In 2017, the trade openness ratio of the global economy would appear to be recovering at last

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In 2016, growth in world trade slowed once again (+1.5% in real terms after +2.5%), reaching its lowest rate since the 2008-2009 crisis. Since 2012, world trade has grown on average by 2.7% a year, compared to 5.9% a year between 1986 and 2011. It has therefore increased slightly less quickly than world activity over the last five years (+3.0% on average), whereas it was growing almost twice as fast before the crisis. The trade openness ratio, calculated as the ratio of imports to economic activity, has thus fallen slightly since 2011, after following an upwards trend over the two decades preceding the recent major crisis.

Several reasons can be proposed to explain this dip. It could be an effect of the composition of final demand: the slowdown in items with a high import content, in particular corporate investment, may have had a negative effect on trade. There could also be an effect of the geographical composition of world growth, with the most open zones having experienced the largest slowdown. Finally, the trend towards greater trade openness may have been reversed because world economies are no longer participating to the same extent as before in the process of international production fragmentation. These explanations are not mutually exclusive and go beyond a simple opposition between cyclical and structural factors.

A modelling exercise based on a set of international macroeconomic panel data on 19 countries makes it possible to quantify the effects of these different factors. For all these countries, the dip in the openness ratio since 2011 would thus appear to be due above all to a halt in the process of international production fragmentation, which seems to explain about half of it. A second significant factor, the change in the geographical composition of trade, is thought to explain a little over a third of the dip in the trade openness ratio. The effect of the composition of demand on the openness ratio, on the other hand, is thought to be weaker.

The model suggests that a recovery in the trade openness ratio could occur in 2017. The contribution of the process of international production fragmentation looks as if it will be less unfavourable to the openness ratio, as suggested in particular by the recent upswing in processing trade in Chinese customs data. In addition, world activity is expected to accelerate in 2017, in particular corporate investment, leading to a strong rebound in global trade.

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Since 2012, world trade has increased more slowly than activity

From 2012 to 2016, the growth in world trade more than halved compared to the years before the 2008-2009 crisis

Since 2012, world trade, defined here as the sum of imports of goods throughout the world, has been slow. In real terms, it has increased by 2.7% on average since 2012, that is to say that the growth rate has been half the average increase between 1986 and 2011 (+5.9%; *Graph 1*). For its part, gross domestic product (GDP) has grown slightly more slowly since 2012 (+3.0% a year) than in the period 1986-2011 (+3.7%): imports, which were increasing almost twice as fast as GDP until then, have also been increasing more slowly than GDP since 2012.

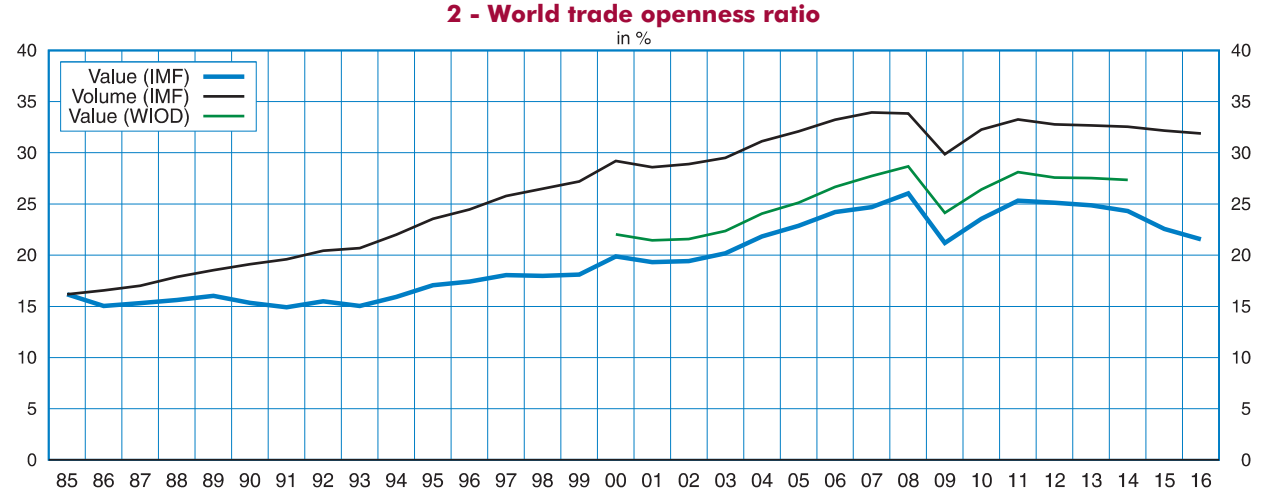
Whereas it rose regularly over the previous two decades, the trade openness ratio of the global economy has fallen slightly since 2011

