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# **On the role of BRIC countries in providing global manufacturing output**

**Future of Manufacturing Project: Evidence Paper 34**

Foresight, Government Office for Science

# On the role of BRIC countries in providing global manufacturing output

By

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October 2013

This review has been commissioned as part of the UK Government's Foresight Future of Manufacturing Project. The views expressed do not represent policy of any government or organisation.

# Contents

<b>Executive summary</b> .....	<b>4</b>
<b>1. Introduction</b> .....	<b>6</b>
<b>2. The overall role of manufacturing in the world economy</b> .....	<b>9</b>
<b>3. Manufacturing and the international fragmentation of production</b> .....	<b>13</b>
3.1 Using global input-output tables to assess global integration patterns .....	13
3.2 International fragmentation of production: The increase in vertical specialisation .....	14
3.3 Value added exports .....	19
<b>4. Future trends in global manufacturing patterns</b> .....	<b>22</b>
4.1 A summary of the previous findings .....	22
4.2 Prospective future trends based on a demand driven Leontief model .....	23
<b>5. Summary and conclusions</b> .....	<b>29</b>
<b>References</b> .....	<b>31</b>
<b>Appendix</b> .....	<b>33</b>

## Executive summary

The manufacturing share of GDP in advanced economies but also globally are on a declining trend. Though this is the case for most countries the relative importance of manufacturing across countries and the developments concerning the manufacturing sectors are quite heterogeneous. On the one hand, the Chinese economy became one of the countries with the largest share of manufacturing in GDP which also was rather stable over the last decade or so. On the other hand, many advanced nations like the US, Japan and some European countries like the UK faced strong declines in their manufacturing base. In between are countries like Germany which still have a rather stable and sizeable manufacturing base. This secular decline of manufacturing as a share of GDP has to be discussed in conjunction with three other trends: (i) the overall rise of demand for services due to real incomes growing and the demographic shifts ageing populations might face, (ii) the emergence of quickly developing economies, notably China, and their integration into the world economy, and (iii) the increasing importance of production fragmentation within manufacturing production implying increased vertical specialisation.

This paper contributes to these issues by first providing some evidence on the past developments concerning the role of emerging economies, particularly the BRIC countries and the international fragmentation of production, and second by a forecasting exercise based on a global Leontief demand driven model attempting to provide a long-term future perspective with respect to the manufacturing share and the role of the BRIC countries in the world economy based on assumptions of differentiated growth dynamics and changes in final demand patterns.

Concerning the past developments, the most important findings are summarised as follows: First, the share of manufacturing in the total world economy was on a declining trend since the 1990s and nowadays makes about 18% of world GDP (from a share of about 20% in 1995). Such declining trends in the shares of manufacturing in a country's GDP are observed for most individual countries with some notable exceptions like Germany. Second, the share of manufacturing in GDP ranges widely across countries. The emerging economies like the BRICs tend to have larger shares. These patterns are roughly in line with development theories that emerging economies build up a strong manufacturing base. China is an outlier with a rather large manufacturing share of more than 30%, whereas other BRICs show more 'balanced' development patterns. It is interesting to note that despite the rising weight of these emerging economies in the world economy and the relatively larger role manufacturing plays in these countries, the total manufacturing share of global GDP is still in decline. Third, the BRIC countries in 2011 produced slightly less than one third of manufacturing GDP as compared to 15% (USA), 9% (Japan) and 15% (the four big EU countries, i.e. Germany, France, Great Britain and Italy). Over the period considered there has been a major shift towards the BRIC countries (from about 10% in 1995 to 28% in 2011). Fourth, within manufacturing one observes for the emerging countries traditional patterns of specialisation, together with a 'climbing up the ladder' development path. However, in a dynamic perspective the BRICs are also gaining shares in medium-high and high tech industries over time. Fifth, concerning the increasing international fragmentation of production, there is an indication that BRICs are increasingly taking the role of providers of all manufacturing products and inputs rather than remaining as mainly assemblers. This can be seen as a decision by these countries to take up all of the stages of production themselves. Sixth, as the BRICs are gaining weight in the world economy they are also becoming more important for

value added exports both amongst themselves but also for the advanced countries. However, the main part of the advanced countries value added exports is still to other advanced countries. This is particularly the case for the European economies due to the strong internal integration.

Second, an assessment of long-term trends based on a simple demand driven Leontief modelling framework is provided. Under the assumptions of long-term convergence of overall growth rates and final demand structures the above trends are expected to broadly continue. According to these scenarios BRIC countries will gain in relative importance as their share in world GDP increases to slightly less than one third. With respect to their share in global manufacturing GDP the increase is projected to be slightly stronger to about 35% whereas the advanced economies are losing in relative importance accordingly. In most countries the share of manufacturing in GDP will decline further with this trend being more pronounced in the BRIC countries as compared the advanced countries considered. Consequently, the share of manufacturing in world GDP is also projected to decline to about 16% (as compared to 18% in 2011), despite the fact that the fastest growing economies tend to have a larger manufacturing share. Under these assumptions therefore overall changes of global structures are projected to continue, though on a less rapid path.

# I. Introduction

The secular decline in the share of manufacturing in most of the advanced but also emerging economies in terms of value added or employment is triggering discussions on its causes and implications amongst policy makers and the public. In essence, the shift towards services is to be expected for advanced nations, in which increasing income per capita as normally services have higher income elasticities with therefore demand shifting towards services when nations become richer. Baumol (1967) discussed this phenomenon already arguing that the implied shift towards services is detriment to overall productivity growth. Together with demographic aspects therefore demand for services activities like health care, education, and the like but also a larger need for business services in the modern manufacturing process tend to be increasing. Another point of concern in this debate is whether and to what extent the relative decline of the manufacturing sector in advanced economies is driven by the rising importance of emerging countries which tend to specialise in manufacturing – perhaps starting with low-tech industries but then also climbing up the ladder to higher tech industries – and therefore becoming important competitors in manufacturing products for the advanced nations. Some of these emerging economies, in particular China, do have an explicit goal for achieving a large manufacturing industry. Similarly, within Europe, the catching-up Eastern European countries tend to be characterised by a relatively larger share of manufacturing as compared to the more advanced Western European countries. The idea that developing and emerging economies require a stronger manufacturing base in the development process is already debated in some older literature (e.g. Chenery, 1960; Chenery and Syrquin, 1975; Rowthorn and Wells, 1987) on structural change issues. As these nations tend to be characterised by higher productivity growth rates due to a catching-up process together with lower wage costs these countries are seen as competitors particularly in (at first, lower tech) manufacturing products therefore contributing to the decline of manufacturing in the advanced countries. On the other hand, these emerging economies are also potential export markets for the advanced nations implying that advanced nations nonetheless might gain from these emerging markets in terms of value added and job creation despite a the relative decline of manufacturing and specialisation towards services.

On top of these global shifts is the fact that the production processes of goods – and in particular manufacturing goods – have changed over the last decade or so. Production of a manufactured final product is no longer only organized in a single country which then competes with the final product on the global market but the production processes themselves become a more and more internationalised which is debated under the headings of ‘international fragmentation of production’, ‘offshoring of production’ and the like. Therefore trade in intermediate products entering the production of final goods in a particular country, like parts and components for an electronic product or a car, become more and more important.

Economies therefore not only specialise in terms of industries but also of activities carried out for production of a particular product. Specifically, the value of a final product sold on the market embodies more and more value added from other countries due to the increasing international vertical specialisation processes. Therefore, using normal trade statistics might be misleading in quantifying a country’s value added creation processes and exports in certain industries. For the advanced economies the increasing importance of the BRIC countries has to be seen, on the one hand, as challenges as these countries might act as competitors with respect to a country’s own firms but also on third markets,

and on the other hand, as an opportunity because, first, the above average growth performance of these countries opens up new export possibilities, and second, allows for firms to source intermediates more cheaply from abroad or to offshore production stages, which is referred to as offshoring activities.

The decline of manufacturing in advanced countries like the US and EU member states nowadays concerns policy-makers and the public. The issue of a dwindling manufacturing sector in the advanced countries came particularly to attention in the aftermath of the financial and economic crisis which hit the world economy in 2008. These concerns also initiated a debate on a renewal in the need of industrial policies which are argued to be conducive for fostering the future growth of economies. Particularly in the US but also in European countries the need for a re-strengthened manufacturing base together with the objective to 'bring manufacturing back home' which was lost due to offshoring is on the policy agenda. The European Commission has set an ambitious goal aiming for a manufacturing share of 20% in 2020 (European Commission, 2010) and there is a lively debate in the US on the need of re-industrialisation to guarantee further growth and job creation (e.g. Warwick, 2013). Such a decline of manufacturing production leads to a loss of 'manufacturing commons' (Pisano and Shih, 2009) including specific knowledge, capabilities, and supplier networks. Several arguments are discussed concerning why a more vibrant and sizeable manufacturing sector might be important for longer term prospects. Rodrik (2012), for example, point out the importance of manufacturing for further innovations and R&D, overall productivity growth, the provision of stable and high-wage jobs and with respect to a country's external balance and therefore argues for a 'manufacturing imperative'. A strengthening of the manufacturing sector can also be argued by the increasing competition from emerging economies with some of them having adopted a kind of activist industrial policies. Finally, in course of the crisis it was argued that more active industrial policy is needed as for its anti-cyclical component with a tendency to counteract the effects of the economic downturns on income and jobs. This view is however not undisputed and authors argue that one should give up the 'manufacturing fetish' (e.g. Bhagwati, 2010) arguing that a country can also earn high income by providing service activities like design, R&D, marketing and finance though at the risk that manufacturing activities themselves are increasingly carried out outside the country. And it is by no means clear whether advanced countries having specialised in service activities like finance will do better and might be able to grow faster than countries still having a stronghold in manufacturing in the medium and long-term prospect.

In summary, there are some points which deserve to be addressed and this paper aims to contribute to some of these points: First, what is the development of the manufacturing in the global economy and in particular countries? In this paper the emphasis lies on the development in the big emerging economies, Brazil, Russia, India and China, i.e. BRIC, in comparison with larger advanced countries. The rising importance of these emerging countries is well documented (see e.g. O'Neill, J. (2001), and McKinsey Global Institute (2012) for a recent study).<sup>1</sup> Developments will be compared with large advanced nations Germany, Great Britain, France and Italy selected from Europe together with the US and Japan. Based on that, indicators

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<sup>1</sup> For an overview concerning EU-27 and BRIC relations see e.g. Ghosh et al. (2009), Hunya and Stöllinger (2009) and Havlik et al. (2009).

recently developed from global input-output tables will be presented assessing the role of the BRICs in the manufacturing process of the selected advanced countries and vice versa. In this respect two aspects are highlighted: First, inputs are more and more sourced from other nations which on the one hand tend to diminish value added and job creation in an economy, but on the other hand might allow countries to reap cost advantages and specialise in activities with comparative advantages thus allowing to compete better on the global markets. Second, the role of the other nations as potential export markets is addressed, which is important for assessing the impact of ongoing internationalisation on economies in general and the manufacturing industries in particular. Finally, based on the reported trends an assessment will be given on the potential future role of manufacturing in the global economy, and the specific role of the BRICs in comparison to the advanced countries considered.



