GRINCOH Growth-Innovation-Competitiveness
Fostering Cohesion in Central and Eastern Europe

Value added trade, structural change and GDP growth – A decomposition approach

Robert Stehrer

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 290657.

Robert Stehrer
The Vienna Institute for International Economic Studies – wiiw
WP1, Task 2, P.1.6 (original title: 'The impact of trade on structural change: changing patterns of specialisation')

Value added trade, structural change and GDP growth – A decomposition approach

Abstract: The paper builds on the Leontief demand driven model and introduces a decomposition analysis allowing one to assess contributions to GDP growth. Empirically the World Input-Output Database (WIOD) is used presenting some stylized facts of growth patterns across countries with an emphasis on the integration of the EU-12 and China into world production systems. The factors considered are changes in the value added input coefficients, changes in the global Leontief inverse, domestic and foreign demand together with structural effects. Results suggest that GDP growth in the EU-12 and China particularly benefitted from integration into the world production systems and value added exports. In all cases, however, domestic demand remains the most important source of GDP growth.

JEL codes: F14, F15, F16

Keywords: Decomposition analysis, value added trade, growth contributions

1 Introduction

Integration of countries and industries into regional and global production networks has become an important factor in the world economy and for the performance of countries and particularly so for emerging economies. The latter group comprises countries like China which has forcefully entered the global scene over the last decades or so, but also the Eastern European countries which have integrated into the European and global production systems. Such integration processes mean that these countries become important sources for provision of intermediates or assembly activities and exports of value added, i.e. value added generated in a country but finally absorbed in other countries. Contributions to GDP growth via these channels can both be level effects but also structural effects, i.e. shifting production and exports to more value added intensive products.

This paper therefore considers drivers of overall income from an input-output perspective. A country's total value added created (equal to its GDP) is determined by the products it can sell to either the domestic or foreign markets. In both cases the country faces competition from other countries. In the first case, a country faces competition on the domestic market, in the second case it competes with other countries in their own market or third markets. The value added created in an economy is therefore driven by the level of products it can sell domestically or abroad and – as these products differ with respect to their overall value added intensity – also by its structure. However, it has to be emphasised that in a world with internationally fragmented production one has not only to consider exports of final goods but also exports of intermediate products embodying domestic value added but being absorbed in another country only after further processing or even sent further to other countries. Therefore, the challenge here is to disentangle a country's GDP growth into changes in final demand and exports, changes in value added intensities needed for their production and changes in technologies and international linkages of production.

The analysis applies a decomposition analysis based on the Leontief demand driven model and is based on the WIOD data (see Timmer et al., 2012, and Dietzenbacher et al., 2013) which provides a global input-output matrix for 41 countries (including a rest-of-world category) over the period 1995-2011. The database distinguishes 35 industries (basically in NACE Rev. 1 industries and aggregates).

2 Structural change, trade and GDP: A decomposition approach

In this section the decomposition approach is introduced which identifies the various contributions to overall GDP growth: According to the demand-driven input-output framework, changes in total value added can result from changes in the value added coefficients, changes in the global Leontief inverse, and changes in final demand potentially broken down into domestic demand on domestic and foreign products and foreign demand on domestic products. The ladder is equivalent to a country's value added exports as defined in Johnson and Noguera (2012). These final demand components are further split into its level effect and structural (or composition) effects with the latter referred to as 'mix' effect according to input-output literature (see Miller and Blair, 2009). Technically a so-called hierarchical structural decomposition analysis is employed which can be seen as a generalized shift-share analysis where one however gets rid of arising interaction terms (for technical details see Miller and Blair, 2009, and Dietzenbacher and Los, 1998).

2.1 Global accounting relations

The starting point for this analysis is a demand-driven input-output framework using Leontief's fundamental insight that a country's gross output equals its output in intermediates and final demand goods, i.e.

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f} \quad \textbf{(1)}$$

where $\mathbf{x}$ denotes a vector of gross output per industry (i.e. of dimension Nx1), $\mathbf{A}$ is the input-output coefficients matrix of dimension NxN, and $\mathbf{f}$ is a vector of final demand again with dimension Nx1 with N denoting the number of industries. A simple rearrangement allows one to rewrite this equation as

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{L}\mathbf{f} \quad \textbf{(2)}$$

with $\mathbf{L}$ denoting the Leontief inverse. Thus, the level and structure of final demand together with technology capturing inter-industry determines the level of gross output in each industry capturing all direct and indirect effects. Pre-multiplying this equation with a vector of value added coefficients, i.e. value added created per unit of gross output for each industry, denoted by $\mathbf{v}$ with dimension 1xN (for notational convenience this vector is written as row vector) transforms this into total value added created in an economy which equals its GDP, i.e.

$$\mathbf{v}\,\mathbf{x} = \mathbf{v}\,(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{v}\mathbf{L}\mathbf{f} = \mathbf{1}\mathbf{f} = \mathbf{GDP} \quad \textbf{(3)}$$

which holds as $\mathbf{v} = \mathbf{1}'(\mathbf{I} - \mathbf{A})$ with $\mathbf{1}$ being a summation vector of appropriate dimension.

