollar spent 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 et al., 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 2000 to 2011 derived from the World Input Output Database (Dietzenbacher et al., 2013) (WIOD). WIOD is particularly well suited for analysing changes in the international sourcing structure since its global input-output tables are derived from annual supply and use tables and 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. 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 allow 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 describes 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 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[1] 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

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

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

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

$$\text{VAX}_s = \sum_{i}^{C} \text{VAX}_s^i \tag{1}$$

After computing value added exports of individual sectors the results were grouped into 10 different sectoral classes for the sake of brevity.[2]

2.2 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, $\Delta\mathbf{f}$.[3] 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. Decompositions were performed for annual changes for the time period from 2000 to 2011, and the arithmetic mean of annual contributions was calculated where indicated. All decompositions are straightforward applications of the single-country structural decompositions described in Miller and Blair (2009) to the multi-country case of global input-output tables with the exception of the final demand decomposition in Section 2.2.1, which requires a moderate extension before it can be applied to a multi-country setting.

2.2.1 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

[2] (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.

[3] 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.

level of demand, the final demand *mix* across demand categories[4] 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 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.*[5]

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.

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

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.

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

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.

[4] 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.

[5] 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.

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

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

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

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

2.2.2 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 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.

2.2.3 Decomposition of $\Delta\mathbf{L}$ - 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 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

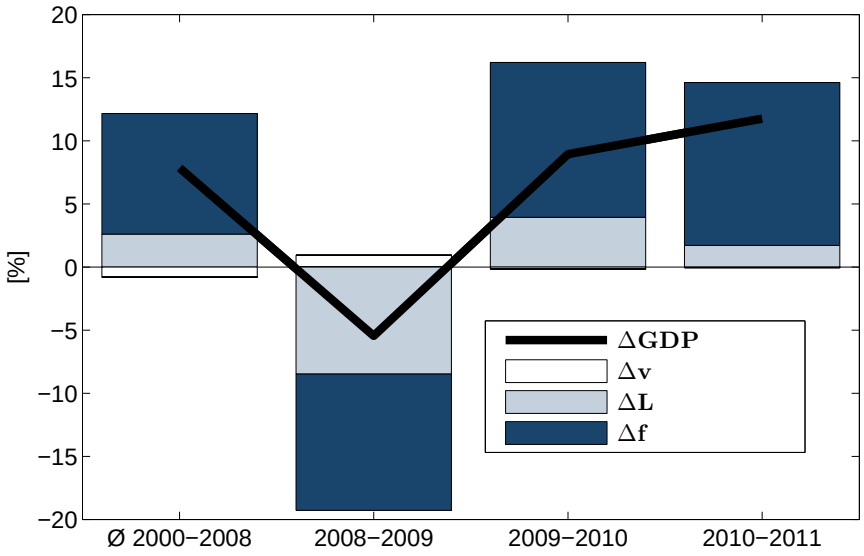
$$\Delta\mathbf{L} = \mathbf{L}^1 - \mathbf{L}^0 = \mathbf{L}^0\mathbf{A}^1\mathbf{L}^1 - \mathbf{L}^0\mathbf{A}^0\mathbf{L}^1 = \mathbf{L}^0(\Delta\mathbf{A})\mathbf{L}^1$$

$\Delta\mathbf{A}$ 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

Figure 1: Decomposition of change in world value added trade.



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 and $\Delta\mathbf{f}$ records changes in final demand. Figure 1 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[6] 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%

[6]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 $\Delta\mathbf{L}$.

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 $\Delta\mathbf{M}_3$ records *inter-country* feedback effects due to the interaction between the first two factors.[7]

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

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.

[7] $\Delta\mathbf{M}_3$ involves second round and higher-order effects that involve both the domestic economy as well as all other countries in the dataset, which is why a complete separation between intra-country and inter-country effects cannot be achieved.