## 2. The overall role of manufacturing in the world economy

Against the background some overall trends concerning the role of the manufacturing sectors in the selected economies are presented. Considering global trends and comparisons across countries will provide insights on a country's past development patterns and give insights for potential future prospects. Particularly, the evolution of the relative importance of the manufacturing sectors in these economies over the period 1995-2011 is analysed.

Let us start with providing some basic patterns and trends on the share of manufacturing in the global economy and the countries mentioned above over the period 1995-2011. The analysis is based on the World Input-Output Database which provides a set of world input-output tables covering 41 countries and 35 industries over the period 1995-2011 which also include industry level data on gross output and value added consistent with national accounts (see Dietzenbacher et al., 2013). Table 2.1 reports the share of manufacturing value added in a country's GDP over the last decades.

**Table 2.1 – Share of manufacturing value added as per cent of GDP, 1995–2011**

	1995	2000	2007	2009	2011
World	20.1	19.0	17.9	16.7	17.9
Brazil	20.7	19.5	19.6	18.8	17.5
China	35.1	33.8	34.8	33.1	33.4
India	20.7	18.3	18.9	17.7	16.8
Russia	18.6	21.8	19.4	16.5	18.1
Germany	23.7	24.3	25.4	20.8	24.2
France	15.2	17.4	13.8	12.0	11.7
Great Britain	21.7	17.7	12.7	11.4	12.4
Italy	23.1	22.0	20.1	17.1	17.7
Japan	22.7	21.3	21.1	17.5	18.8
USA	15.7	14.5	12.4	11.5	12.5

*Note:* Underlying value added data are in current US\$.

*Source:* WIOD; author's calculations

At the global level, the share of manufacturing dropped from about 20% in 1995 continuously to slightly less than 18% in 2011. The share was even smaller during the recent global crisis in which the manufacturing sector was hit particularly.<sup>2</sup> Thus, despite the growing weight of emerging countries which tend to have larger manufacturing shares in the global economy the manufacturing share was still on a declining trend.

Concerning the advanced economies, one first observes that the shares and therefore the relative importance of manufacturing in the respective economies differed already in

<sup>2</sup> This recent share of about 18% should be seen against the EU commissions aim to raise the manufacturing share in the EU to 20% until 2020 (European Commission, 2012).

1995 to a large extent. Whereas most of the advanced countries had shares of more than 20% in 1995, in France and the US these have already been at much lower levels around 15-16%. With the exception of Germany all countries followed the global trend of a decline of these shares in the range of 3-4 percentage points. A much stronger decline is observed for Great Britain where the manufacturing share declined from 21.7 to 12.4%, i.e. by almost 10 percentage points. Due to this stronger decline Great Britain is now in a position similar to other countries like France (11.7%) and the USA (12.5%) in this respect. Thus, though Great Britain is therefore in line with other advanced countries, notably the US, the decline of the manufacturing shares was particularly severe as compared to other countries. Structural change in Germany developed differently. The manufacturing share even slightly increased from 23.7% in 1995 to 24.2% in 2011.

The BRIC countries are also characterised by a wide range of shares between 35.1% in China to 18.6% in Russia already in 1995. With the exception of China there is therefore no significant difference of these countries as compared to the more advanced nations. Similarly to the advanced nations, three out of the four BRIC countries experienced declines between 3-4 percentage points with the decline in China being slightly smaller (at about 1.5 percentage points). The one exception is Russia for which this share remained more or less constant.

Against this background of the developments of national economic structures it is worthwhile to consider the relevance of these economies in the global economy. Table 2.2 presents this information reporting the shares of the selected economies in total global manufacturing compared to the overall shares of in world GDP.

**Table 2.2 – Share of global GDP and manufacturing value added (%), 1995-2011**

	Share in world GDP					Share in manufacturing GDP				
	1995	2000	2007	2009	2011	1995	2000	2007	2009	2011
Brazil	2.5	1.9	2.4	2.7	3.3	2.6	2.0	2.6	3.0	3.2
China	2.5	3.8	6.5	8.8	10.7	4.4	6.8	12.7	17.5	19.9
India	1.3	1.5	2.2	2.3	2.7	1.3	1.5	2.3	2.5	2.5
Russia	1.1	0.8	2.2	2.0	2.5	1.0	0.9	2.4	2.0	2.5
<i>BRIC</i>	<i>7.4</i>	<i>8.0</i>	<i>13.2</i>	<i>15.8</i>	<i>19.1</i>	<i>9.3</i>	<i>11.1</i>	<i>19.9</i>	<i>24.9</i>	<i>28.1</i>
Germany	8.2	5.7	5.8	5.6	5.0	9.6	7.3	8.3	6.9	6.8
France	5.0	4.0	4.5	4.4	3.9	3.8	3.6	3.5	3.2	2.5
Great Britain	3.8	4.4	5.0	3.7	3.4	4.1	4.1	3.5	2.5	2.3
Italy	3.7	3.3	3.7	3.5	3.0	4.2	3.8	4.2	3.6	3.0
Japan	18.0	14.7	8.0	8.7	8.5	20.3	16.5	9.4	9.1	9.0
USA	25.5	31.6	26.0	24.9	21.9	19.9	24.1	18.0	17.1	15.3

*Note:* Underlying value added data are in current US-\$.

*Source:* WIOD; author's calculation

The common pattern is that the advanced economies have lost importance in terms of overall GDP due to the higher overall growth rates in the emerging economies. Most severely, for Japan which phased a decade of slow growth the share of GDP in world GDP declined by about 10 percentage points, from 18% in 1995 to 8.5% in 2011. In the other countries these declines have been less pronounced between 3 percentage points as in Germany and almost negligible declines of 0.2 percentage points as in the case of

Great Britain and 0.5 percentage points in Italy.<sup>3</sup> The BRICs generally gained shares which even doubled in the case of Russia and India. However, this is little when compared to China of which the share increased from 2.5% in 1995 to almost 11% in 2011, i.e. by a factor of more than 4. Taken together, the four BRIC countries almost tripled their share in world GDP from 7.4% in 1995 to 19.1% in 2011.

This is to be compared with the changes in shares concerning the manufacturing sector. For most of the advanced countries these resemble the one for overall GDP. Noteworthy examples are Great Britain and France where this decline was much more pronounced: In the former country the share declined from 4.1 to 2.3 in manufacturing as compared to 3.8 to 3.4 in overall GDP. Concerning the BRIC countries their overall share in manufacturing GDP increased from 9.3 to almost 25% in 2011. Thus, these four countries nowadays provide more than a quarter of income generated in manufacturing which is more than the share of the USA and Japan together and about 10 percentage points larger than that of the four big European countries considered. However, this is mostly driven by dominant increase of world manufacturing shares of China which increased by a factor of 5 – from 4.4% in 1995 to almost 20% in 2011 - underpinning China's emerging role as the global manufacturer.

The manufacturing sector of course comprises a wide range of activities from low tech activities in food processing or textile industry to manufacturing of sophisticated products in the electronics or transport equipment sectors. Though it goes beyond the scope of this paper to provide a detailed account of manufacturing structures it is worthwhile to examine how the above considered global and economy wide dynamics look when differentiated by broad sectoral aggregates comprising low tech, medium-low tech and medium-high and high-tech activities (see Appendix Table A.1 for a detailed classification). In Table 2.3 the sectoral shares of these broad aggregates for each economy together with the respective world shares are provided.

At the world level there is a slight decline of the low tech industries from 33.5 to 30.8% with increasing shares of medium-low (from 25.6 and 28% respectively) and medium-high and high-tech industries. The latter comprise the most important part which, however; only slightly increased from 40.9% to 41.2% over the period 1995-2011. These global shifts might be compared with the developments at the country level.

Considering the advanced economies a pronounced pattern of specialisation towards the medium- high and high-tech industries is observed for Germany with an increase from 51.1% in 1995 (which, by the way, has already been relatively large as compared to other economies) to 57.8% in 2011, together with a significant de-specialisation with respect to the low tech industries (from 25.1 to 17.1%). A similar though less pronounced pattern is observed for Italy. In the other advanced economies these changes have either been less pronounced – e.g. in Great Britain the shares remained roughly constant – or a more pronounced increase can be seen mainly in the medium-low tech industries whereas the shares of medium-high and high tech industries even declined (examples being the US and Japan).

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<sup>3</sup> It should be noted that here also exchange rate movements play a certain role in this respect.

**Table 2.3 – Manufacturing patterns by broad categories, 1995 and 2011**

	Share in manufacturing GDP						Share in world manufacturing GDP					
	Low tech		Medium-low tech		Medium-high and high tech		Low tech		Medium-low tech		Medium-high and high tech	
	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
World	33.5	30.8	25.6	28.0	40.9	41.2						
Brazil	42.4	36.3	23.4	27.6	34.3	36.1	3.2	3.7	2.3	3.1	2.1	2.8
China	34.2	29.0	32.2	29.9	33.7	41.2	4.5	18.7	5.5	21.2	3.6	19.9
India	38.7	30.3	29.2	33.9	32.1	35.8	1.5	2.5	1.5	3.1	1.0	2.2
Russia	31.9	23.8	36.6	50.0	31.5	26.2	1.0	1.9	1.5	4.4	0.8	1.6
<i>BRIC</i>	36.8	29.5	29.8	31.8	33.4	38.8	10.2	26.9	10.8	31.9	7.6	26.4
Germany	25.1	17.1	23.8	25.1	51.1	57.8	7.2	3.8	9.0	6.1	12.0	9.6
France	30.7	27.6	25.4	31.1	43.9	41.3	3.5	2.3	3.8	2.8	4.1	2.5
Great Britain	35.5	35.8	22.1	22.7	42.4	41.6	4.3	2.7	3.5	1.9	4.2	2.4
Italy	37.8	34.6	28.4	28.1	33.8	37.3	4.8	3.4	4.7	3.0	3.5	2.7
Japan	28.2	26.9	28.3	30.2	43.5	42.9	17.1	7.8	22.5	9.7	21.6	9.3
USA	32.5	27.9	22.4	25.3	45.2	46.8	13.8	13.8	17.4	13.8	22.0	17.3

Source: WIOD, author's calculations

For the BRIC countries – with the exception of Russia - there is an overall tendency of an increase in the shares of medium-high and high tech industries which is particularly strong in China where the share increased from 33.7 to 41.2%; these numbers are therefore similar with the shares of the other advanced economies (with the exception of Germany). In all BRIC countries the shares of the low-tech industries declined which are now in the range of 29% in China to 36.6% in Russia. It is interesting to note that these shares are similar to the ones found for Great Britain (35.8%) and Italy (34.6%).