The trade openness ratio, which is calculated as the ratio of imports to economic activity, is an indicator of the interdependence between economies. Before the 2008-2009 crisis, it was increasing fast and steadily: expressed in real terms, it doubled between 1986 and 2007, going from 17% to 34% over the period (*Graph 2*). During the major recession that occurred in 2008-2009, it fell back sharply, before picking up again in 2010-2011. Since then however, the trade openness ratio has not returned to its pre-crisis trend, and has even fallen slightly again (–2 points to 32% in 2016). A similar trend is found when the openness ratio is calculated based on changes in value terms.

1 - World trade growth

Sources: DG Trésor, INSEE calculations

2 - World trade openness ratio



Note: the global trade openness ratio corresponds to the ratio of global imports to world activity, expressed as a percentage. The trade openness ratio in real terms has been calculated from the changes in volumes of imports and world activity, taking the trade openness ratio in 1985 as the base year.
How to read it: in 2014, the openness ratio in value is 27% according to the source WIOD and 24% according to the source IMF. In volume, it is 33%.

Sources: IMF data for 193 countries, World Input-Output Database (WIOD) for 44 countries, calculations by authors

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The trade openness ratio of emerging Asian countries has seen a particularly marked slowdown

The detailed data in value terms from the WIOD2 project concerning 44 countries representative of the world economy from 2000 to 2014 (*Box 1*) provide information first of all on the geographical origin of this dip. Between 2000 and 2011, the global trade openness ratio calculated in value terms increased by 6 points to 28%, then fell by 1 point to 27% in 2014, representing a slowdown of 0.8 points as an annual average between the two periods.

The slowdown in the openness ratio affected all five major economic zones, with the exception of that consisting of the non-Asian emerging countries (*Table 1*). The most significant slowdown concerned the Asian emerging countries (China, India, Malaysia), whose trade openness ratio in 2014 fell back to its 2000 level (18%) after reaching 23% in 2011.

A geographical composition effect explains just over a third of the overall slowdown

However, the slowdown in each of the different zones alone does not explain the dip at global level: regional economic dynamics have also played a role. Given the substantial disparities in the ratios of openness between them, variations in the relative weights of these zones in the global economy also have an influence on the overall trade openness ratio. For example, for a country with an above-average openness ratio, when its weight in global GDP increases, the proportion of imports in GDP increases at world level.

By following the framework proposed by Berthier (2002),[1] a geographical composition effect can be identified in the slowdown in the global trade openness ratio between the 2000/2011 and 2011/2014 periods (*Table 1*). While most of the slowdown is due to that of the openness ratios of the different zones, just over

1. For a presentation, see appendix 2 of the Special analysis, *Conjoncture in France*, December 2016 "Why have French exporters lost market share?", p. 56-57.

Table 1 - Slowdown in the openness ratio, contribution by zone and geographical composition effect

	All	Eurozone	North America	Other advanced and CEEC	Emerging Asian countries	Other emerging countries
Openness ratio by zone in value (in %)						
(a) in 2000	22	31	14	19	18	36
(b) in 2011	28	37	16	29	23	37
(c) in 2014	27	37	15	31	18	38
Annual average variation 2000-2011 (in points) d = (b–a)/11	0.55	0.57	0.22	0.89	0.41	0.03
Annual average variation 2011-2014 (in points) e = (c–b)/3	–0.25	0.03	–0.29	0.65	–1.49	0.53
Slowdown between the periods 2000-2011 and 2011-2014, in points (e–d)	–0.80	–0.54	–0.51	–0.24	–1.90	0.50
Weight of the zone in the world GDP in value (in %)						
in 2000	100	19	34	27	6	15
in 2011	100	18	25	21	15	22
in 2014	100	16	25	19	18	22
Contribution to the slowdown in the openness ratio (in points)	**–0.80**	**–0.15**	**–0.26**	**–0.11**	**–0.32**	**0.04**
of which slowdown of the zone's openness ratio	–0.50	–0.11	–0.14	–0.08	–0.28	0.11
of which variation of the zone's weight in the world economy (geographical composition effect)	–0.30	–0.04	–0.12	–0.02	–0.04	–0.07