With international fragmentation of production and final goods this framework has to be extended by considering imports and exports of final goods and trade in intermediates. The latter is captured by considering an international coefficients matrix $\mathbf{A}$, therefore being of dimension NCxNC with C denoting the number of countries. The on-diagonal blocks of this matrix capture domestic inputs per unit of gross output whereas the off-diagonal blocks capture imports of intermediates per unit of gross output. The vector of total demand in the world is again denoted by $\mathbf{f}$ which now is also of dimension NCx1. Similar to above a country's GDP can now be calculated by pre-multiplying the international Leontief inverse times the global final demand vector by the vector of value added coefficients, denoted $\mathbf{v}^{\mathrm{r}}$ and being of dimension NCx1, containing this countries value added coefficients as non-negative entries and zeros for the other elements; therefore

$$\mathbf{v}^{\mathbf{r}}\mathbf{x} = \mathbf{v}^{\mathbf{r}}\,(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{v}^{\mathbf{r}}\mathbf{L}\mathbf{f} = \mathbf{GDP}^{\mathbf{r}} \quad \textbf{(4)}$$

To further gain insights into the role of trade and demand structures the global final demand vector can be written as the sum of national final demand vectors, i.e.

$$\mathbf{f} = (\mathbf{f}^{\mathbf{1}} + \cdots + \mathbf{f}^{\mathbf{C}}) \quad \textbf{(5)}$$

with each country-specific vector being of dimension NCx1. Such a vector contains final demand of a country for its own products, i.e. subvector $\mathbf{f}^{\mathrm{rr}}$ (final demand on domestic final goods) and for other countries final goods, i.e. subvector $\mathbf{f}^{\mathrm{sr}}$ (final demand on imported final goods). Therefore, one can write

$$\mathbf{f}^{\mathbf{r}} = \mathbf{f}^{\mathbf{rr}} + \mathbf{f}^{*\mathbf{r}} \quad \textbf{(6)}$$

$\mathbf{f}^{\mathrm{rr}}$ is a vector of dimension NCx1 which contains non-negative entries capturing final demand on domestic products and zeros otherwise whereas $\mathbf{f}^{*\mathrm{r}} = \mathbf{f}^{\mathrm{r}} - \mathbf{f}^{\mathrm{rr}}$ is of dimension NCx1. For further usage we summarise all final demand vectors of the other countries as

$$\mathbf{f}^{\mathbf{r}*} = \mathbf{f} - \mathbf{f}^{\mathbf{r}} \quad \textbf{(7)}$$

Using these simple rewritings of a final demand equation (4) above can be rewritten as

$$\mathbf{v}^{\mathbf{r}}\mathbf{x} = \mathbf{v}^{\mathbf{r}}\,(\mathbf{I} - \mathbf{A})^{-1}(\mathbf{f}^{\mathbf{rr}} + \mathbf{f}^{*\mathbf{r}} + \mathbf{f}^{\mathbf{r}*}) = \mathbf{v}^{\mathbf{r}}\mathbf{L}(\mathbf{f}^{\mathbf{rr}} + \mathbf{f}^{*\mathbf{r}} + \mathbf{f}^{\mathbf{r}*}) = \mathbf{GDP}^{\mathbf{r}} \quad \textbf{(8)}$$

In the recent literature special attention was paid to the part when considering only the other countries final demand, i.e. $\mathbf{v}^{\mathrm{r}}\mathbf{x} = \mathbf{v}^{\mathrm{r}}\mathbf{L}\mathbf{f}^{\mathrm{r}*} = \mathrm{VAX}^{\mathrm{r}}$, which is referred to as value added exports (VAX, see Johnson and Noguera, 2012), as this captures value added directly and indirectly absorbed in other countries (see also Koopman et al. 2011; Foster-McGregor and Stehrer, 2013). This is closely linked a country's domestic value added content of its gross exports (see Stehrer, 2013, for technical details).[1]

The role of a country's international fragmentation of production for its performance – either as sourcing intermediates from abroad or as deliverer of intermediates to further production stages abroad – can be considered in more detail when splitting the Leontief inverse into some sub-components. The Leontief inverse can be split into three effects: (i) the intra-regional effects contain all direct and indirect within a region; (ii) the inter-regional spillover effects account for demand for intermediates from other regions (for a given change in final demand); third, inter-regional feedback effects finally capture the effects that production of these intermediates again need inputs from the first country. Following Stone (1985) this multiplier decomposition can be expressed in linear terms. Therefore, the Leontief inverse can then be written as $\mathbf{L} = \mathbf{M}_1\mathbf{M}_2\mathbf{M}_3$ in a multiplicative form.[2] This can be further used to isolate net effects following Stone (1985) which expresses this as an additive form:

$$\mathbf{L} = (\mathbf{I} + \bar{\mathbf{M}}_{\mathbf{1}}) + \bar{\mathbf{M}}_{\mathbf{2}} + \bar{\mathbf{M}}_{\mathbf{3}} \quad \textbf{(9)}$$

with $\mathbf{I} + \bar{\mathbf{M}}_1$ (with $\bar{\mathbf{M}}_1 = \mathbf{M}_1 - \mathbf{I}$) capturing the initial injection and *net* intra-regional effects, $\bar{\mathbf{M}}_2 = (\mathbf{M}_2 - \mathbf{I})\mathbf{M}_1$ capturing the *net* inter-regional effects and $\bar{\mathbf{M}}_3 = (\mathbf{M}_3 - \mathbf{I})\mathbf{M}_2\mathbf{M}_1$ the *net* inter-regional feedback effects. This additive form makes it particularly attractive for the decomposition analysis described next.

2.2 Decomposition analysis

What are the main determinants of changes in a country's GDP over time? The concern is to decompose changes in overall GDP, i.e. GDP growth, into changes of the value added coefficients, changes in the global Leontief inverse and the three linear components just described, and changes in final demand split into the three components as outlined above in equation (8). These are further split into shifts in levels and demand structures. Therefore, the aim is to decompose GDP growth into 11 different components. Using the simple equation (4) above, $\mathrm{GDP}^{\mathrm{r}} = \mathbf{v}^{\mathrm{r}}\mathbf{L}\mathbf{f}$, the change in a country's GDP can result from changes in the value added coefficients vector, the global Leontief and changes in final demand, therefore

$$\mathbf{GDP}_{\mathbf{t}}^{\mathbf{r}} - \mathbf{GDP}_{\mathbf{t-1}}^{\mathbf{r}} = \mathbf{v}_{\mathbf{t}}^{\mathbf{r}}\mathbf{L}_{\mathbf{t}}\mathbf{f}_{\mathbf{t}} - \mathbf{v}_{\mathbf{t-1}}^{\mathbf{r}}\mathbf{L}_{\mathbf{t-1}}\mathbf{f}_{\mathbf{t-1}} \quad \textbf{(10)}$$