Though there are also wide differences of the actual activities of the production process within these broad aggregates it is important to see this tendency of specialisation dynamics towards higher tech industries of the emerging economies together with the overall rise of their importance in global manufacturing with only a few countries like Germany being able to compete in this respect.

### 3. Manufacturing and the international fragmentation of production

These overall trends are partly driven by the growing importance of the global fragmentation of production processes which are dominant in the low tech and medium-high and high-tech industries. Recently, the advent of global input-output tables allows one to study the particular role of countries in the world production system in a more detailed way, giving emphasis on the role of global value chains and international production linkages. Two indicators highlighting the role of increasing internationalisation: First, a country might increasingly use inputs from other countries in the production of its final products or exports, a process often referred to as ‘offshoring’. Second, a country might be increasingly able to sell its products (either final goods or intermediates which are then further used for production purposes) in other countries. Whereas the first aspect is often discussed in the advanced countries as a threat to domestic income and jobs which might go abroad, it might also serve as a driver of competitiveness as it allows firms and industries to be more cost efficient and specialise in production stages for which there are comparative advantages.

#### 3.1 Using global input-output tables to assess global integration patterns

These two indicators are derived from the WIOD database which provides a set of world input-output tables covering 41 countries and 35 industries over the period 1995-2011 (see Dietzenbacher et al., 2013). The basic insight of Leontief, that gross output equals intermediate demand plus final demand is extended to the world level: formally,  $x = Ax + f$  where  $x$  denotes an  $NC \times 1$  ( $N$  being the number of industries and  $C$  being the number of countries) vector of gross output by industry,  $A$  is an  $NC \times NC$  matrix providing the inputs per unit of output for each industry from other industries in the domestic and foreign countries, and  $f$  is an  $NC \times 1$  vector of final demand consisting of household and government consumption and gross fixed capital formation. A simple manipulation,  $x = (I - A)^{-1}f = I + A + A^2 + A^3 \dots = Lf$  accounts for the fact that production uses direct and indirect inputs from its own industry and other industries. Using additional information concerning the value added per unit of output created (or paid to primary factors like labour and capital) in each industry and country allows one to calculate the above mentioned indicators: First, how much of foreign value added is directly and indirectly embodied in a countries production (“vertical specialisation”, see Section 3.2), and second, how much value added is created in a particular country due to final demand in the other countries (“value added exports”, see Section 3.3); for technical details see the Appendix.

Such world input-output tables and calculations allow one to analyse the magnitudes and trends of the increasing global integration both in production and export opportunities. Such an approach is however not without caveats. First, such an analysis is based on a National Accounting principle which focuses on the location of value added creation or production but not on the ownership of the factors of production, i.e. a domestic rather than national approach. As such, if a US firm produces in China this accrues to value added created in China. This is less problematic in cases of wage

income which is paid to Chinese workers but more so for profit income which might not rest in China but be transferred to other countries.<sup>4</sup> A second concern is that such a framework does not directly allow for assessing the role of technical change with respect to inter-industry relations without more detailed information. However, one should keep in mind that, first; the WIOD was built on a time series of data thus implicitly having taken account of technical changes in several respects. Second, the international transactions or coefficients matrix is also driven by changes in trade relations (e.g. increasing imports of intermediates) which are also taken into account in the time series.

### 3.2 International fragmentation of production: The increase in vertical specialisation

A first aspect is the role of other countries - and the BRICs in particular – which are increasingly serving as deliverers of inputs into a country's production system for either exports or, more generally, final goods production. This increasing international fragmentation of production (referred to as the 'second unbundling' by Baldwin, 2011) has two aspects: First, it allows countries to source more intermediates from other countries which should enable domestic firms to produce more (cost) efficiently or – from a country perspective – to specialise in production stages for which it has a comparative advantage. The main example is that advanced countries offshore low-tech/low-skill intensive assembly of final products but keep the higher tech manufacturing of sophisticated parts and components or even more service activities like R&D, product developments, design and marketing, etc. Second, however; these offshoring activities could be seen as moving production and jobs to other countries thus implying a loss in activity level and employment, particularly for manufacturing activities. The latter aspect might be interpreted as form of labour-saving technical change and thus might harm a country and its manufacturing sector whereas, the former aspect might allow firms to exploit cost advantages which allow them to better compete in global markets, perhaps outstripping the negative effects of the former.

To analyse the magnitudes and trends of this phenomenon a measure of vertical specialisation used. This vertical specialisation measure is computed following Hummels et al. (2001) but on a value added basis also allowing a differentiation into respective partner countries (Foster and Stehrer, 2013). This measure starts from considering a country's final goods (or total exports) production. In a world with internationally fragmented production the value of the final output does not only embody value added – or income – generated domestically, but also value added generated in foreign countries which enter the production of the final product in form of intermediates. An example for this is the production of a car or electronic product which is assembled (and maybe exported) in a particular country which however uses – and

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<sup>4</sup> As the fragmentation of global value changes is driven by multinational corporations, the ownership of factors can play an important role. If for example the share in global manufacturing value added of a country increases because a firm from another country starts operating there, then it would be more accurate to impute the profits of this firm as valued added from country B (the home country, instead of the country of residence). Data on such transfers are however not available in this amount of detail. Potentially useful information on the role of foreign ownership is available from FDI statistics (e.g. UNCTAD, 2012, for the latest release). A recent overview is provided in Hunya (2012) and with a focus on the BRIC countries in Hunya and Stöllinger (2009).

therefore previously imported – dozens of intermediates of which production generated income in the other countries. Then only the assembly activities of the specific product create GDP in this country though the value of the produced goods also contains the intermediates sourced from abroad.

Table 3.1 shows the magnitude of the foreign value added in a country's final output and exports respectively for the countries considered over the period 1995-2011. The upper part of the table presents the share of foreign value added in a country's total final output and its exports whereas the second part provides this information for the manufacturing industries and exports only. Let us highlight a few important facts: First, there is a generally increasing trend of higher quantities of foreign value added shares observable in all countries with the exception of Russia at least up to 2007. This exception is driven by its exports bias towards raw materials. Second, levels as well as changes over time differ across these countries to a large extent. Considering total final goods production the foreign value added shares in 2011 range from around 8% in Brazil, Russia, Japan and the US with much larger shares observed for China (15.3%), India (11.9%), and the four big European countries with about 14-15% (France has 12.5%). Thus, though larger countries tend to have lower shares of foreign value added in their final output production there are exceptions like China and India. Further, European integration seems to be important for the European economies explaining part of the larger shares for the European countries. In this respect the dynamics over time also differs: Whereas the shares have been significantly increasing in most countries (with the exception of Russia as already mentioned above), there are some differences in dynamics amongst the advanced countries. Whereas in Germany the share increased from 9.3% to 15.7% it was much less dynamic in Great Britain with an increase from 12.2% to 14% in 2011 and France (from 9.8% to 12.5%).

When considering the foreign content in total exports the shares are in all cases higher as exports in all countries mainly consist of manufactured goods. The differences in magnitudes across countries are in line with the shares observed for final goods production. However, the dynamics seem to be different. For example, the foreign content of Germany's exports increased from 17.1% to 27.3%, i.e. by 10 percentage points as compared to 6 percentage points when considering total final goods production. This was similarly strong for other European economies and also for Japan and the US (though in this case the increase was less pronounced). However, for Great Britain the change over time was rather minor: the foreign value added content of exports increased only from 19.3 to 21.6%, i.e. by slightly above 2 percentage points and thus is now lower as for the other countries.

**Table 3.1 – Vertical specialisation, 1995-2011**

	Total economy									
	Final goods production					Exports				
	1995	2000	2007	2009	2011	1995	2000	2007	2009	2011
Brazil	4.9	7.2	7.3	6.6	7.7	7.9	12.0	11.9	10.2	11.9
China	11.5	12.1	16.9	13.2	15.3	15.8	17.3	24.7	19.3	21.8
India	7.7	9.7	14.1	12.0	11.9	10.5	14.6	21.1	23.3	21.7
Russia	7.6	10.0	8.0	6.1	7.8	7.4	10.1	6.9	5.3	6.2
Germany	9.3	12.7	15.2	13.2	15.7	17.1	22.2	26.7	23.8	27.3
France	9.8	12.0	12.1	10.6	12.5	19.5	24.4	26.7	24.3	28.5
Great Britain	12.2	11.9	12.3	12.7	14.0	19.3	18.9	18.1	18.7	21.6
Italy	11.2	12.7	14.3	12.2	14.9	18.7	20.8	25.1	21.4	27.1
Japan	3.8	4.6	8.2	6.3	8.1	6.3	8.5	15.4	13.4	17.0
USA	5.2	5.8	7.4	6.1	7.9	9.6	10.6	13.3	11.4	14.9
	Manufacturing industries									
	Final goods production					Exports				
	1995	2000	2007	2009	2011	1995	2000	2007	2009	2011
Brazil	9.3	13.8	13.6	12.3	14.6	9.0	14.1	13.9	12.0	14.1
China	14.9	16.2	23.0	18.0	20.6	17.5	19.5	26.8	20.9	23.5
India	12.0	15.8	22.7	21.4	21.4	12.2	17.4	27.7	29.3	28.2
Russia	13.2	16.8	14.6	11.3	14.3	12.0	15.4	10.3	8.1	8.7
Germany	17.8	23.3	28.1	26.2	29.3	18.3	23.9	29.0	26.3	29.8
France	21.4	26.1	28.8	27.0	32.0	22.1	27.2	29.8	27.4	32.5
Great Britain	21.5	21.5	23.7	24.5	27.9	23.0	23.9	25.9	26.8	30.8
Italy	20.0	22.7	26.6	23.3	28.9	20.6	22.9	27.8	23.8	30.1
Japan	6.6	8.8	16.9	14.3	17.6	6.7	9.0	16.9	15.0	18.9
USA	12.6	13.8	18.4	15.9	19.9	13.1	14.2	18.1	15.7	20.2

Source: WIOD; author's calculations

When considering total final production and exports in manufacturing industries, only the foreign contents are again higher because for manufacturing production, trade in intermediates is more important. Furthermore, the respective changes over time are even more pronounced with increases of about 10-12 percentage points in the European countries and Japan, and 6.5 to 7 percentage points in Great Britain and the USA, respectively. A similar though slightly less pronounced dynamic can be seen for the BRICs with the exception of Russia. For Great Britain this difference between the foreign value added content when comparing the shares for total production and exports to those for manufacturing only highlights the increasing importance of services in the UK economy which tend to increase more than compared to other countries like Germany. Even more nuanced, the remaining industries in the UK internationally fragmented their production process similar to other countries like Germany, though the manufacturing industries in the UK lost importance. At this stage it can only be speculated whether internationalisation of production in Germany on the one hand was conducive to the manufacturing sector in the country and more harmful in other countries or whether there are other more important reasons explaining the differences in manufacturing performance.