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

Table 2 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 2: 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

Table 3 lists the contribution of changes in vertical specialisation to the overall change in world value added trade in percentage points. Note that since our analysis considers changes in *world* value added trade, contributions of countries with a small world market share are expected to be smaller than those of countries with bigger world market shares. 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. In Section 4 we provide a detailed discussion of factors that might be driving the observed contribution of $\Delta \mathbf{L}$ to the decline in value added trade in 2009.

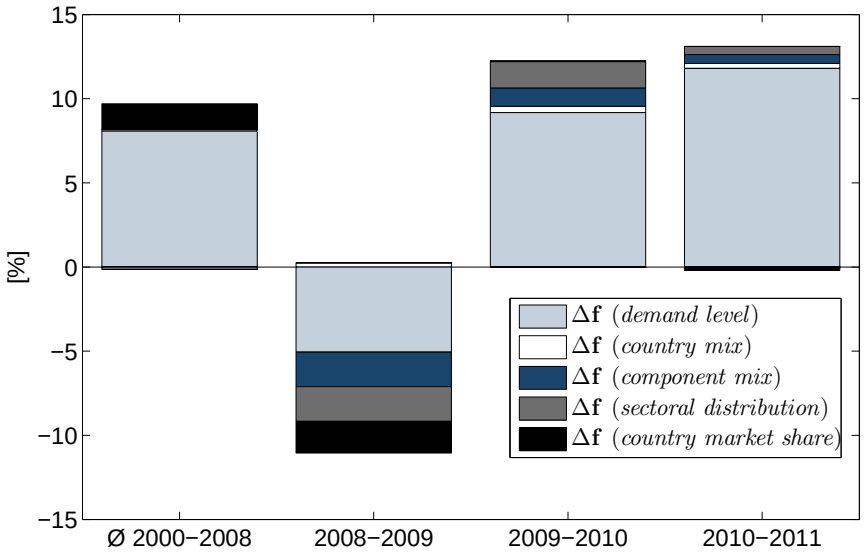
Table 3: Contribution of changes in individual countries' sourcing structure, $\Delta\mathbf{A}^{(c)}$, to the overall change in world value added trade in percentage points.

	∅ 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

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 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 2. In addition, we delineate i) which demand components were behind changes in the *component mix* (Table 4), ii) for which goods and services demand declined most (Table 5) and

Figure 2: Final demand contribution to change in world value added trade.



iii) which countries contributed to changes in the *country market share distribution* (Table 6).

Table 4: 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

Table 5: 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

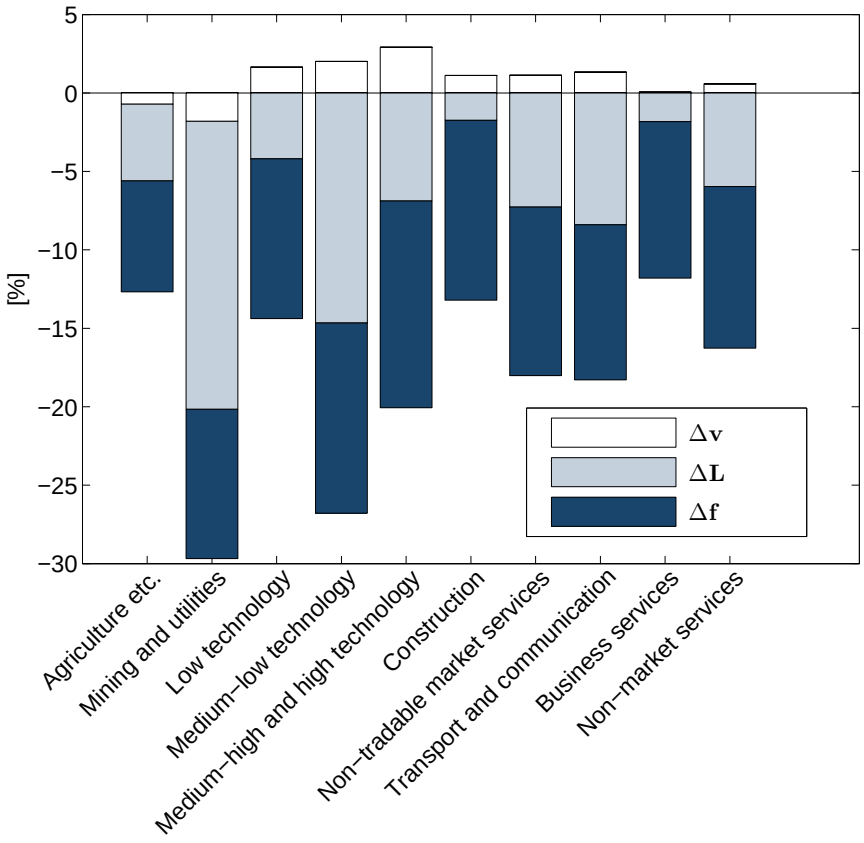
In an average year before the crisis almost the entire final demand contribution to growth in value added trade derived from increases in the overall level of final demand in parallel with strong world economic growth (Figure 2). The only other significant contribution came from the country market share distribution (1.5pp), which reflects gains in export market shares of countries such as China and other emerging countries to the detriment of Japan and the United States which are less strongly integrated in global value chains (Table 6). 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,