For doing so a decomposition analysis is an appropriate tool though not without complications. These arise due to the fact that even with only two factors, e.g. $\mathrm{x} = \mathrm{xz}$, already two mathematically

[1] It goes beyond the scope of this report to show this in detail as it requires some technicalities. Importantly, the domestic value added content of gross exports are larger than a countries value added exports as defined above as the former include value added created in the home country which is shipped abroad in form of intermediates but returns back as final product consumed in that country, whereas the latter contains only value added created in the home country which is absorbed abroad. Generally these differences are rather small and make only about 2-3 percentage points.

[2] For technical details see Miller and Blair (2009).

equivalent decomposition forms can be derived: $\Delta x = \Delta y\, z_0 + y_1 \Delta z = \Delta y\, z_1 + y_0 \Delta z$. In the first case year-0 values of z are used to evaluate changes of y and year-1 values are used to evaluate changes of z on changes on x whereas this is turned around in the second case. However, results on the relative importance of each factor would differ according to which particular decomposition is chosen. Alternatively, one might use only year 0 or year 1 weights to evaluate changes in a particular variable in which case an interaction term which lacks an appealing interpretation in most cases would appear, i.e. $\Delta x = \Delta y\, z_0 + y_0 \Delta z + \Delta y \Delta z = \Delta y\, z_1 + y_1 \Delta z + \Delta y \Delta z$. A number of attempts in the literature explored this and one solution suggested was to calculate the averages over the two possible decompositions above (see Dietzenbacher and Los, 1998). However, with more than 2 factors additional possibilities of equivalent decomposition forms arise. More generally, for 2 factors there are 2! = 2 possibilities, for 3 factors there are 3! = 6 and 4! = 24, etc. For 11 components as envisaged in this paper the number of combinations would be almost 40 million (11! = 39916800). Thus for higher dimensions the computational burden can become quite large. Therefore one suggestion is to use only the two so-called polar decompositions and take the average of these or use mid-point weights though none of these alternatives seems to be completely satisfactory (see Dietzenbacher and Los, 1998, for a detailed assessment, and Miller and Blair, 2009, for a summary). Dietzenbacher and Los (1998) report a sensitivity analysis and conclude that using polar decomposition is close to the results using all permutations even at a detailed sectoral level. [3]

A solution which allows one to avoid the problem of hierarchical inconsistency and reduces the computational burden is to apply a 'hierarchical decomposition' method. In this case, first, a hierarchical structure of the decomposition has to be assumed, which second allows one to calculate the decomposition of each hierarchy which is then consistent with the upper level results. In our particular case we first calculate the decomposition with respect to $\mathrm{GDP}^{\mathrm{r}} = \mathbf{v}^{\mathrm{r}}\mathbf{L}\mathbf{f}$, then split final demand into its three components, i.e. $\mathbf{f} = (\mathbf{f}^{\mathrm{rr}} + \mathbf{f}^{*\mathrm{r}} + \mathbf{f}^{\mathrm{r}*})$, and the Leontief inverse into its three components $\mathbf{L} = (\mathbf{I} + \bar{\mathbf{M}}_1) + \bar{\mathbf{M}}_2 + \bar{\mathbf{M}}_3$ at the second level, and analyse the effects of level changes and structural shifts in the three final demand categories at the third level. Using this hierarchical strategy at the first level 3! = 6 decompositions have to be calculated. At the second level again three factors are considered but two times such that 2 3! = 12 decompositions have to be calculated resulting in 3! (2 3!)= 72 decompositions to be calculated in total. At the third level each of the three final demand categories is split into two effects (levels and structures) which result for further 2! = 2 decompositions for each. This therefore results in 3! (2 3!) (3 2!) = 432 different decompositions as compared to 11! = 39916800 decompositions when applying a non-hierarchical strategy. The latter has the further advantage that lower levels are consistent with higher level results[4].

3 Trade, structural change and growth

In this section results from the polar decomposition analysis for changes between 1995 and 2011 based on data in current US-$ are presented. The changes in value added and its components have been transferred into yearly growth rates and therefore the individual components can be interpreted as contributions to overall (nominal) GDP growth in current US-$ in terms of percentage points.

[3] Preliminary analysis employing a hierarchical decomposition analysis (see e.g. Koller and Stehrer, 2009) provides similar results which justifies using the simple polar decomposition.

[4] A more detailed technical treatment can be found in the working paper version, Koller and Stehrer (2009).

Table 1 presents detailed decomposition results with respect to equation (8) for selected countries and country groups and the total world. In the following these results are discussed first at the global level and then at the level of the individual countries and country groups. This is then followed by highlighting results at the country level. Finally, further details with respect to the decompositions at lower levels are summarised.