One of these aspects might be that international fragmentation of production might have been more pronounced in particular industries and thus one country might have gained advantages due to initial specialisation patterns. Table 3.2 provides the foreign value



added content of final goods production in the three broad manufacturing sectors. Indeed, though the foreign value added shares tended to increase relatively stronger in the medium-high and high tech industries, the foreign value added content increased particularly strong in the case of Germany (from 18.4 to 30.7%) and France (from 24.5 to 34.3%). In the case of Germany it was clearly the advantage of being located close to the emerging Eastern European economies and engaging in production fragmentation with these countries.

**Table 3.2 – Vertical specialisation in final goods production by broad manufacturing industry, 1995-2011**

	Total		Low tech		Medium-low tech		Medium-high and high tech	
	1995	2011	1995	2011	1995	2011	1995	2011
Brazil	9.3	14.6	6.7	9.5	15.3	19.3	11.1	18.3
China	14.9	20.6	13.0	12.6	14.7	26.0	17.9	25.3
India	12.0	21.4	9.8	21.5	17.2	25.5	14.0	19.6
Russia	13.2	14.3	12.7	10.7	10.5	6.9	14.7	22.2
Germany	17.8	29.3	15.7	25.5	21.3	29.4	18.4	30.7
France	21.4	32.0	15.7	20.5	27.1	49.2	24.5	34.3
Great Britain	21.5	27.9	17.7	18.3	21.4	38.8	24.9	31.8
Italy	20.0	28.9	16.8	21.4	27.3	53.1	22.1	28.5
Japan	6.6	17.6	5.8	11.4	11.8	38.3	6.2	16.1
USA	12.6	19.9	9.4	13.3	19.6	38.0	14.1	19.6

Source: WIOD; author's calculations

A similar dynamic can be observed for some countries in the medium-low tech industries. Here the foreign content increased particularly for France (27.1 to 49.2%), Great Britain (21.4 to 38.8) and Italy (27.3 to 53.1%) and similar magnitudes for Japan and the US. Interestingly the foreign content in Germany for these industries increased much less from 21.3% to 29.4%. However, in the low-tech industries the foreign value added share increased relatively strongly for Germany as compared to other countries. Similar patterns of increasing foreign value added contents are observed for the BRICs with again a differentiated pattern across countries. For example, in China the foreign shares increased in the medium-high and high tech industries by about 7 percentage points and even stronger in the medium-tech industries by about 15 percentage points. However, in the low tech industries these even declined slightly from 13 to 12.6%. This pattern is completely different from those of India which faced stronger increases in the foreign content in the latter industry group though slightly less significant changes in the other two. Russia shows particularly strong increases in the medium-high and high-tech industries. Finally, Brazil also experienced strongest increases in this category of industries.

**Table 3.3 – Foreign content of final goods production by partner in % of total value added in manufacturing final goods production, 1995 and 2011**

1995										
Partner	Brazil	China	India	Russia	Germany	France	Great Britain	Italy	Japan	USA
Brazil		0.9	0.9	1.8	1.5	1.3	0.9	1.4	1.8	1.8
China	1.7		3.0	2.0	1.4	1.0	1.7	1.5	5.9	2.8
India	0.4	0.6		1.1	0.6	0.3	0.8	1.0	1.7	1.0
Russia	0.9	1.6	3.3		4.9	3.6	1.3	5.4	1.7	1.1
	3.0	3.1	7.3	4.9	8.4	6.2	4.7	9.3	11.1	6.7
Germany	11.2	4.5	9.5	13.9		20.2	17.3	17.4	4.3	6.5
France	4.3	2.0	3.1	3.5	10.2		9.0	12.1	2.2	4.5
Great Britain	2.6	3.0	4.3	3.3	7.2	7.3		6.0	2.7	5.5
Italy	4.2	2.5	3.3	5.6	7.6	8.4	5.4		1.6	2.8
Japan	6.1	21.1	10.0	4.3	4.9	3.8	6.1	2.8		15.2
USA	18.5	12.4	8.8	7.3	9.4	10.9	12.4	8.3	22.0	
	46.9	45.6	38.9	38.0	39.3	50.6	50.1	46.6	32.7	34.5
Other EU-27	10.2	5.5	10.9	23.4	32.1	25.2	24.5	22.0	5.5	8.5
Rest of world	39.9	45.9	42.9	33.7	20.2	18.0	20.6	22.1	50.7	50.3
2011										
Partner	Brazil	China	India	Russia	Germany	France	Great Britain	Italy	Japan	USA
Brazil		2.8	1.0	2.5	2.9	2.0	1.2	1.9	1.6	2.4
China	11.4		17.6	11.9	8.9	6.0	7.3	6.8	13.6	12.0
India	1.4	1.3		0.8	1.6	1.1	1.9	1.2	1.0	2.0
Russia	2.6	3.6	1.8		3.5	7.1	3.7	13.5	4.2	2.8
	15.3	7.8	20.4	15.1	16.9	16.2	14.1	23.4	20.3	19.2
Germany	7.2	5.8	3.8	13.5		16.5	12.8	11.4	2.5	4.6
France	3.6	1.7	1.2	3.4	6.7		5.3	6.0	1.1	1.8
Great Britain	2.2	1.6	2.2	3.3	5.4	5.3		3.2	1.2	3.2
Italy	2.7	1.7	1.5	3.9	5.7	5.8	3.9		0.7	1.5
Japan	4.1	10.3	3.0	8.2	3.1	2.2	3.1	1.4		5.1
USA	14.7	11.5	10.0	5.3	7.4	7.9	11.4	5.0	9.4	
	34.5	32.6	21.5	37.6	28.3	37.7	36.4	27.1	14.9	16.2
Other EU-27	8.5	6.0	5.4	18.4	30.3	21.5	21.9	18.5	3.2	7.0
Rest of world	41.7	53.6	52.7	28.9	24.4	24.5	27.6	30.9	61.6	57.6

Source: WIOD; author's calculations

Tables 3.1 and 3.2 above indicated that the share of foreign value added in a country's production has increased over time which is a more or less consistent pattern across countries. Table 3.3 informs about the geographic structure of foreign sourcing. Whereas in 1995 the BRICs accounted for between almost 5% in Great Britain and 11% (Japan) of foreign value added in the advanced countries' final goods production these shares have increased to levels between 14% (Great Britain) and more than 23% (Italy) in 2011. It is important to note here that this increase of the BRIC countries in terms of vertical specialisation is mostly driven by China and to a lesser extent by Russia (though this is also driven by raw material exports). Correspondingly, the shares of other advanced countries in delivering inputs for production purposes has dropped in value added terms. Whereas in 1995 Great Britain sourced more than

50% from the advanced countries singled out in Table 3.3 this share has declined to about 36% in 2011. Also the shares from the other EU-27 countries have declined for the set of advanced economies whereas the shares of other countries (rest of world) have generally increased. Conversely, the shares of foreign sourcing from BRICs to BRICs have increased over this period. Whereas the shares from BRICs ranged from 3% (Brazil) to 7% in India in 1995 these increased to levels of 15 to 20% in 2011 for all countries with the exception of China which still sources only less than 8% from other BRICs. The shares of sourcing from the advanced countries and the other EU-27 countries have declined for all BRIC countries over the same period.

### 3.3 Value added exports

Given the increasingly international fragmentation of production it is less and less useful to consider a country's exports in gross terms as these contain increasingly larger shares of foreign value added embodied in these exports. Alternatively, one therefore can calculate the value added a country contributes to satisfy final demand in other countries. For example, if the US demands (imports) a final product assembled in Mexico, this product also contains inputs which created value added in, for example, Great Britain and therefore should be accounted as exports in value added terms of the latter country. It is also important to note that, first, this concept includes also value added created in, for example, services industries, and second, would also take account of service demand from the US in Mexico. Using global input-output data (WIOD) this allows one to study, for example, not only direct exports of a country like Great Britain to other countries but also value added created in the UK which is indirectly (i.e. via third countries like the US or EU member states) sent to the final consumers in the BRICs, for example. Methodologically this exercise will use the indicator of 'value added exports' as developed in Johnson and Noguera (2012) (see also Koopman et al., 2010, and Stehrer, 2012). In this literature the value added created in an economy but absorbed in other economies are related to a country's gross exports. Here we present the shares in per cent of GDP of the respective country in Table 3.4 for, first, the total economy, i.e. the whole of value added created in a country due to consumption in other countries, and second, value added created in the manufacturing sectors of the respective economy.

**Table 3.4 – Value added exports in % of GDP and manufacturing value added exports in % of manufacturing GDP, 1995-2011**

	Total economy					Manufacturing				
	1995	2000	2007	2009	2011	1995	2000	2007	2009	2011
Brazil	7.1	9.3	12.5	10.4	11.5	15.9	21.3	24.9	19.8	22.3
China	19.1	18.9	27.7	20.8	21.3	28.5	29.4	42.2	32.7	33.7
India	10.2	12.1	16.1	13.1	14.0	19.1	25.6	27.4	26.5	27.5
Russia	23.3	36.4	25.5	23.7	26.5	27.9	42.1	28.2	28.0	29.7
Germany	19.2	25.3	33.2	29.3	31.9	47.1	57.4	70.6	69.7	70.0
France	17.9	20.5	18.5	16.5	18.0	49.7	54.4	56.8	52.6	57.2
Great Britain	21.7	21.2	20.8	21.6	23.1	48.6	48.9	51.3	57.4	59.0
Italy	19.7	20.3	21.0	18.0	20.4	44.0	45.9	50.0	47.8	53.3
Japan	8.5	9.9	14.8	11.0	12.4	21.4	25.5	37.4	31.5	34.1
USA	8.5	7.7	8.5	8.2	9.6	20.6	20.5	24.5	26.3	29.1

Source: WIOD; author's calculations

In 2011, in Germany 31.9% of its value added was created and finally absorbed in other countries basically due its superior export performance. This ratio is much higher as compared to other European countries with Great Britain having a ratio of 23.1%, Italy 20.4% and France 18%. Whereas in Germany these shares have increased quite tremendously from 19.2% in 1995 there are almost no or only slight changes in the other European countries considered here. This is similar to the experience of the US for which this ratio increased from 8.5 in 1995 to 9.6% in 2011 as compared to Japan for which this ratio increased to 12.4% starting from the same level. The flipside of this is of course the large arising trade deficit of the US and the surplus in Germany. These value added exports in per cent of GDP also increased for the BRICs between 2 and 4 percentage points. Whereas China and Russia nowadays show ratios above 20% these are much lower for Brazil (11.5%) and India (14%). Thus the latter countries are less dependent on international demand as is China which also explains the severe decline from 27.7% to 21.3% between 2007 and 2011 due to the sluggish demand in the advanced countries.