How to read it: the trade openness ratio slowed by 0.80 points between the periods 2000-2011 and 2011-2014, and the Eurozone contributed –0.15 points to this slowdown; this contribution breaks down into an effect linked to the slowdown in the trade openness ratio in the Eurozone on the one hand (–0.11 points) and a geographical composition effect due to the change in the weight of the Eurozone in global GDP on the other (–0.04 points).
Sources: World Input-Output Database (WIOD), calculations by authors

a third can be explained by the change in the geographical structure of the global economy. During the 2000s in particular, the least open zone, North America, was less dynamic than the rest of the world. Conversely, this zone has been growing at a rate close to that of world activity since 2012: the stabilisation of its share in global GDP has mechanically led to a dip in the global trade openness ratio.

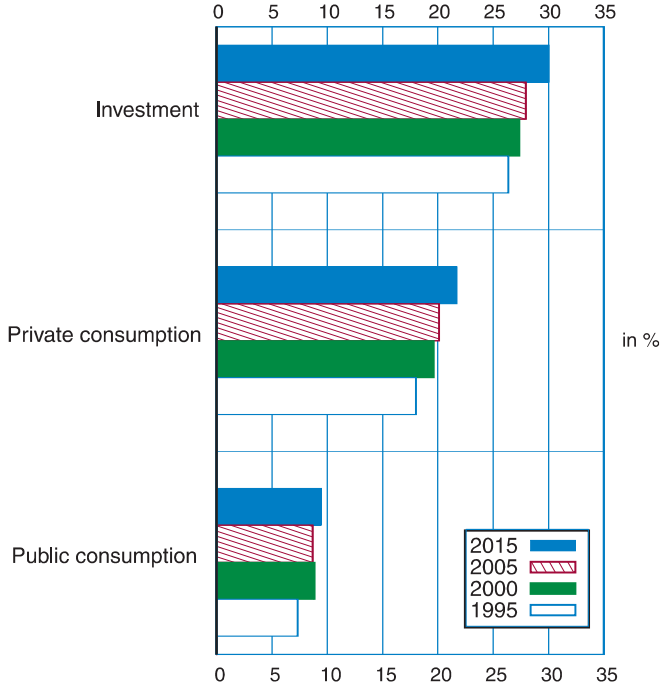
All in all, the two zones contributing the most to the slowdown are North America, particularly the United States, and emerging Asia, each accounting for about a third of the overall slowdown. For emerging Asia, this is due above all to the wide variation in its own trade openness ratio.

Changes in the composition of demand account for about 15% of the slowdown in the trade openness ratio

Import intensity-adjusted aggregate demand traces the slowdown in world trade better than global activity

To grasp the influence of economic activity on imports and world trade, it has become customary to use, instead of GDP, an aggregate variable taking into account the differences in import content of the components of demand (Bussières *et al.*, 2013; INSEE, 2017). The growth in world trade is all the stronger, at a given level of economic growth, when the latter rests on demand components requiring a high proportion of imports. In particular, corporate investment uses a lot of imported goods, especially capital goods, unlike household consumption or general government consumption, which have a strong non-tradable services component (*Graph 3*). The aggregate variable that is used, known as "import intensity-adjusted aggregate demand" (IAD), is calculated as the sum of the final demand for goods and services of the different demand components, weighted according to their relative content of imports of manufactured goods (*Appendix*).