Table 6: 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

the share of investment and inventory demand declined substantially relative to that of household and government consumption during the crisis (Table 4). 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 5). 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 6). 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

Figure 3: Decomposition of change in world value added exports between 2008 and 2009 by sector.



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 4). 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 along with the use of only three aggregated composite sectors does not appear to be an innocuous assumption. Table 7 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 3). While value added exports fell particularly strongly in the medium-low technology sector (-24.8%), the dichotomy between services and manufacturing sectors observed in gross exports is not apparent in value added trade data.[8]

Table 7: 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

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.[9] During the crisis year sourcing

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

[9] 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 **Δv** and a big positive contribution of **ΔL** presumably reflecting the pronounced outsourcing and

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. In the year after the crisis most sectors saw above average contributions of 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 qualify 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 et al., 2012).

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 this section we argue that price changes, inventory adjustments, intra-sectoral composition effects or an increase in protectionism were unlikely to be the main driver for the observed contribution of $\Delta\mathbf{L}$ to the decline in value added trade in 2009.

All of the literature on trade in value added considers nominal flows since global input-output tables are currently only available in current prices. This implies that changes in the relative prices of different sectors (e.g. commodities versus manufactures) may potentially have a bearing on our results. The literature on the great trade collapse has documented that the price of manufactures/differentiated goods increased (Haddad et al., 2010) or remained broadly stable (Gopinath et al., 2012) while the prices of other goods declined substantially in the crisis year. If price changes were the only factor accounting for the contribution of $\Delta\mathbf{L}$, *ceteris paribus*, this suggests that sectors whose prices increased relative to those of other sectors should have benefited from changes in international production sharing. However, the results in Table 7 indicate that value added exports of all sectors were negatively impacted by changes in vertical specialisation. On the whole, manufacturing industries were not even less affected than other sectors. Only the large contribution of $\Delta\mathbf{L}$ to the decline in mining and utilities value added exports is

off-shoring dynamics in this sector.

consistent with the sharp fall in commodity prices during the global recession (Baldwin, 2009). Overall, this suggests that price changes are unlikely to have played a major role for explaining the contribution of $\Delta\mathbf{L}$ to the collapse in value added trade during the crisis with the exception of mining and utilities value added.

Changes in inventories have been proposed to have played an amplifying role during the great trade collapse (Alessandria et al., 2013, 2011; Altomonte et al., 2012). 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 4). Inventory adjustments may also have additionally affected the international sourcing structure, $\mathbf{L}$, 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 4), the observed changes in $\mathbf{L}$ 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 $\mathbf{L}$ during the crisis (Table 7).