The second part of the table reports the value added created in manufacturing industries which is absorbed in other countries. These ratios are in all cases higher as manufacturing goods are more tradable. In the European economies these ratios are well above 50% in 2011 with a particular high ratio observed for Germany. These much higher ratios stem from the fact that in these figures intra- EU trade is included. The corresponding shares for the BRICs are around 30% in 2011 and therefore in a similar range as for Japan and the US. In all cases the ratios have increased partly strongly over the period considered. Table 3.5 reports these ratios for the three broad categories of manufacturing industries. Similar to the general trend, these have increased in all countries for all manufacturing industries (with a few exceptions only like Russia) with a tendency that increases have been more pronounced in the medium-high and high-tech industries.

**Table 3.5 – Value added exports in % of sectoral GDP, 1995-2011**

	Total		Low tech		Medium-low tech		Medium-high and high tech	
	1995	2011	1995	2011	1995	2011	1995	2011
Brazil	15.9	22.3	14.0	21.3	21.2	26.1	14.5	20.4
China	28.5	33.7	33.3	32.8	23.9	28.2	27.9	38.3
India	19.1	27.5	23.1	31.3	18.6	21.4	14.5	30.1
Russia	27.9	29.7	11.6	11.0	39.9	39.7	30.5	27.7
Germany	47.1	70.0	28.3	55.1	43.7	67.0	57.9	75.7
France	49.7	57.2	37.6	44.1	47.1	49.2	59.6	71.9
Great Britain	48.6	59.0	29.3	36.6	46.5	57.4	66.0	79.1
Italy	44.0	53.3	36.1	40.5	45.3	55.4	51.9	63.5
Japan	21.4	34.1	6.0	8.9	19.8	36.5	32.5	48.2
USA	20.6	29.1	13.2	16.4	19.6	27.4	26.4	37.6

Source: WIOD; author's calculations

Table 3.6 indicates the geographic structure of the value added exports for the total economy, as reported in Table 3.4. (Similar results are found when considering manufacturing value added exports only). The most striking trends from this table are that, first, the share of value added exports from BRICs to other BRICS and from the advanced countries to BRICS increased over time, and second, the role of the advanced countries as absorbers of value added from BRICs and the other advanced countries declined. In 1995 less than 5% of BRICs value added exports have been absorbed in other BRICs whereas in 2011 these shares ranged from 10% for China to

almost 15% in case of Brazil. For the advanced economies, the share of BRICs in their value added exports increased from values of less than 4% (France) to slightly less than 8% (Japan) in 1995 to shares well beyond 20% as in the case of Japan and up to 15% in Germany and the US. Great Britain, France, and to a less extent Italy, are lagging behind somewhat as the share of value added exports to BRICs is only about 10% in 2011 (13.8% in Italy).

The main target of value added exports of BRICs in 1995 have been the advanced countries which accounted for about 70% of their value added exports when also adding the other EU-27 countries. Similarly high shares are found for the advanced countries. Particularly, for the EU countries selected in this study about 70% of value added exports have been to other advanced countries. In both cases the shares declined dramatically: For the BRICs these shares declined to about 55% and even less (45% in case of Brazil) and similarly to slightly above 50% in case of the European countries considered. For Japan and the US the value added export shares to the other advanced countries selected together with the remaining EU-27 countries account only for about 30% in 2011 from 42% in 1995 in the case of Japan and 36% in the case of the US.

**Table 3.6 – Value added exports by partner in % total value added exports, 1995-2011**

	Total	1995											
		Brazil	China	India	Russia	Germany	France	Great Britain	Italy	Japan	USA	Other EU-27	Rest of world
Brazil	100.0		1.6	0.7	0.9	10.7	4.0	3.5	4.4	7.7	18.8	11.3	36.4
China	100.0	0.7		1.0	1.2	6.6	2.7	3.9	2.4	18.6	26.3	7.4	29.3
India	100.0	0.5	1.5		1.9	9.4	3.1	5.9	6.2	14.6	22.3	9.5	25.3
Russia	100.0	0.6	2.3	1.3		18.4	7.3	2.5	8.6	5.2	6.2	24.7	22.7
Germany	100.0	1.7	1.7	0.9	1.9		9.0	8.0	7.1	3.7	10.4	27.6	28.0
France	100.0	1.0	1.5	0.5	0.9	14.4		7.8	8.3	4.0	12.2	20.9	28.5
Great Britain	100.0	0.6	1.8	0.8	1.1	11.6	7.7		5.0	4.4	17.3	21.0	28.7
Italy	100.0	1.6	1.9	0.8	1.8	15.3	10.2	5.9		4.1	11.8	19.5	27.2
Japan	100.0	0.8	5.7	1.0	0.5	5.2	2.1	3.2	1.3		24.9	5.4	49.9
USA	100.0	1.8	2.3	0.6	0.8	5.5	4.3	4.5	2.5	10.7		8.5	58.4

	Total	2011											
		Brazil	China	India	Russia	Germany	France	Great Britain	Italy	Japan	USA	Other EU-27	Rest of world
Brazil	100.0		11.7	1.0	1.9	7.2	3.0	2.7	2.9	3.6	13.5	12.0	40.4
China	100.0	2.0		3.7	3.4	5.5	2.9	3.1	2.2	8.6	22.0	7.9	38.8
India	100.0	1.4	7.1		1.7	5.8	2.9	5.6	2.3	3.4	24.2	11.5	34.2
Russia	100.0	1.2	10.2	1.1		5.0	5.5	3.2	8.9	5.3	9.9	17.7	32.0
Germany	100.0	2.0	8.5	1.1	3.3		7.2	5.8	5.3	2.1	10.2	23.2	31.4
France	100.0	2.2	6.4	0.8	2.2	10.7		6.3	6.3	2.3	9.8	20.3	32.8
Great Britain	100.0	1.6	5.1	1.4	1.7	9.9	5.5		3.5	2.1	14.8	19.7	34.6
Italy	100.0	2.2	6.4	1.2	4.0	9.9	8.3	4.7		2.3	9.5	18.9	32.8
Japan	100.0	1.3	18.2	1.3	2.8	3.6	1.8	2.0	1.1		16.0	4.6	47.4
USA	100.0	2.5	10.3	2.2	1.1	4.8	3.0	5.3	1.9	5.1		10.7	53.0

Source: WIOD; author's calculations

## 4. Future trends in global manufacturing patterns

### 4.1 A summary of the previous findings

When considering these global developments, a vital concern is not only to detect and analyse past trends, though this will be informative, but also to assess what the future developments, in the medium and long-term, might be. This is fuelled by the discussion concerning the trend of overall declining shares of manufacturing in the advanced economies and the rising importance of the emerging economies which play an increasingly important role in providing manufacturing goods (as shown in Section 4). The most important trends and facts identified in the previous section in this respect are summarised as follows:

First, the share of manufacturing in the total world economy was on a declining trend since the 1990s and nowadays makes about 18% of world GDP (from a share of about 20% in 1995). Such declining trends in the shares of manufacturing in the country's GDP are observed for most individual countries with some notable exceptions like Germany.

Second, the share of manufacturing in GDP ranges widely across countries. The emerging economies like the BRICs tend to have larger shares. These patterns are roughly in line with development theories that suggest emerging economies build up a strong manufacturing base. China is an outlier with a rather large manufacturing share of more than 30%, whereas other BRICs show more 'balanced' development patterns. It is interesting to note that despite the rising weight of these emerging economies in the world economy and the relatively larger role manufacturing plays in these countries, that the total manufacturing share of the world economy has still been in decline.

Third, the BRIC countries in 2011 produced slightly less than one third of manufacturing GDP as compared to 15% (USA), 9% (Japan) and 15% (the four big EU countries, i.e. Germany, France, Great Britain and Italy). Over the period considered there has been a major shift towards the BRIC countries (from about 10% in 1995 to 28% in 2011).

Fourth, within manufacturing one observes for the emerging countries traditional patterns of specialisation together with a 'climbing up the ladder' development path. However, in a dynamic perspective the BRICs are also gaining shares in medium-high and high tech industries over time.

Fifth, concerning the increasing international fragmentation of production, there is an indication that BRICs are increasingly taking on the role of providing all manufacturing products and inputs rather than remaining mainly assemblers. This can be seen as a trend that these countries are taking over more and more manufacturing production stages within themselves.

Sixth, as the BRICS are gaining weight in the world economy they are also becoming more important for value added exports both amongst themselves but also for the

advanced countries. However, the majority of the advanced countries value added exports are still to other advanced countries. This is particularly the case for the European economies due to the strong internal integration.