Table 1. Detailed decomposition results, 1995-2011

Growth rates and contributions – Change in global final demand

	Change in value added	Change in input coefficients	Change in global IO tables	Change in domestic demand (for domestic products)			Change in domestic demand for foreign products			Change in value added exports		
				Total	Total	Level effect	Structural effect	Total	Level effect	Structural effect	Total	Level effect	Structural effect
	2	3	4	5	6	7	8	9	10	11	12	13	14
	=3+4+5			=6+9+12	=7+8			=10+11			=13+14		
EU-27	4.59	-0.32	0.12	4.79	3.29	3.25	0.04	0.01	0.01	0.00	1.49	1.44	0.05
EU-15	4.31	-0.33	0.07	4.57	3.13	3.09	0.04	0.01	0.01	0.00	1.43	1.41	0.01
EU-12	9.32	-0.25	0.83	8.74	6.22	6.16	0.06	0.01	0.01	0.00	2.51	1.80	0.71
China	15.72	-0.67	1.85	14.55	12.14	12.19	-0.05	0.01	0.02	0.00	2.39	1.28	1.11
Japan	1.08	-0.26	-0.30	1.64	0.92	0.90	0.02	0.01	0.00	0.00	0.71	0.74	-0.02
USA	4.56	-0.07	-0.18	4.81	4.30	4.28	0.02	0.03	0.03	0.00	0.49	0.45	0.03
World	5.70	-0.27	0.27	5.70	4.51	4.49	0.02	0.02	0.02	0.00	1.17	1.03	0.14

Note: Country groups are weighted averages across countries; therefore intra-EU trade is taken into account.
Source: WIOD; wiiw calculations

3.1 Growth decomposition and the role of value added exports

3.1.1 Results at world level

At the world level value added (i.e. global income) has increased by 5.56 per cent (in current US-$) on average over the period 1995-2011. This corresponds to the growth of total final demand as - by definition - global value added equals global final demand.

The effects of changes in the value added coefficients has a counterpart in the change of the global Leontief inverse as input coefficients for intermediates and value added coefficients are summing up to one by definition. Therefore, the effects of a change in value added coefficients with -0.32 and the change in the global Leontief inverse with 0.32 cancel out each other. As expected the increasing fragmentation of production resulted in a higher roundaboutness of the global production system and therefore the effects of the changes in the global Leontief are positive.

Calculating these changes at the global level as a sum over the individual countries allows one to calculate the contributions of overall changes in domestic final demand which amounts to 4.46 percentage points. This suggests that – despite the overall increasing production fragmentation – about 80% of global income increase results from an increase in domestic final demands. A small part of this stems from value added generated domestically which is first exported and then comes back home, e.g. raw materials produced in

a country which are exported and return back home in form of an intermediate or final product. This (Column 9) amounts however only to a negligible contribution of 0.01 per cent.[5]

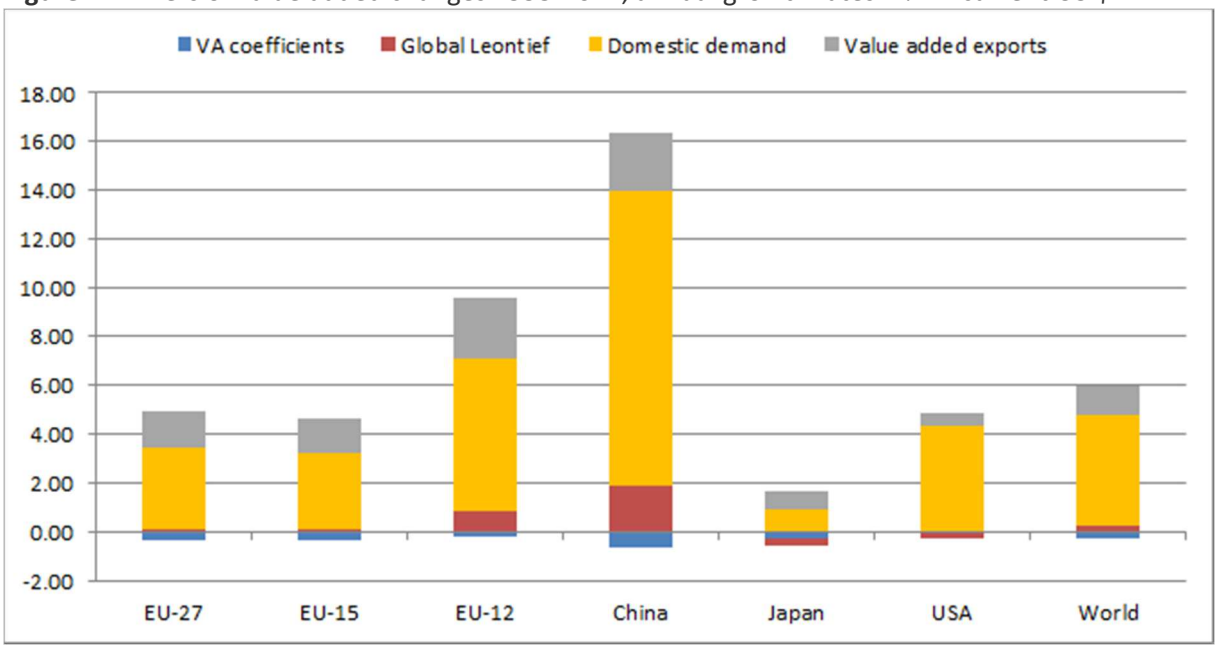
The remaining growth stems from the change in value added exports amounting to 1.08 percentage points or about 20% of global growth. It should be noted that these value added exports do not only account for value added created for exports of final goods but indirectly also embodies value added created in a country which are exported in form of intermediates and finally absorbed in another country.

Each of the final demand categories can be split into the effects of changes in the overall levels of demand and changes in the structures of demand. Whereas changes in the structure of final consumption are small with respect to both categories of domestic demand this contributed 0.11 percentage points to overall world GDP growth which is about 10% of world GDP growth due to growth in value added exports. This indicates that at the world level trade in value added terms shifted to more value added intensive activities.

3.1.2 Differentiated patterns across major country groups

To highlight specific cross-country differences selected decomposition results for the countries and country groups listed in Table 1 are visualized in Figure 1. In general, the patterns are broadly in line with the general tendencies at the global level though some differences arise when considering individual countries or country groups. In all countries – maybe with the exception of Japan – changes in domestic final demand are the most important source of growth accounting for 93 per cent of overall growth in the US and 80 per cent in China. For the EU aggregates this share is somewhat lower with 73.6 per cent for EU-15 and 66.6 per cent for the EU-12 resulting in 72.8 per cent of overall growth for the EU-27.