3 - Import content of the main components of world GDP in %



Sources: World Input-Output Database 2 (international tables of input-output), Johnson and Noguera, calculations by authors

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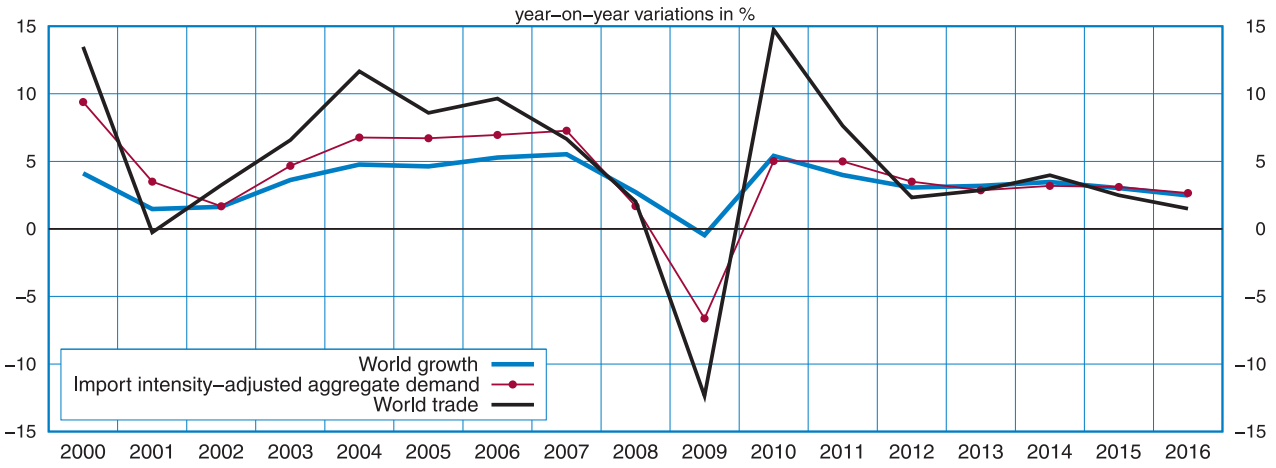
The weak level of investment accounts for about half of the slowdown in IAD

Between 2012 and 2016, IAD grew by about 1.3 points less per year than between 2000 and 2011 (*Graph 4*). This slowdown was more pronounced than that in global GDP (–0.6 points). First of all, it reflects the sharp drop in global investment (*Graph 5*). Indeed, investment has contributed an average of 1.0 point a year to IAD since 2012, compared to 1.6 points between 2000 and 2011, making a contribution of –0.6 points to the slowdown in that demand (even –1.5 points if 2009 is excluded). Private consumption has contributed only slightly more to the slowdown in global demand (0.7 points), although its weight in GDP is substantially greater. On the other hand, public consumption has had virtually no effect on global demand, its contribution having remained basically stable since 2000.

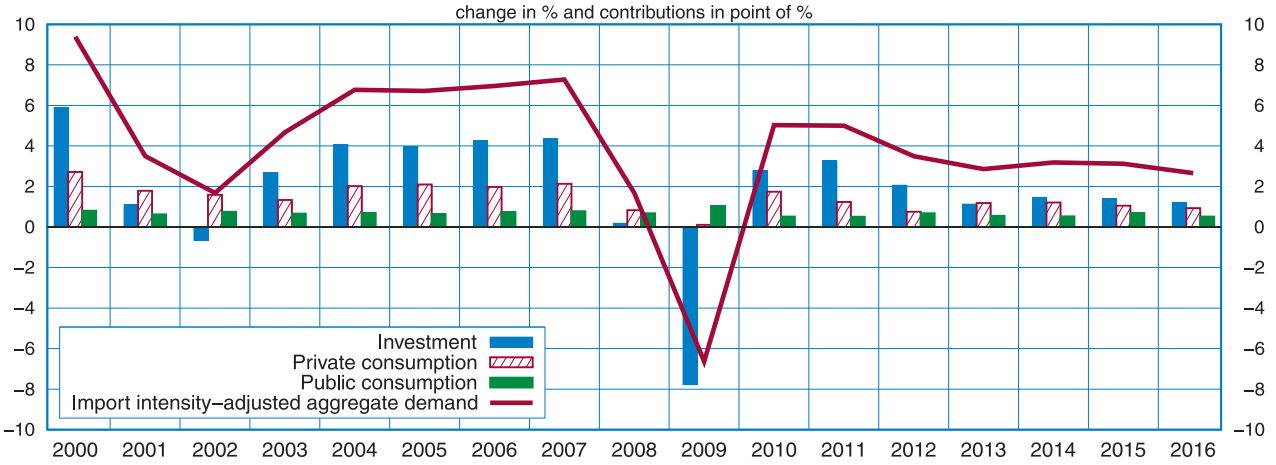
As far as the trade openness ratio is concerned, this demand composition effect accounts for about 15% of the slowdown between the two subperiods.