## 4.2 Prospective future trends based on a demand driven Leontief model

### 4.2.1 Scenario approach and assumptions

What are the implications of these trends for the future with respect to global manufacturing and manufacturing in the countries considered? In this section we provide some reflections based on the trends reported above underpinned by some simple input-output modelling and scenarios. The well-known Leontief model starts from the fact that gross output equals the Leontief inverse times the final demand vector,

$$\mathbf{x}_t = \mathbf{A}_t \mathbf{x}_t + \mathbf{f}_t = (\mathbf{I} - \mathbf{A}_t)^{-1} \mathbf{f}_t = \mathbf{L}_t \mathbf{f}_t \quad (4.1)$$

In a global input-output model the gross output  $\mathbf{x}_t$  and final demand vectors  $\mathbf{f}_t$  are of dimension  $NC \times 1$  where  $N$  denotes the number of countries and  $C$  is the number of countries. The coefficient matrix, i.e. the matrix  $\mathbf{A}_t$  providing the inputs by country and industry per unit of output, is of dimension  $NC \times NC$  as the Leontief inverse  $\mathbf{L}_t$ . This can be pre-multiplied with a vector of value added coefficients, i.e. value added per unit of gross output which translates the model to show the value added created in each industry and country due to final demand,  $\hat{\mathbf{v}}_t \mathbf{x}_t = \mathbf{w}_t = \hat{\mathbf{v}}_t \mathbf{L}_t \mathbf{f}_t$ , where  $\mathbf{v}_t$  denotes the value added coefficient vector of dimension  $1 \times NC$ ,  $\mathbf{w}_t$  denotes a  $NC \times 1$  vector of (primary factor) income, and " $\hat{\phantom{x}}$ " indicates the diagonalization of a vector. Starting from such a simple Leontief input-output model and expressed in value added terms, Stehrer (2013b) shows that the most important determinants of value added growth is growth in domestic final demand (on domestic products) and changes in value added exports (the latter contributed to about 20% of the overall growth rate in the world). Changes in the value added coefficients and the global Leontief inverse play a minor role. In fact, the effects are relatively minor due to the fact that  $\mathbf{v}' = \mathbf{1}'(\mathbf{A}-\mathbf{A})^5$ . Furthermore, the levels of changes in final demand and value added exports are much more important than changes in the structures of these. These results suggest that most of the dynamics concerning the overall shares as summarised in section 4.1 are driven by differential growth rates across countries and changing demand patterns. To be more precise, behind the growth rate of final demand are other developments of which the most prominent are: population growth which under full employment assumption feeds into higher growth of final demand, labour productivity growth and technical change leading to higher real wages, and capital accumulation which is also included in final demand. According to the growth literature capital accumulation is larger for countries lagging

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<sup>5</sup> This effect of a change in the global Leontief inverse is significant only for China and the EU-12 where this component contributes about 10% of growth. A negative impact of these changes arises only for Japan and the US. Changes in the value added coefficients impact negatively on growth in all cases. Together, the effect of changes in the Leontief inverse and the value added coefficients account for about 5% on average in absolute terms of the growth rates achieved. It should be noted here that this does not contradict the findings concerning the increasing vertical specialisation as discussed in Section 4.2 as one has to take into account that all countries become mutually more dependent on each other.

behind which is one reason for these countries to experience higher growth rates. A country's final demand might also grow driven by foreign borrowing and capital inflows.

In this approach a shortcut is taken and the strategy is to assess the impacts of the developments of a country's demand levels and patterns. In doing so the above equation is rewritten in the form

$$\mathbf{w}_t = \hat{\mathbf{v}}_t \mathbf{L}_t \mathbf{F}_t \mathbf{1} \quad (4.2)$$

where  $\mathbf{F}_t = (\mathbf{f}_t^1, \dots, \mathbf{f}_t^C)$  denotes a  $NC \times C$  matrix of final demand and  $\mathbf{1}$  is a  $C \times 1$  summation vector and. Extrapolating final demand into the future allows one to calculate the implied change in income by industry and country, i.e.

$$\mathbf{w}_t = \hat{\mathbf{v}}_0 \mathbf{L}_0 \mathbf{F}_t \mathbf{1} \quad (4.3)$$

Thus changes in the levels and structures of incomes, i.e.  $\mathbf{w}_t$ , are then determined, first, by differential growth rates across countries e.g. a faster growing China impacts on European countries in the way that levels of exports are increasing directly and indirectly (via production fragmentation are increasing) and due to different consumption patterns of China, also the structure of these exports and via inter-industry linkages the structure of production changes. These impacts however differ across countries due to the fact that trade linkages across countries differ. If technical change is faster in the less advanced countries leading to higher real income growth and therefore convergence of income levels it might also be expected that demand patterns change in these countries because of Engel curve effects.

These are the most important drivers of change in the simulations reported below. Before presenting the results let us summarize a few caveats: First, this approach takes a shortcut in modelling final demand and does not start from modelling underlying factors like demographic change and technical changes. In doing so no attempt is undertaken to translate such changes into relative wage and price movements which would give rise to changes in demand and comparative advantages which would require to explicitly model demand systems (for both capital, consumption and intermediates) together with labour markets and wage effects of technical and demographic change, and international macro variables like exchange rate movements and effects of international capital flows. Given the challenge to simulate long term trends thus the approach that these important impacts feed into differential growth rates of final demand and to model the effects of these on global structures in a more direct way might be justified, or are at least interesting to study.<sup>6</sup> Of course, such an approach rules out to explicitly modelling country-specificities which are difficult to predict in the long run and by this for example, rules out 'growth spurts' and discontinuous changes driven by unforeseen technical developments.<sup>7</sup>

Going back to the model, in a first step one might assume that final demand in each country is growing at past rates (e.g. the mean growth rates over the period 1995-2011).<sup>8</sup> This assumes that expenditure structures across industries and

<sup>6</sup> More precisely, the underlying assumption is that in the long-run equilibrating forces are at work – though at different speeds – driving countries towards full employment and sustainable external positions.

<sup>7</sup> Financial turmoils might be another factor affecting countries current performance.

<sup>8</sup> These overall final demand growth rates are closely related to the growth rates of GDP; in fact, if the trade



countries remain constant. Changes in the relative shares of countries in world GDP and the importance of manufacturing are only driven by the differentiated growth dynamics across countries. This seems to be rather unlikely as most catching-up countries experienced a slow-down of their growth rates after some convergence in income levels.<sup>9</sup> Therefore, in a second step we assume that growth rates converge over time to a pre-defined mean growth. The mean growth rate over the period (at current US-\$) was at about 5% per year (expressed in current US-\$). Such a convergence of growth rates would be in line with the existing growth literature following the concept of beta and sigma-convergence; countries farther away from the technology frontier tend to grow faster due to capital accumulation and easier technology adoption and imitation (see Barro and Sala-i-Martin, 1995; Acemoglu, 2009). But as countries converge, the technology frontier growth rates tend to become more similar. Further, some other important trends - particularly the demographic structures and population growth rates - play a role in determining a countries growth rate. For this exercise we assume a simple convergence process of growth rates model as:

$$g_{FD,t} = g_{FD,t-1} - \beta \ln \left( \frac{g_{FD,t-1}}{\bar{g}_{FD}} \right)$$

The convergence parameter  $\beta$  was set equal to 0.00625; this implies that the growth rates in a country which has a growth rate two (three) times larger as the reference growth rate would decline by about 4.3% (4.6%). As such, this scenario assumes that countries like China tend to grow faster in the first years and converge to mean growth rates over the long run from above. Countries having grown less favourably in the past converge to the overall growth rate from below. This assumes that, for example, European countries escape the recent turmoil and start growing again in the medium run whereas the Chinese growth rates steadily declines from about 15% (in current US-\$) to 7% in 2030 and slightly more than 5% in 2050. As a comparison, Cribbs et al. (2011) also assume that growth rates in China tend to decline to about 5% in 2030. In such a scenario therefore is again solely driven by differential – however converging – growth rates across countries.

The third aspect argued above is the changing demand structures. When countries become richer their demand structures change driven by different income elasticities across industries. In this respect demand structures in the emerging countries converge to the demand structures of the advanced economies. The third scenario therefore assumes that demand structures across industries in all countries gradually converge to the demand structure of the US with the structure of imported versus domestic demand is assumed to remain constant for each product. Specifically, we assume the same rate of convergence in demand structures as for the growth rates. Based on these assumptions, the global Leontief model as formulated in equation (4.1) is modelled for all 41 countries and 35 industries included in the WIOD database where for each country final demand levels and structures change according to the assumptions outlined above. The starting values are those of 2011 and the simulations are run until 2050. Table 4.1 reports the results of this scenario which can be directly compared to the evolution of the manufacturing as reported in Tables 2.1 and 2.2, respectively.

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balances would be unchanged these growth rates would coincide.

<sup>9</sup> Prominent examples are Japan, the East Asian countries and more recently the slowdown of growth in the emerging markets and BRIC countries.

**Table 4.1 – Scenario results**

	Share in world GDP		Share in world manufacturing GDP		Manufacturing share in GDP	
	2015	2050	2015	2050	2015	2050
Brazil	3.3	3.1	3.1	2.6	16.7	14.0
China	13.2	21.1	22.7	29.5	30.7	22.8
India	3.0	3.6	2.6	2.5	15.4	11.3
Russia	2.7	3.2	2.6	2.8	17.3	14.4
Germany	4.6	3.9	6.4	5.7	24.6	23.8
France	3.6	3.0	2.4	2.1	11.7	11.3
Great Britain	3.2	2.7	2.2	2.0	12.3	11.9
Italy	2.9	2.4	2.8	2.3	17.4	15.7
Japan	7.6	6.2	8.2	7.4	19.4	19.7
USA	20.6	17.4	14.7	13.7	12.6	12.9

The most important outcome is that the Chinese share goes up significantly and would reach about 21% of world GDP in 2050 with most of the other emerging economies only slightly gaining in their relative importance. Taking all BRIC countries together their share in world GDP would increase to about 30% in 2050 (as compared to about 19% in 2011 as reported in Table 2.2) in current US-\$ where most of that dynamics is driven by China. The advanced economies are slightly losing between less than half a percentage point (as for Great Britain and Italy) and 3 percentage points as in the case of the US. Similar developments can be observed when considering the share of BRIC contribution to manufacturing GDP which would increase to 37% (from 28% in 2011 as reported in Table 2.2). Here again China play the dominant role.

With respect to the manufacturing share of each country, this simulation results in a further decline in most countries (though slightly increasing in Japan and the US due to stronger trade linkages to emerging countries in Asia). The only more dramatic change is observed for China where this share drops to 22.8% (from 33.4% in 2011 as reported in Table 2.1). At the world level, the manufacturing share would decline to 16.4% from about 18% in 2011 (see Table 2.1). Thus, the simulations suggest a slightly lower rate of decline of the manufacturing sector as compared to the period 1995 -2011 (where a decline of 2 percentage points was observed within less than 20 years).

In that sense, the results are somewhat more conservative as these do not allow for explicit changes of relative prices between manufacturing and services which might imply a further shift away from manufacturing<sup>10</sup>. Second, it is worthwhile to mention that – as discussed above – changes in the global Leontief inverse might direct the demand for intermediates towards emerging countries. Though the effect is rather small it might slightly increase the relative importance of the BRICs (under the assumption that these trends are ongoing). Finally, the assumption that final demand structures converge to that of the US is less innocent and results could partially differ (particularly concerning the share of manufacturing in each economy).<sup>11</sup>

<sup>10</sup> Such relative price changes would affect the shares only when allowing for demand structures different from Cobb-Douglas.

<sup>11</sup> Shares are particularly different concerning the agricultural sector and food sectors on the one hand and the construction and public services sectors on the other. A detailed sensitivity analysis concerning the specific role of these sectors goes beyond the scope of this paper.