Figure 1. Drivers of value added changes 1995-2011, annual growth rates in% in current US-$



Note: Country groups are weighted averages across countries; therefore intra-EU trade is taken into account.
Source: WIOD; wiiw calculations

[5] In Figure 1 below this is added to the growth rates due to changes in domestic final demand (on domestic and foreign products).

In all cases the major part was again due to a level change as documented in Table 4.1. The structural effect though being relatively small was positive in all countries considered here with the exception of China indicating that demand shifted towards more value added intensive activities.

The second most important part of overall growth of these countries is the value added exports which for the US and China accounts for 12.4 and 14.2 per cent of overall growth, respectively. This is even higher for the EU aggregates: In case of the EU-15 value added exports accounted for 33.7 per cent of overall growth whereas for the EU-12 the share is 20.5 per cent. These larger shares result from the European integration and particularly the integration with the EU-12 on the one hand and the fact of the EU remaining rather competitive in world markets.[6] In all cases the level effect is again dominating. It is however interesting to note that a strong positive mix effect can be observed for the EU-12 and China with respect to value added exports. This effect contributed 7.1% to overall growth in the EU-12 and 6.2 per cent in China again pointing towards the fact that these countries successfully shifted production to higher value added intensive activities. For the advanced countries these shift effects are either negligible (0.5 per cent of overall growth in the US) or even slightly negative (-1.1 per cent of overall growth in the case of EU-15). With respect to domestic final demand these mix effects are in the range of about 1 per cent and therefore much smaller as compared to the mix effects in value added exports particularly for the EU-12 and China.

Considering the effects of changes in the global Leontief inverse one finds again strong positive growth effects for the EU-12 and China where this component contributed 9.1 and 12.6 per cent to overall growth, respectively. There is still a positive but much smaller effect for the EU-15 (2.6 per cent of overall growth) but a relatively large negative effect is found for US with -4.5 per cent of overall growth. Further, a strong negative effect can be seen for Japan where this contributed -0.33 percentage points from an overall growth rate of 0.73 per cent. This is counteracted by the growth effects of a change in value added coefficients which are negative for all countries and particularly so in the case of the EU-15 and China with -9.1 and -6.8 per cent contributions to overall growth and also Japan with -0.25 percentage points out of 0.73 per cent overall growth.

As these two effects are intimately related to each other it is interesting to jointly look at these by adding them up. This joint effect remains positive for EU-12 and China (with a positive contribution of 5.7 per cent to overall growth in each country) and becomes negative for EU-15 and the US with -6.5 and -6.1 per cent respectively. This might suggest that the former two countries profited from becoming more integrated in the world markets and world production systems.

3.1.3 Differentiated patterns across major country groups

Table 2 presents the same set of results for individual EU member states. Generally, the results reported above when comparing EU-12 to EU-15 also show up at the member state level. Particularly, concerning the overall effect of value added exports - as shown in Figure 2 - one finds large differences across countries with contributions of above 60% to overall GDP growth in Germany to slightly more than 10% for Greece. For the EU-12 in particular one finds strong positive effects of changes in the structure of value added exports with an exception being Slovenia. This effect is in most cases stronger as compared to the EU-15 member states as already indicated above.

[6] It should be noted that over the whole period the EU as a whole was running a trade surplus of about 1% of GDP on average.