4 - GDP and world import intensity-adjusted aggregate demand



Sources: DG Trésor, IMF, quarterly national accounts, calculations by authors

5 - Contributions of final demand posts to the import intensity-adjusted aggregate demand



Sources: World Input-Output Database (WIOD), OECD, quarterly national accounts, calculations by authors

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Box 1 - Sources

Usually used for forecasting exercises for *Conjoncture in France*, world trade corresponds here to the sum of imports of goods in volume. The data necessary to construct this indicator are available at different frequencies, based on different concepts, and coming from different sources.

The International Monetary Fund (IMF) (*Graph 2*, p. 20) is the the most comprehensive source on imports, both for its geographical coverage (193 countries tracked) and the number of years (from 1980 to 2016); these data are available in nominal and real terms and annually.

For the breakdown of the trade openness ratio by zone (*Table 1*, p. 21), the data are taken from the inter-country input-output tables of the World Input Output Database (WIOD2), version 2016. This project funded by the European Commission provides annual series of nominal data from 2000 to 2014. The WIOD2 covers 43 countries representative of the global economy (as well as the rest of the world) for 56 sectors of activity.

At zone level, the following scope was used:

Zones	Countries
Eurozone	Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, Spain
North America	Canada, the United States
Other advanced	Australia, Croatia, Denmark, Hungary, Norway, South Korea, Sweden, Switzerland, Taiwan, the United Kingdom
CEEC	Bulgaria, Czech Republic, Poland, Romania
Emerging Asian countries	China, Indonesia, India
Other emerging	Brazil, Mexico, Russia, Turkey, rest of the world

This source was also used to weight the import content of the final demand components (*Graphs 3* to *5*), jointly with Johnson and Noguera's data (2017), which allowed the content to be backcast to 1995.

The bilateral trade figures necessary for the global value chain (GVC) indicators (*Appendix*) can be traced from quarterly nominal customs data, collected in the IMF's Direction of Trade Statistics (DOTS) database and available from 1980 to the end of 2016.

A more restricted scope for volume indicators

The volume data are taken from the national accounts of the different countries. The import data were collected by the Treasury and from national statistics institutes. The other components in GDP come from the OECD or national sources, as not all countries produce quarterly volume figures for the national accounts. The import intensity-adjusted aggregate demand (*Graphs 3* to *5*) and participation in value chains indicators (*Graph 8*) have therefore been calculated for a limited set of 26 countries: Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, India, Italy, Japan, Mexico, the Netherlands, Norway, Poland, Portugal, Russia, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. For China, which does not produce detailed quarterly accounts, the data come from the authors' calculation, based mainly on customs data.

Econometric modelling of global imports (*Box 2*) requires a substantial amount of hindsight (since 1995). It covers a slightly more restricted set of 19 countries (the same ones minus Belgium, Brazil, India, South Korea, Switzerland and Turkey). ■

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The integration process in global value chains has been stalled since 2011