## 4.2.2 Robustness check: randomization of growth rates

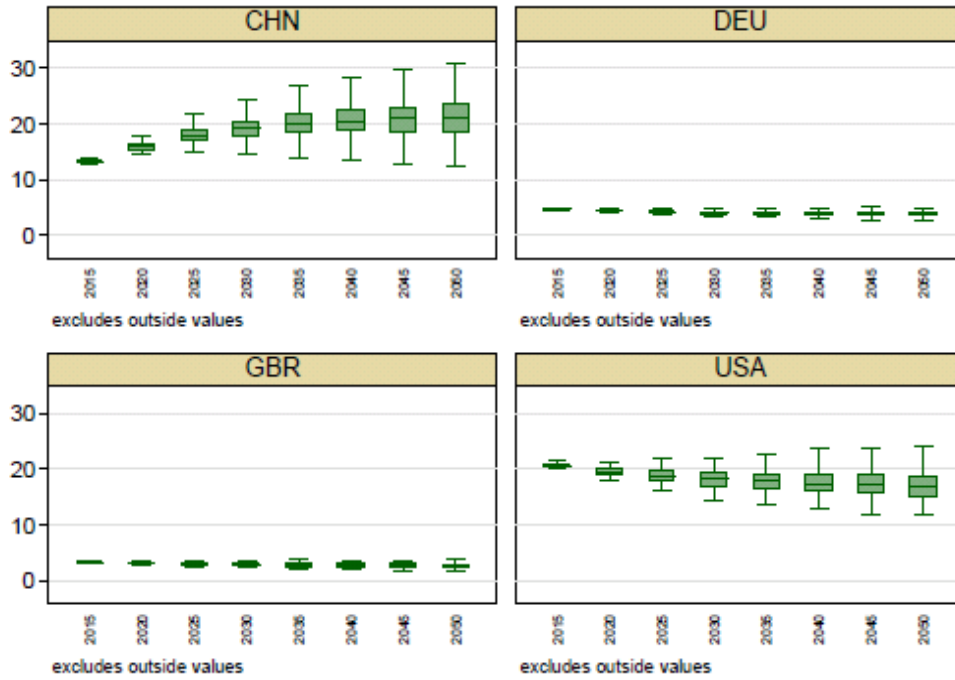
The above scenarios are of course based on a rather strict set of assumptions concerning the evolution of growth rates. Generally, overall growth rates are difficult to grasp as being dependent on demographic structures, rates of technical progress, specialisation structures, etc. and other macro- economic developments like exchange rate movements and differences in inflation rates. These variables are of course difficult to take into account over a long scenario period. In this final section we present some results when allowing the growth rates to be disturbed by a random error. In fact, the results presented here are based on a set of 100 simulations with the growth rate being disturbed by a normally distributed error with mean zero and variance 0.005 in each year. Furthermore, the convergence rate is randomized by a normally distributed variable with mean 0.00625 and variance 0.005 in each simulation.

**Table 4.2 – Scenario results (Means based on 100 simulations)**

	Share in world GDP		Share in world manufacturing GDP		Manufacturing share in GDP	
	2015	2050	2015	2050	2015	2050
Brazil	3.3	3.0	3.1	2.6	16.7	14.1
China	13.2	21.3	22.7	29.6	30.7	22.9
India	3.0	3.6	2.6	2.5	15.4	11.4
Russia	2.7	3.1	2.6	2.7	17.3	14.4
Germany	4.6	3.9	6.4	5.7	24.6	24.1
France	3.6	3.1	2.4	2.1	11.7	11.3
Great Britain	3.2	2.7	2.2	2.0	12.3	12.2
Italy	2.9	2.4	2.8	2.3	17.4	15.9
Japan	7.6	6.4	8.2	7.6	19.3	19.7
USA	20.7	17.2	14.7	13.6	12.6	13.0

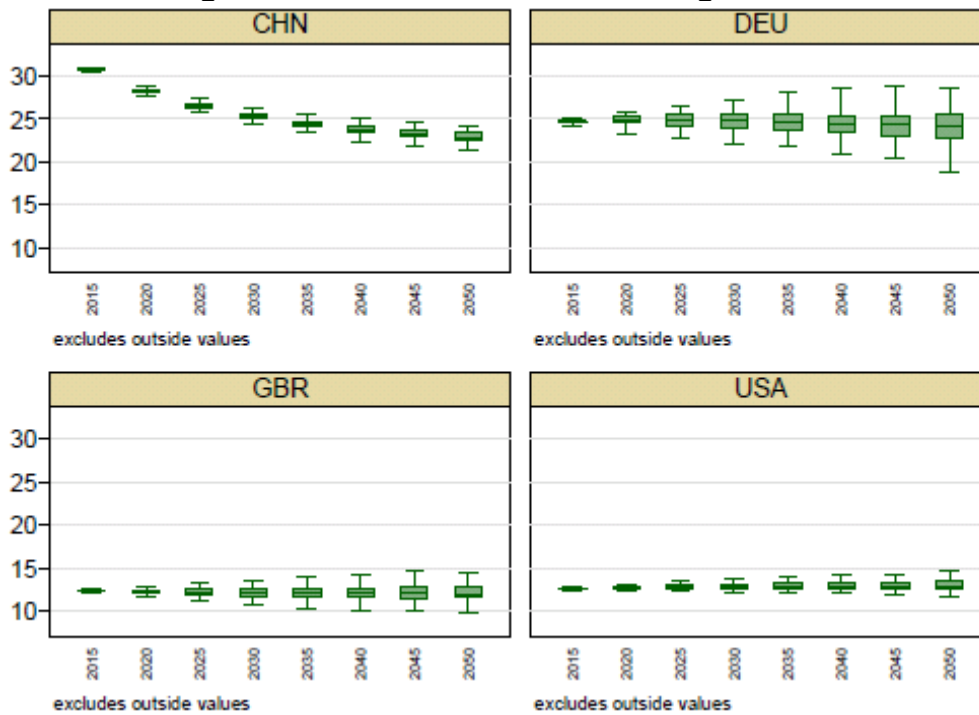
Table 4.2 reports the averages of the results of the outcome of 100 simulation runs. As can be seen the results are very close to those reported in table 4.1. However the more interesting aspect is to look at the variation of results across the simulation runs which are visualized in the next three figures for China, Germany, Great Britain and the US. These figures report the box plots indicating the distribution of the simulation outcomes. The lines in the boxes represent the median of the respective variables, whereas the boxes indicate the range, where 50% of the simulation outcomes are placed; the whiskers present the observations lying within the 1.5 x inter-quartile range (outside values are not reported). Figure 4.1 presents the shares of each country in the world economy. For China, the median is slightly above 20% in 2050, with the boxes ranging from about 18 to 23%, whereas the whiskers range from about 12% to more than 30%. Similarly, the median for the US is at about 18% with the boxes showing a range between 16 and 19% and the whiskers between 12 and 25%. For Germany and the UK the variation in outcomes is much more similar with the median being in line with the means reported in Table 4.2. Figure 4.2 presents the distribution of the manufacturing shares in each of the four economies with the medians again being in line with the means reported in Table 4.2. Whereas the decline of the manufacturing share in China is confirmed, there is more variation now in the case of Germany (ranging from 18 to 28% when considering the whiskers) and Great Britain (from 10 to 15%). Finally, the median share of manufacturing in the world economy is at 16.4% with the box ranging from 16.3 to 16.7% and the whiskers between 15.6 and 17.3%.

**Figure 4.1 – Share of countries in world GDP**



Graph source: REP

**Figure 4.2 – Share of manufacturing in GDP**



Graph source: REP

## 5. Summary and conclusions

The role of emerging countries, notably the BRIC countries, in providing manufacturing global output has been analysed in comparison with trends in selected larger advanced countries in Europe together with the US and Japan. First, it was shown that the share of manufacturing is on a declining trend at the global level, though levels as well as the dynamics of these shares differ greatly amongst economies. The share of manufacturing at the world level dropped from about 20 to 18% over the period 1995-2011 (expressed at current US-\$). Whereas Germany kept a share of almost 25% over this period, this share in the UK declined from more than 20% in 1995 to about 12% in 2011. China is outstanding – even amongst the BRIC countries - with a manufacturing share of more than 30% and only a slight decline over the period considered. The other BRIC countries show shares in line with the global share. The share of the BRIC countries in providing global manufacturing output in 2011 was at almost 30% which increased from less than 10% in 1995. This is to be compared with these countries' share in global GDP of slightly less than 20% in 2011 (about 7% in 1995) pointing towards the changing global specialisation patterns. It is important to notice here that this was particularly driven by China which accounts for about half of the BRIC share in global GDP and almost two- third in manufacturing GDP.

It was further shown that the BRICs also gained relative importance in the medium-high and high tech industry segments given the global trends. Thus for advanced countries it will become increasingly difficult to specialise in high-tech activities leading to a general erosion of comparative advantage patterns over the longer run. This latter aspect is also important as advanced countries tend to lose the role of being higher tech intermediate inputs providers for manufacturing processes as emerging countries tend to take over more and more production stages themselves.

The second aspect analysed in depth was the increasing importance of production fragmentation in the global economy which shows that BRIC countries become increasingly important for the advanced countries which have been assessed using information from global input-output tables: First, their role as providers – directly and indirectly – of intermediate inputs for production giving rise to increasing vertical specialisation as measured by the share of foreign value added (or value added from BRIC countries) in the value of final production and exports of the advanced countries was increasing with China again playing a dominant role. Second, fast growth of output but also final demand in the emerging economies also implies increasing market and export opportunities for the advanced countries giving rise to increase in income and growth due to exports as indicated by measuring value added exports.

Finally, an assessment of long-term future (scenarios up to 2050 are discussed) aspects based on a simple demand driven Leontief modelling framework and trends concerning future growth and structures of final demands by countries, which are the most important drivers in such a framework, have been given. Under the assumptions discussed above – convergence of overall growth rates and final demand structures – these trends are expected to broadly continue. According to these scenarios BRIC countries will gain in relative importance as their share in world GDP will increase to slightly less than one third and with respect to their share in world manufacturing GDP even more so to more than 35% with the advanced economies losing in relative importance accordingly. In most countries the share of manufacturing in GDP will further decline with this trend being more pronounced in the BRIC countries as compared the

advanced countries considered. Consequently, the share of manufacturing in world GDP is also projected to decline to about 16% (as compared to 18% in 2011). Under these assumptions therefore overall changes of global structures are expected to continue though on a less rapid path. It should however be emphasised that there is a great deal of uncertainty with respect to the specific numbers given which are only partly addressed in the robustness check reported as well. From the advanced countries perspective, therefore the issue of losing relative importance due to differentiated growth dynamics and favourable developments in the emerging markets implying on the one hand more competition and perhaps increased need for specialisation within manufacturing or towards services and on the other hand opportunities remain in selling ones products to the arising markets.