Table 2. Results by individual countries (in percentage points), 1995-2011

Growth rates and contributions – Change in global final demand

	Change in value added	Change in input coefficients	Change in global IO tables		Change in domestic demand			Change in value added exports		
				Total	Total	Level effect	Structural effect	Total	Level effect	Structural effect
	2	3	4	5	6	7	8	12	13	14
	=3+4+5			=6+9+12	=7+8			=13+14		
Austria	4.1	-0.7	0.5	4.3	2.2	2.2	0.0	2.1	1.9	0.2
Belgium	4.2	-0.5	0.0	4.7	2.6	2.6	0.0	2.1	2.3	-0.3
Denmark	4.2	-0.7	0.4	4.5	2.8	2.8	0.1	1.7	1.8	-0.1
Finland	4.8	-0.7	0.2	5.3	3.7	3.7	0.0	1.7	1.7	-0.1
France	4.2	-0.1	-0.3	4.5	3.5	3.5	0.0	1.0	1.1	-0.1
Germany	2.8	-0.4	0.0	3.1	1.3	1.3	0.0	1.9	1.7	0.1
Great Britain	5.2	-0.2	0.1	5.3	4.2	4.1	0.1	1.2	1.2	0.0
Greece	5.9	0.4	-0.3	5.8	5.0	5.0	0.0	0.8	0.6	0.1
Ireland	8.4	-0.6	1.7	7.3	3.8	3.8	0.0	3.5	2.9	0.6
Italy	4.6	-0.5	0.2	5.0	3.9	3.8	0.0	1.1	1.1	-0.1
Luxembourg	7.5	-1.7	2.1	7.1	3.0	3.0	0.0	4.1	3.4	0.7
Netherlands	4.8	-0.3	0.1	5.0	3.1	3.0	0.1	1.9	2.1	-0.2
Portugal	5.0	-0.1	0.1	5.0	4.1	4.0	0.1	0.9	1.1	-0.2
Spain	6.4	-0.3	0.3	6.4	5.3	5.2	0.1	1.1	1.0	0.1
Sweden	5.4	-0.4	0.3	5.6	3.6	3.6	0.0	2.0	1.9	0.1
Bulgaria	9.1	-0.9	1.5	8.5	6.1	6.2	0.0	2.3	1.9	0.4
Cyprus	6.6	-1.0	1.0	6.6	5.7	5.5	0.2	0.9	0.9	0.0
Czech Republic	9.4	-0.2	1.1	8.5	5.2	5.1	0.1	3.2	2.3	1.0
Estonia	12.3	0.3	1.5	10.5	7.7	7.6	0.1	2.8	2.1	0.6
Hungary	8.1	-0.3	1.0	7.4	4.4	4.2	0.2	3.0	2.2	0.8
Latvia	12.5	-0.5	1.6	11.4	8.9	8.9	0.0	2.5	1.7	0.8
Lithuania	13.0	0.5	0.9	11.6	8.7	8.6	0.0	2.9	1.8	1.1
Malta	6.0	-0.9	1.2	5.7	3.4	3.1	0.3	2.3	2.2	0.2
Poland	9.1	-0.4	0.7	8.8	6.6	6.6	0.0	2.2	1.5	0.7
Romania	11.7	0.3	0.6	10.8	8.8	8.8	0.0	2.0	1.4	0.6
Slovakia Republic	11.4	0.5	0.6	10.3	6.7	6.6	0.0	3.6	2.4	1.3
Slovenia	6.2	-0.2	0.4	6.0	3.9	3.8	0.1	2.1	2.0	0.1
Australia	9.5	0.0	0.6	8.9	7.7	7.6	0.0	1.2	1.0	0.2
Brazil	8.7	-0.1	0.4	8.4	7.4	7.4	0.0	1.0	0.7	0.2
Canada	7.2	-0.3	0.7	6.9	5.4	5.5	-0.1	1.5	1.6	-0.1
China	15.7	-0.7	1.9	14.5	12.2	12.2	-0.1	2.4	1.3	1.1
India	10.9	0.1	0.2	10.7	9.4	9.4	0.0	1.3	0.8	0.5
Indonesia	11.5	-0.4	1.5	10.5	8.9	8.9	-0.1	1.6	1.5	0.1
Japan	1.1	-0.3	-0.3	1.6	0.9	0.9	0.0	0.7	0.7	0.0
Korea	5.9	-0.9	0.5	6.3	4.1	4.1	0.0	2.2	1.6	0.6
Mexico	8.8	0.2	0.2	8.4	7.1	7.1	0.0	1.3	1.0	0.3
Russia	13.7	-0.3	2.1	11.9	9.7	9.7	0.0	2.2	1.7	0.5
Taiwan	3.5	-0.4	-0.2	4.2	2.0	1.9	0.1	2.2	2.0	0.1
Turkey	8.7	-1.0	1.2	8.6	7.5	7.4	0.1	1.1	0.8	0.3
USA	4.6	-0.1	-0.2	4.8	4.3	4.3	0.0	0.5	0.5	0.0
Rest of World	8.4	-0.4	1.2	7.6	5.9	5.9	0.0	1.7	1.3	0.4