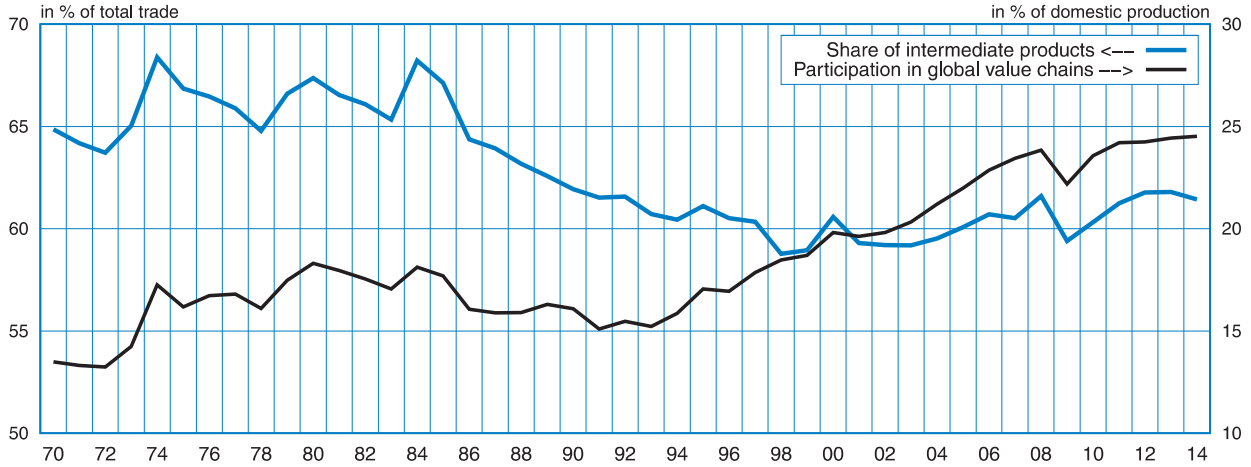
The fragmentation of international production had increased considerably over the fifteen years prior to the 2008-2009 crisis

Beyond the composition of demand, the slowdown in world trade can also be explained by a number of more structural factors. Most notably, the momentum in world trade from the middle of the 1990s until the 2008-2009 financial crisis resulted partly from an increased fragmentation of the international production process between different centres spread across many countries. However, since 2008-2009, this process has stagnated, thereby contributing to a slowdown in the trade openness ratio compared to the earlier period.

To measure this process, an indicator of global value chains (hereafter GVC) indicator has been developed. The intuition behind this indicator is that, instead of producing finished goods at home and then exporting them, countries are using more and more imported goods in their own production processes or, conversely, are manufacturing goods abroad using exported intermediate products. This process is in fact inadequately taken into account by a commonly used indicator, which simply measures the share of intermediate products in total exports and which has virtually stagnated since 2000 (*Graph 6*), essentially because the definition of "intermediate products" in the classification does not cover all the goods that enter into processing trade.[2] Several studies (Hummels, Ishii and Yi, 1999; Johnson and Noguera, 2012; Koopman, Wang and Wei, 2014) have put forward an alternative indicator of international production fragmentation (sometimes also called "participation in global value chains") which is based on the inter-country input-output (ICIO) tables and measures the weight of foreign value added in domestic output. International institutions, in particular the World Trade Organisation (WTO) and the Organisation for Economic Co-operation and Development (OECD), have helped to construct such indicators by bringing together comparable and disaggregated accounting tables on the global production process.

2. For example, in the Chinese customs data, imports of intermediate goods did not represent half of processing trade imports.

6 - Integration in global value chains: indicator of participation in value chains (GVC indicator) and proportion of intermediate products in exports



Sources: quarterly national accounts, IMF and OECD data, international input-output tables from the World Input-Output Database (2016) and from Johnson and Noguera (2017)

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Specifically, the GVC indicator measures the share of foreign value added in the exports of a given country. This indicator will be zero if the country only uses domestic value added to export its goods. It becomes positive if exports incorporate foreign inputs. However, imports can also incorporate inputs that were themselves imported, sometimes even from the initial country. The GVC indicator thus measures the foreign value added, after correction of the value added initially exported and which comes back to its country of origin. This proportion is not directly observable and hypotheses need to be made to compute it. The GVC indicator used here (*Appendix*) attests to an increase in the fragmentation of value chains over the fifteen years preceding the 2008-2009 crisis, a period when the global trade openness ratio was also increasing sharply.

Global trade liberalisation and the fall in transport costs that were driving international production fragmentation process have seized up

The growing participation in global value chains before the crisis can be explained by a dual trade liberalisation movement, in particular with a reduction in customs tariffs and a fall in the cost of transport and communications (*Graph 7*). Johnson and Noguera (2017) have shown that these movements have had a more than proportional effect on trade in intermediate products, enabling them to cross borders several times, or in other words magnifying their impact on world trade.