## References

- Acemoglu, D. (2009), *Introduction to Modern Economic Growth*, Princeton University Press.
- Baldwin, R. (2011), Trade and industrialisation after globalisation's 2<sup>nd</sup> unbundling: How building and joining a supply chain are different and why it matters, NBER Working Paper Nr. 17716.
- Barro, R.J. and Sala-i-Martin, X. (1995), *Economic Growth*, MIT Press.
- Baumol, W.J. (1967), Macroeconomics of Unbalanced Growth: The Anatomy of the Urban Crisis, *American Economic Review*, 57(3), 415-426.
- Bhagwati, J. (2010), The Manufacturing Fallacy, <http://www.project-syndicate.org/commentary/the-manufacturing-fallacy>
- Chenery, H. B. (1960), "Patterns of Industrial Growth" *The American Economic Review*, 50(4): 624-654.
- Chenery, H. B. and Syrquin, M. (1975), "Patterns of Development 1950–1970", *Oxford University Press*.
- Cripps, F., A. Izurieta, and A. Singh (2011), Global Imbalances, Under-Consumption, and Over-Borrowing: The State of the World Economy and Future Policies, Working Paper, CBR Research Programme on Corporate Governance.
- Dietzenbacher, E., B. Los, R. Stehrer, M. Timmer and G. de Vries (2013), The Construction of World Input-Output Database in the WIOD Project, *Economic Systems Research*, 25(1), 71-98.
- European Commission (2010), An integrated industrial policy for the globalisation era. Putting Competitiveness and Sustainability at Centre Stage, COM(2010)614, Brussels. European Commission (2011), *Global Europe 2050*, European Commission.
- Foster, N. and R. Stehrer (2013), Value added in Trade: A Comprehensive Approach, *Economics Letters*, 120, 354-357.
- Ghosh, J., P. Havlik, M.P. Ribeiro and W. Urban (2009), Models of BRICs' Economic Development and Challenges for EU Competitiveness, *wiiw Research Report 359*.
- Havlik, P., O. Pindyuk, and R. Stöllinger (2009), Trade in Goods and Services between the EU and the BRICs, *wiiw Research Report 357*.
- Hummels, D., J. Ishii, and K.M. Yi (2001), The Nature and Growth of Vertical Specialization in World Trade, *Journal of International Economics*, 54(1).
- Hunya, G. and R. Stöllinger (2009), Foreign Direct Investment Flows between the EU and the BRICs *wiiw Research Report 358*.
- Johnson, R.C. and G. Noguera, (2012), Accounting for Intermediates: Production Sharing and Trade in Value Added, *Journal of International Economics*, 87, 105-111.
- Koopman, R., W. Powers, Z.Wang, and S.-J.Wei (2013). Give credit where credit is due: Tracing value added in global production chains, *American Economic Review*, forthcoming.
- McKinsey Global Institute (2012), *Manufacturing the future: The next era of global growth and innovation*, November 2012.

O'Neill, J. (2001), Building Better Global Economic BRICs, Global Economic Papers No. 66, GoldmanSachs.

Rodrik, D. (2012) The Manufacturing Imperative, project-syndicate, 10 August 2012. <http://www.project-syndicate.org/commentary/the-manufacturing-imperative>

Rowthorn, R.E. and J.R. Wells (1987), De-industrialisation and foreign trade, Cambridge: Cambridge University Press.

Stehrer, R. (2012), Trade in Value Added and the Value Added in Trade, wiiw Working Paper No. 81, Vienna.

Stehrer, R. (2013a), Accounting relations in bilateral value added trade, unpublished.

Stehrer, R. (2013b), Growth and structural change from a global demand perspective, mimeo.

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



# Appendix

**Appendix Table A1 – Manufacturing sector classification and WIOD correspondence**

WIOD sector	Description	Broad aggregates
15t16	Food, Beverages and Tobacco	Low technology
17t18	Textiles and Textile Products	Low technology
19	Leather, Leather and Footwear	Low technology
20	Wood and Products of Wood and Cork	Low technology
21t22	Pulp, Paper, Printing and Publishing	Low technology
23	Coke, Refined Petroleum and Nuclear Fuel	Medium-low technology
24	Chemicals and Chemical Products	Medium-high and high technology
25	Rubber and Plastics	Medium-low technology
26	Other Non-Metallic Mineral	Medium-low technology
27t28	Basic Metals and Fabricated Metal	Medium-low technology
29	Machinery, Nec	Medium-high and high technology
30t33	Electrical and Optical Equipment	Medium-high and high technology
34t35	Transport Equipment	Medium-high and high technology
36t37	Manufacturing, Nec; Recycling	Low technology

Source: OECD-Eurostat correspondence adapted to WIOD sectors

## Technical appendix - Assessing the role of a country's manufacturing with internationally fragmented production

### The World Input Output Database (WIOD)

The data used for analysis is taken from the World Input-Output Database (WIOD), which became available in April 2012 (see [www.wiod.org](http://www.wiod.org)) and was compiled within the EU Framework programme. This data provides international supply and use and input-output tables for a set of 41 countries (EU-27, Australia, Brazil, Canada, China, India, Indonesia, Japan, Korea, Mexico, Russia, Taiwan, Turkey, USA and Rest of World) over the period of 1995–2009. It was compiled on the basis of national accounts, national supply and use tables and detailed trade data on goods and services, combining information for 59 products and 35 industries. Corresponding data at the industry level allow the splitting-up of value added into capital and labour income. More detailed information is provided by Timmer et al. (2012) and Dietzenbacher et al. (2013). The database provides a time series from 1995-2009 which was unofficially updated until 2011. This results in a world input-output database for 41 countries (including Rest of World) and 35 industries, i.e. the intermediates demand block is of dimension 1435x1435, plus additional rows on value-added and columns on final demand categories. The outline of such a world input-output table is presented below. Each industry in a country listed vertically sources intermediates from its own industries and from other countries' industries. Together with value added from the country, the level of gross output is obtained. Furthermore, each country also demands products from its own economy and the other economies for final use, like consumption and gross fixed capital formation. The horizontal view shows what each industry provides to industries in its own and the other countries, and as final demand for domestic and foreign consumers. Gross output produced in one country equals the value of demand for each country's industries.

**Figure 2.1 - Outline of world input-output table (industry by industry)**

	Intermediate use			Final use			
	Country A	Country B	Country C	Country A	Country B	Country C	
<b>Country A</b>	A sources from A	B sources from A	C sources from A	A demands in A	B demands in A	C demands in A	GO in A
<b>Country B</b>	A sources from B	B sources from B	C sources from B	A demands in B	B demands in B	C demands in B	GO in B
<b>Country C</b>	A sources from C	B sources from C	C sources from C	A demands in C	B demands in C	C demands in C	GO in C
<b>Value added</b>	VA in A	VA in B	VA in C				
<b>Gross output</b>	GO in A	GO in B	GO in C				

### Indicators assessing the role of international fragmentation of production

Let us provide a quick technical discussion of the indicators used in this paper which are derived from a world input-output table. The world input output relation is given by the equation  $\mathbf{x} = \mathbf{Ax} + \mathbf{f} = \mathbf{Lf}$  where  $\mathbf{A}$  denotes a  $\text{NC} \times \text{NC}$  ( $\text{N}$  is the number of industries,  $\text{C}$  is the number of countries) matrix of input coefficients both domestic and imported. Matrix  $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$  denotes the global Leontief inverse. The  $\text{NC} \times 1$  vectors  $\mathbf{x}$  and  $\mathbf{f}$  denotes gross output and final demand levels. Further  $\mathbf{v}^r$  denotes a vector of value added coefficients (value added over gross output) of dimension  $1 \times \text{NC}$  with the coefficients of country  $r$  included and 0's elsewhere;  $\mathbf{v}^{-r}$  denotes a similar vector with 0's for country  $r$  and the coefficients included for all other countries.  $\mathbf{f}^r$  is a  $\text{NC} \times 1$  vector of final demand in country  $r$  thus also including import demand.  $\mathbf{f}^{-r}$  is the vector of world demand minus demand of country  $r$ , i.e.  $\mathbf{f}^{-r} = \mathbf{f} - \mathbf{f}^r$ . The vector  $\mathbf{x}^r$  denotes a  $\text{NC} \times 1$  vector of country  $r$ 's exports with 0's included for other countries.  $\tilde{\mathbf{f}}^r$  is a  $\text{NC} \times 1$  vector with final demand in country  $r$ , i.e. domestic and foreign demand for country  $r$ 's products. The indicators used later on are then as follows: The share of foreign value added in final output and exports of this country is  $\mathbf{VS}^r = \mathbf{v}^{-r} \mathbf{L} \mathbf{x}^r$  expressed as a ratio to total value added created in the world for production of  $\mathbf{x}^r$ , i.e.  $\mathbf{v} \mathbf{L} \mathbf{x}^r$ . When using instead of the country  $r$ 's exports its total final output, one can derive a vertical specialisation measure for final output production; formally,  $\mathbf{VS}^r = \mathbf{v}^{-r} \mathbf{L} \tilde{\mathbf{f}}^r$  as ratio to  $\mathbf{v} \mathbf{L} \tilde{\mathbf{f}}^r$  where  $\tilde{\mathbf{f}}^r$  denotes a  $\text{NC} \times 1$  vector including total final demand (i.e. both domestic and exported) on country  $r$  products and 0's otherwise. These measures of vertical specialisation are akin to the VS measures introduced in Hummels, et al. (2001) (see also Stehrer et al. (2012) for a detailed discussion).

The value added of a country's exports can be misleading due to the fact that this may embody value added created in other countries which enter the product as intermediate inputs. This is already taken into account in the measure of vertical specialisation already introduced above. When one is interested in the domestic value added which is embodied in a country's exports one can subtract the foreign content from the export value in gross terms or calculate the domestic content directly as  $\mathbf{V}^r \mathbf{L} \mathbf{x}^r$ . This however might include value added which after some processing maybe returns back home and is finally absorbed domestically. Therefore an alternative is to calculate the domestic value added directly and indirectly embodied in the other countries consumption, referred to as value added exports and calculated as  $\mathbf{VA}^{r, \text{for}} = \mathbf{v} \mathbf{r} \mathbf{u} - \mathbf{r}$  which might either be expressed in relation to gross exports (the VAX ratio as used in Johnson and Noguera, 2012) or in relation to a country's GDP as we do here. However, the difference between the

domestic content of exports and a country's value added content is in most rather small (see Koopman et al., 2013 and Stehrer, 2013).