In theory, changes in the sourcing structure of a given sector could also be 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. Although to our knowledge this question has not been addressed directly in the literature, indirect evidence from existing studies is inconsistent with this line of argument. 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 Lf, 2009; Kasahara and Lapham, 2013; Silva, 2011). Evidence from various studies (Grg and Spaliara, 2014; Behrens et al., 2013; Bricongne et al., 2012) suggests that particularly these firms weathered the crisis better than others, i.e. the opposite of what a compositional account would predict. This implies that intra-sectoral composition effects are unlikely to account for the observed changes in $\mathbf{L}$ (Table 1).

Previous studies have investigated whether a rise in protectionism 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 et al. (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.

A more likely explanation of the observed changes in vertical specialisation appears to be related to firms' unfavourable financing conditions during the crisis and its ramifications on the sourcing of intermediate inputs. For gross trade it has been shown that adverse credit supply conditions played a significant role in explaining the contraction in trade volumes during the crisis (Bricongne et al., 2012;

Behrens et al., 2013; Chor and Manova, 2012). In particular, Bricongne et al. (2012) document that many of the most affected products were intermediate goods. This would lead to a decline in international production sharing in our framework if inputs sourced from national suppliers did not decline to the same extent, which is probable given that they are less likely to be affected by financing conditions. The observed persistence of the decline in vertical specialisation is also in accordance with a financial explanation since the supply of credit remained tight or even continued to decline in the years after the financial crisis, for example in the euro-area, making liquidity management a top priority for firms (Campello et al., 2011). Alternatively, differences between intra-group trade and arms-length trade in intermediates could potentially account for the fast decline and slow recovery in international production sharing. Using a French firm-level dataset Altomonte et al. (2012) show that during the trade collapse intra-group trade in intermediates was characterised by a faster drop followed by a faster recovery than arms-length trade. Finally, changes in the pre-crisis trend of production relocation and incipient back-shoring activities may also have played a role (Kinkel, 2012). Looking to the future, additional studies on the determinants of the sourcing of intermediate inputs as well as outsourcing decisions at the firm-level – along the lines of (Kee and Tang, 2014) – during economic crises would be highly desirable in order to better understand the variation in production sharing at the global level.

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 decade. 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. 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. Studies at the firm-level on the international organisation of production in times of crisis provide a promising avenue for future research.

References

Acemoglu, D., Carvalho, V.M., Ozdaglar, A., Tahbaz-Salehi, A., 2012. The network origins of aggregate fluctuations. Econometrica 80, 1977–2016.

Alessandria, G., Kaboski, J., Midrigan, V., 2013. Trade wedges, inventories, and international business cycles. Journal of Monetary Economics 60, 1–20.

Alessandria, G., Kaboski, J.P., Midrigan, V., 2011. US Trade and Inventory Dynamics. American Economic Review 101, 303–07.

Altomonte, C., di Mauro, F., Ottaviano, G., Rungi, A., Vicard, V., 2012. Global value chains during the great trade collapse: a bullwhip effect? Working Paper Series 1412. European Central Bank.

Andersson, M., Lf, H., 2009. Learning-by-exporting revisited: The role of intensity and persistence*. Scandinavian Journal of Economics 111, 893–916.

Baldwin, R. (Ed.), 2009. The great trade collapse: Causes, consequences and prospects. Centre for Economic Policy Research (CEPR), London.

Baldwin, R., 2011. Trade And Industrialisation After Globalisation's 2nd Unbundling: How Building And Joining A Supply Chain Are Different And Why It Matters. Working Paper 17716. National Bureau of Economic Research.

Behrens, K., Corcos, G., Mion, G., 2013. Trade Crisis? What Trade Crisis? The Review of Economics and Statistics 95, 702–709.

Bems, R., 2014. Intermediate inputs, external rebalancing and relative price adjustment. Journal of International Economics 94, 248 – 262.

Bems, R., Johnson, R.C., Yi, K.M., 2010. Demand spillovers and the collapse of trade in the global recession. IMF Economic Review 58, 295–326.

Bems, R., Johnson, R.C., Yi, K.M., 2011. Vertical linkages and the collapse of global trade. American Economic Review 101, 308–12.