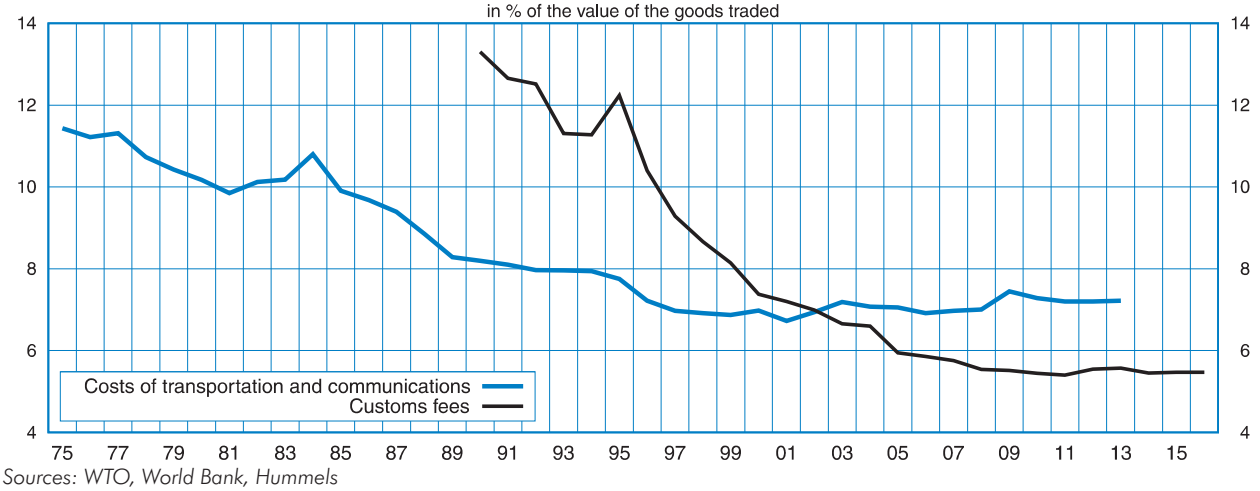
The process of trade liberalisation was driven at the beginning of the 1990s by the success of the Uruguay Round (1986-1994), then by China's entry into the WTO in 2001 and finally by the multiplication of regional and bilateral free trade agreements (François *et al.*, 2016). But this process had already been seriously curtailed even before the 2008-2009 crisis. Most notably, the failure of multilateral trade negotiations in the Doha round (2001 to 2008 for the initial phase of the discussions) prevented further falls in customs tariffs. The recession led to a limited rise in trade protectionism, mainly through measures concerning certain products, such as steel, or by the increase in certain non-tariff barriers.

Since 2012, the intensity of the participation in global value chains has no longer depended as much on the economic cycle

The aggregate participation in value chains indicator fell temporarily with the 2008-2009 crisis, before returning to its earlier level. This profile corresponds to the highly cyclical nature of intermediate products, linked to the "bullwhip effect" when a rise in demand for a product is amplified throughout the supply chain. The 2008-2009 drop was more marked than the weakening of this indicator in earlier periods of global slowdown, in 1991-1993 or in 2001. The 2008-2009 crisis was in fact much more severe. But above all, this indicator stagnated even after the recovery in 2010-2011, unlike what happened the previous times.