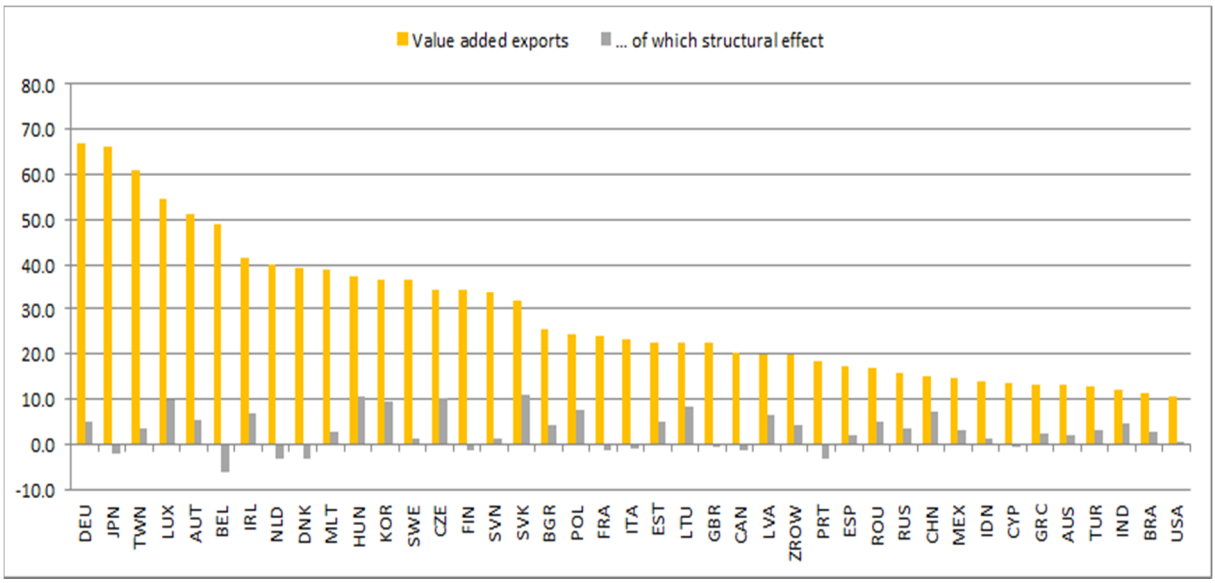
Source: WIOD; wiiw calculations

Table 3. Results by individual countries, in % of total GDP growth

	Growth rates and contributions – Change in global final demand									
					Change in domestic demand			Change in value added exports		
	Change in value added	Change in input coefficients	Change in global IO tables	Total	Total	Level effect	Structural effect	Total	Level effect	Structural effect
	2	3	4	5	6	7	8	12	13	14
	=3+4+5			=6+9+12	=7+8			=13+14		
Austria	100	-17	13	105	53	52	1	51	46	5
Belgium	100	-12	0	112	63	63	0	49	55	-6
Germany	100	-14	1	113	46	45	1	67	62	5
Denmark	100	-17	11	106	67	65	2	39	42	-3
Spain	100	-4	4	100	82	81	1	17	15	2
Finland	100	-15	5	110	76	76	0	35	36	-1
France	100	-2	-6	108	84	84	0	24	26	-1
Great Britain	100	-5	2	103	80	79	1	23	23	0
Greece	100	6	-5	99	85	85	0	13	11	2
Ireland	100	-7	20	88	46	46	0	42	35	7
Italy	100	-11	3	107	84	83	1	23	24	-1
Luxembourg	100	-22	28	94	40	39	0	55	45	10
Netherlands	100	-6	3	103	63	62	1	40	43	-3
Portugal	100	-2	2	100	82	80	2	18	22	-3
Sweden	100	-7	5	102	66	65	0	37	35	1
Bulgaria	100	-9	17	93	67	68	0	25	21	4
Cyprus	100	-15	15	100	87	84	3	14	14	0
Czech Republic	100	-2	12	90	56	55	1	35	24	10
Estonia	100	3	12	85	63	62	1	23	17	5
Hungary	100	-4	12	92	55	53	2	38	27	10
Lithuania	100	4	7	89	67	66	0	23	14	8
Latvia	100	-4	12	91	71	71	0	20	14	6
Malta	100	-15	21	95	56	51	5	39	36	3
Poland	100	-5	7	97	73	73	0	24	17	7
Romania	100	3	5	92	75	76	0	17	12	5
Slovak Republic	100	5	5	90	58	58	0	32	21	11
Slovenia	100	-3	6	97	63	61	2	34	33	1
Australia	100	0	6	94	81	81	0	13	11	2
Brazil	100	-2	5	97	85	85	0	11	8	3
Canada	100	-4	9	95	74	76	-1	20	22	-1
China	100	-4	12	93	77	78	0	15	8	7
Indonesia	100	-4	13	91	77	78	-1	14	13	1
India	100	1	2	98	86	86	0	12	7	5
Japan	100	-24	-28	152	86	83	2	66	68	-2
Korea	100	-15	9	106	70	69	1	37	27	10
Mexico	100	2	2	96	81	81	0	15	12	3
Russia	100	-2	15	87	71	71	0	16	12	3
Turkey	100	-12	13	99	86	84	1	13	10	3
Taiwan	100	-12	-6	118	57	52	4	61	57	4
USA	100	-1	-4	105	95	94	0	11	10	1
Rest of world	100	-5	14	90	71	70	0	20	16	4

Source: WIOD; wiiw calculations

Figure 2. Growth contributions of value added exports, in % of GDP growth



Source: WIOD; wiiw calculations

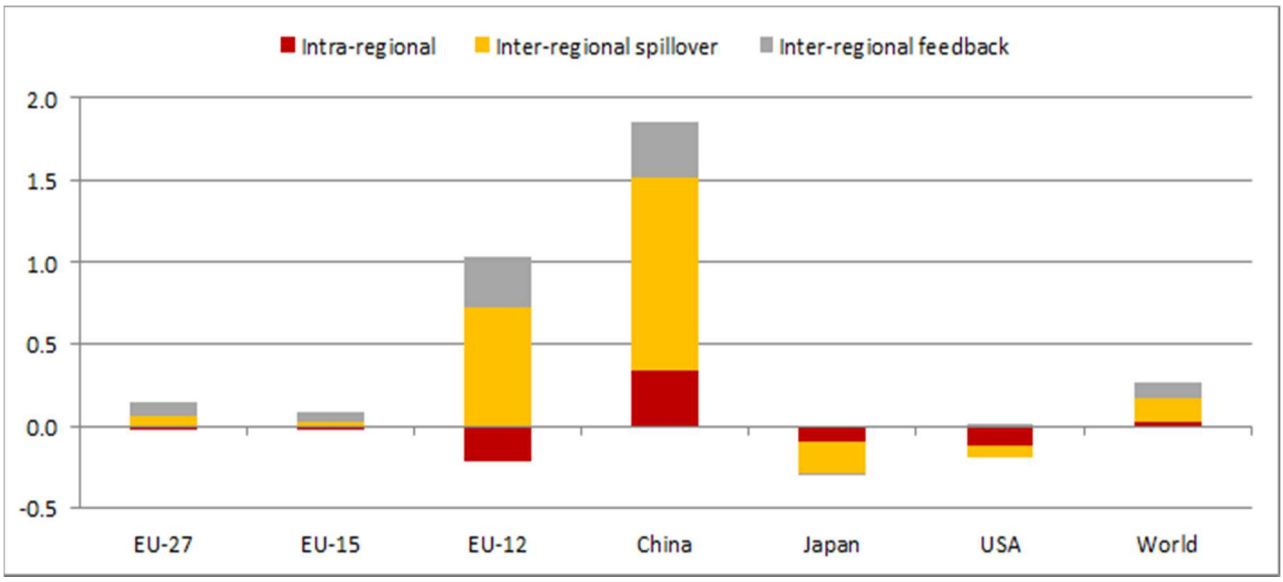
3.2 Growth effects of international fragmentation of production

Concerning changes in the global Leontief one finds generally positive contributions to overall GDP growth, exceptions being France and Greece for the EU countries together with Japan, Taiwan and the US. These tend to be larger (also as per cent of overall GDP) for smaller countries and the EU-12 countries consistent with the results reported above. Contrary, the effects of changes in value added coefficients tend to be negative in most countries (with a few exceptions) and is particularly strong for the EU-15 member states pointing towards stronger vertical specialisation or changes in input-output technologies.

Figure 3 presents the results when applying the decomposition to equation (9) above, i.e. splitting the effects into intra-regional, inter-regional spillover and inter-regional feedback effects. Again, this graph first confirms that changes in the international production system have been particularly strong for the group of EU-12 and China. In both cases the inter-regional spillover effect and inter-regional feedback effects dominate underpinning the fact that these countries have been integrated into international production systems. Difference is that intra-regional effects have contributed slightly negative in case of the EU-12 but positively in China. For the advanced regions one finds that the negative contributions are mostly due to changes in inter-regional spillover effects, which in case of the US is even dominated by the negative contribution of intra-regional effects. This is not the case for the EU-15 countries.[7]

[7] Country-level results are reported in Appendix Table A.1.