Bems, R., Johnson, R.C., Yi, K.M., 2013. The Great Trade Collapse. Annual Review of Economics, Annual Reviews 5, 375–400.

Bricongne, J.C., Fontagné, L., Gaulier, G., Taglioni, D., Vicard, V., 2012. Firms and the global crisis: French exports in the turmoil. Journal of international Economics 87, 134–146.

Bussière, M., Callegari, G., Ghironi, F., Sestieri, G., Yamano, N., 2013. Estimating Trade Elasticities: Demand Composition and the Trade Collapse of 2008-2009. American Economic Journal: Macroeconomics 5, 118–51.

Campello, M., Giambona, E., Graham, J.R., Harvey, C.R., 2011. Liquidity management and corporate investment during a financial crisis. Review of Financial Studies 24, 1944–1979.

Chen, Y.Y., Wu, J.H., 2008. Simple keynesian input-output structural decomposition analysis using weighted shapley value resolution. The Annals of Regional Science 42, 879–892.

Chor, D., Manova, K., 2012. Off the cliff and back? credit conditions and international trade during the global financial crisis. Journal of International Economics 87, 117 – 133.

Constantinescu, C., Mattoo, A., Ruta, M., 2015. The global trade slowdown: cyclical or structural ? Policy Research Working Paper Series 7158. The World Bank.

Dietzenbacher, E., 2002. Interregional multipliers: Looking backward, looking forward. Regional Studies 36, 125–136.

Dietzenbacher, E., Los, B., 1998. Structural Decomposition Techniques: Sense and Sensitivity. Economic Systems Research 10, 307–324.

Dietzenbacher, E., Los, B., 2000. Structural Decomposition Analyses with Dependent Determinants. Economic Systems Research 12, 497–514.

Dietzenbacher, E., Los, B., Stehrer, R., Timmer, M., de Vries, G., 2013. The Construction of World Input-Output Tables in the WIOD Project. Economic Systems Research 25, 71–98.

Eaton, J., Kortum, S., Neiman, B., Romalis, J., 2011. Trade and the Global Recession. NBER Working Papers 16666. National Bureau of Economic Research, Inc.

Ferrantino, M.J., Taglioni, D., 2014. Global Value Chains in the Current Trade Slowdown. World Bank - Economic Premise , 1–6.

Foster-McGregor, N., Stehrer, R., 2013. Value Added Content of Trade: A Comprehensive Approach. Economics Letters 120, 354 – 357.

Gopinath, G., Itskhoki, O., Neiman, B., 2012. Trade prices and the global trade collapse of 2008-09. IMF Economic Review 60, 303–328.

Grg, H., Spaliara, M.E., 2014. Exporters in the Financial Crisis. Kiel Working Papers 1919. Kiel Institute for the World Economy.

Haddad, M., Harrison, A., Hausman, C., 2010. Decomposing the Great Trade Collapse: Products, Prices, and Quantities in the 2008-2009 Crisis. Working Paper 16253. National Bureau of Economic Research.

Horvath, M., 2000. Sectoral shocks and aggregate fluctuations. Journal of Monetary Economics 45, 69 – 106.

Johnson, R.C., Noguera, G., 2012. Accounting for Intermediates: Production Sharing and Trade in Value Added. Journal of International Economics 86, 224 – 236.

Kasahara, H., Lapham, B., 2013. Productivity and the decision to import and export: Theory and evidence. Journal of International Economics 89, 297 – 316.

Kee, H.L., Neagu, C., Nicita, A., 2013. Is Protectionism on the Rise? Assessing National Trade Policies during the Crisis of 2008. The Review of Economics and Statistics 95, 342–346.

Kee, H.L., Tang, H., 2014. Domestic value added in exports: Theory and firm evidence from china. Unpublished, World Bank, Washington .

Kinkel, S., 2012. Trends in production relocation and backshoring activities: Changing patterns in the course of the global economic crisis. International Journal of Operations & Production Management 32, 696 – 720.

Koller, W., Stehrer, R., 2009. Trade Integration, Outsourcing and Employment in Austria: A Decomposition Approach. wiiw Working Papers 56. The Vienna Institute for International Economic Studies, wiiw.

Koopman, R., Wang, Z., Wei, S.J., 2014. Tracing Value-Added and Double Counting in Gross Exports. American Economic Review 104, 459–94.

Levchenko, A.A., Lewis, L.T., Tesar, L.L., 2010. The Collapse of International Trade during the 2008-09 Crisis: In Search of the Smoking Gun. IMF Economic Review 58, 214–253.

Mattoo, A., Borchert, I., 2009. The Crisis-Resilience Of Services Trade. The World Bank.

Miller, R., Blair, P., 2009. Input-Output Analysis: Foundations and Extensions. Cambridge University Press.

Nagengast, A.J., Stehrer, R., 2014. Collateral imbalances in intra-european trade? Accounting for the difference between gross and value added trade balances. Working Paper Series 1695. European Central Bank.

Round, J.I., 1985. Decomposing Multipliers for Economic Systems Involving Regional and World Trade. Economic Journal 95, 383–99.

Silva, A., 2011. Financial constraints and exports: Evidence from portuguese manufacturing firms. International Journal of Economic Sciences and Applied Research 4, 7–19.

Timmer, M.P., Los, B., Stehrer, R., de Vries, G.J., 2013. Fragmentation, Incomes and Jobs: An Analysis of European Competitiveness. Economic Policy 28, 613–661.

Yi, K.M., Bems, R., Johnson, R.C., 2010. Demand Spillovers and the Collapse of Trade in the Global Recession. IMF Working Papers 10/142. International Monetary Fund.

Competitiveness Research Network
This paper presents research conducted within the Competitiveness Research Network (CompNet). The network is composed of economists from the European System of Central Banks (ESCB) - i.e. the 29 national central banks of the European Union (EU) and the European Central Bank – a number of international organisations (World Bank, OECD, EU Commission) universities and think-tanks, as well as a number of non-European Central Banks (Argentina and Peru) and organisations (US International Trade Commission).

The objective of CompNet is to develop a more consistent analytical framework for assessing competitiveness, one which allows for a better correspondence between determinants and outcomes.

The research is carried out in three workstreams: 1) Aggregate Measures of Competitiveness; 2) Firm Level; 3) Global Value Chains CompNet is chaired by Filippo di Mauro (ECB). Workstream 1 is headed by Pavlos Karadeloglou (ECB) and Konstantins Benkovskis (Bank of Latvia); workstream 2 by Antoine Berthou (Banque de France) and Paloma Lopez-Garcia (ECB); workstream 3 by João Amador (Banco de Portugal) and Frauke Skudelny (ECB). Monika Herb (ECB) is responsible for the CompNet Secretariat.

The refereeing process of CompNet papers is coordinated by a team composed of Filippo di Mauro (ECB), Konstantins Benkovskis (Bank of Latvia), João Amador (Banco de Portugal), Vincent Vicard (Banque de France) and Martina Lawless (Central Bank of Ireland).

The paper is released in order to make the research of CompNet generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the ones of the author(s) and do not necessarily reflect those of the ECB, the ESCB, and of other organisations associated with the Network.

Acknowledgements
Discussion Papers represent the authors' personal opinions and do not necessarily reflect the views of the Deutsche Bundesbank and the European Central Bank. We thank Peter Eppinger and Philipp Meinen for valuable comments on an earlier version of this manuscript.

Arne J. Nagengast
Deutsche Bundesbank, Frankfurt am Main, Germany;
e-mail: arne.nagengast@bundesbank.de

Robert Stehrer
Vienna Institute for International Economic Studies, Vienna, Austria;
e-mail: stehrer@wiiw.ac.at

Postal address	60640 Frankfurt am Main, Germany
Telephone	+49 69 1344 0
Internet	www.ecb.europa.eu

ISSN	1725-2806 (online)
ISBN	978-92-899-1646-2
DOI	10.2866/814599
EU catalogue number	QB-AR-15-073-EN-N