Figure 3. Growth effects of changes in global Leontief 1995-2011, in percentage points



Source: WIOD; wiiw calculations

4 Conclusions

The paper builds on the Leontief demand driven model and introduces a decomposition analysis allowing one to assess contributions to GDP growth. The factors considered in this decomposition are changes in the value added input coefficients, changes in the global Leontief inverse, domestic and foreign demand together with structural effects. Empirically the World Input-Output Database (WIOD) is used presenting some stylized facts of growth patterns across countries with an emphasis on the integration of the EU-12 and China into world production systems. Results suggest that GDP growth in the EU-12 and China particularly benefitted from integration into the world production systems and value added exports. In all cases, however, domestic demand remains the most important source of GDP growth.

References

Dietzenbacher, E., B. Los, R. Stehrer, M. Timmer and G. deVries (2013), The Construction of World Input-Output Database in the WIOD, Economic Systems Research, Vol. 25, No. 1, 2013, pp. 71-98

Dietzenbacher, E. and B. Los (1998), Structural Decomposition Techniques: Sense and Sensitivity, Economic Systems Research 10(4), 307-323.

Foster-McGregor, N. and R. Stehrer (2013), Value added content of trade: A comprehensive approach, Economics Letters, 2(2), 354-357.

Johnson and Noguera (2012), Accounting for Intermediates: Production Sharing and Trade in Value Added, Journal of International Economics, 87, 105-111.

Koller, W. and R. Stehrer (2010), Trade Integration, Outsourcing and Employment in Austria: A Decomposition Approach, Economic Systems Research 22(3), 237-261.

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

Koopman, R., W. Powers, Z. Wang and S.-J. Wei (2011), Give Credit where Credit is Due: Tracing Value Added in Global Production Chains, NBER Working Paper 16426 (revised version September 2011).

Miller, R.E. and P.D. Blair (2009), Input-Output Analysis. Foundations and Extensions, 2nd ed., Cambridge University Press.

Stehrer, R. (2013), Trade in Value Added and the Value Added in Trade, wiiw Working Paper, Nr. 81, The Vienna Institute for International Economic Studies, Vienna.

Timmer. M. (2012, ed.), The World Input-Output Database (WIOD): Contents, Sources and Methods, WIOD Working Paper No. 10.

Appendix table A.1. Growth effects of changes in global Leontief 1995-2011

	in percentage points			in % of value added growth		
	Intra-regional	Inter-regional spillover	Inter-regional feedback	Intra-regional	Inter-regional spillover	Inter-regional feedback
Austria	0.17	0.20	0.15	4.0	4.8	3.6
Belgium	0.02	-0.03	0.03	0.5	-0.7	0.7
Denmark	0.16	0.16	0.12	3.8	3.9	3.0
Finland	0.22	-0.04	0.07	4.6	-0.9	1.5
France	-0.15	-0.11	0.01	-3.7	-2.7	0.3
Germany	-0.07	0.03	0.08	-2.5	1.1	2.8
Great Britain	0.05	-0.02	0.06	1.0	-0.5	1.1
Greece	-0.37	0.06	0.03	-6.4	1.0	0.5
Ireland	-0.22	1.52	0.35	-2.7	18.2	4.2
Italy	0.15	-0.03	0.04	3.2	-0.6	0.9
Luxembourg	0.18	1.49	0.44	2.4	19.7	5.8
Netherlands	-0.07	0.07	0.13	-1.5	1.4	2.7
Portugal	0.03	0.04	0.05	0.6	0.9	0.9
Spain	-0.06	0.23	0.10	-0.9	3.7	1.6
Sweden	0.03	0.11	0.11	0.6	2.1	2.1
Bulgaria	0.45	0.74	0.35	5.0	8.0	3.8
Cyprus	0.77	0.13	0.08	11.6	1.9	1.2
Czech Republic	-0.17	0.87	0.42	-1.8	9.3	4.5
Estonia	-0.02	1.08	0.42	-0.1	8.8	3.4
Hungary	-0.32	0.92	0.37	-4.0	11.4	4.5
Latvia	0.50	0.75	0.31	4.0	6.0	2.5
Lithuania	-0.27	0.85	0.35	-2.0	6.5	2.7
Malta	0.61	0.49	0.14	10.2	8.2	2.3
Poland	-0.37	0.73	0.30	-4.1	8.0	3.3
Romania	-0.33	0.66	0.27	-2.9	5.7	2.3
Slovak Republic	-0.52	0.64	0.45	-4.6	5.6	3.9
Slovenia	0.01	0.20	0.17	0.2	3.3	2.8
Australia	-0.03	0.40	0.21	-0.3	4.2	2.2
Brazil	-0.04	0.34	0.13	-0.4	3.9	1.5
Canada	0.30	0.31	0.08	4.1	4.2	1.1
China	0.34	1.17	0.34	2.2	7.5	2.1
India	-0.32	0.37	0.13	-3.0	3.4	1.2
Indonesia	0.50	0.67	0.29	4.4	5.9	2.5
Japan	-0.10	-0.19	-0.01	-8.9	-18.0	-0.7
Korea	0.11	0.20	0.20	1.9	3.4	3.4
Mexico	-0.31	0.43	0.10	-3.5	4.9	1.1
Russia	0.17	1.09	0.83	1.2	8.0	6.0
Taiwan	-0.12	-0.24	0.17	-3.3	-6.9	4.7
Turkey	0.64	0.39	0.15	7.3	4.5	1.8
USA	-0.12	-0.07	0.01	-2.6	-1.6	0.1
Rest of world	0.30	0.65	0.27	3.6	7.7	3.2

Source: WIOD; wiiw calculations