7 - Trade barriers

in % of the value of the goods traded



Sources: WTO, World Bank, Hummels

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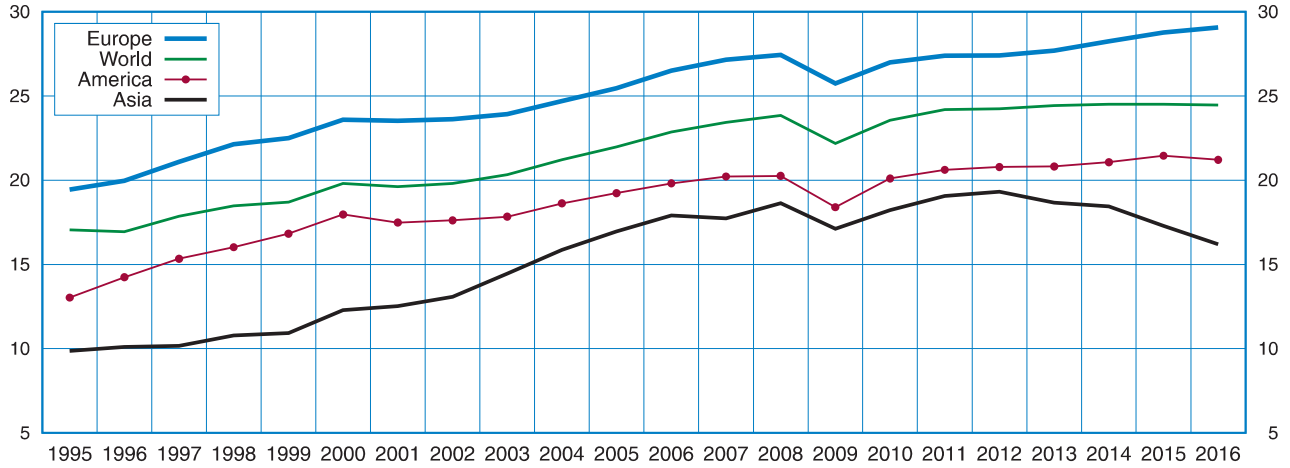
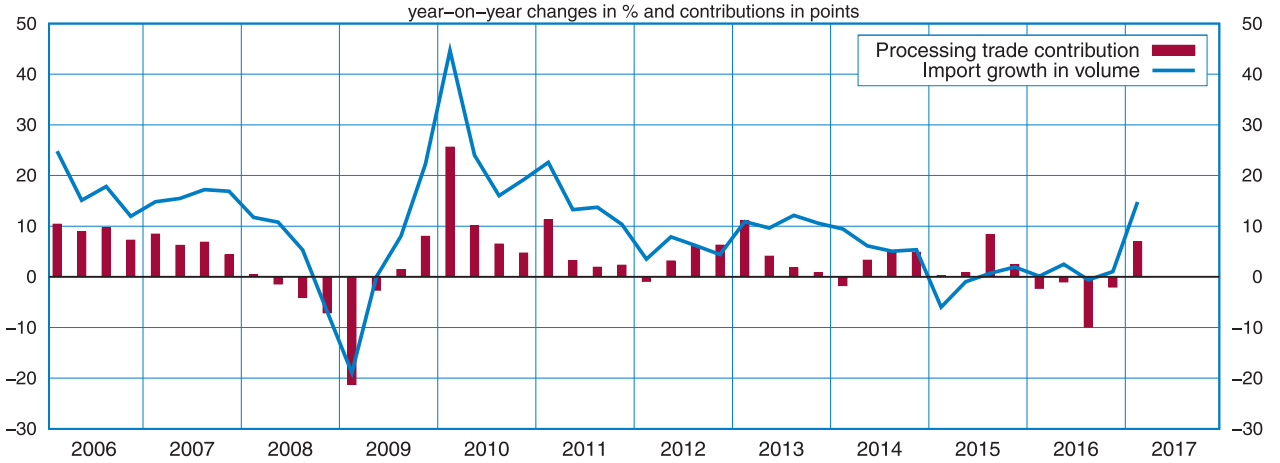
The trend towards participation in global value chains has not been consistent across the regional zones (*Graph 8*). It has continued in Europe since 2011, driven by the increased integration of the countries of Central and Eastern Europe with the other European economies. In North America, the GVC indicator has virtually stagnated. In Asia, the substantial drop in the share of processing trade in international trade led to a lower participation in global value chains from 2013 onwards, as is shown by the contribution of processing trade to the growth of Chinese imports (*Graph 9*). The slowdown in the GVC indicator has therefore been more marked in sectors where Asian goods are predominant, such as electronics.

8 - Participation in value chains by regions (GVC indicators)



Sources: quarterly national accounts, IMF and OECD data, calculations by authors

9 - Growth of imports and contribution of processing trade in China



How to read it: after remaining flat since 2015, in Q1 2017, imports grew by 14.8% year on year, of which 6.9 points driven by processing trade imports.

Sources: Chinese customs administration, INSEE calculations

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Box 2 - Modelling of imports

The modelling of imports is based on the data for a panel of 19 countries (see *Box 1*), between the first quarter of 1995 and the first quarter of 2016. The modelling starts from a common import equation in which the changes in volumes of imports have as determinants the changes in volume of demand and a price effect linked to the difference in the relative price of imports at domestic prices.

Three successive models are tested: the first one uses only GDP growth as the indicator of demand in volume terms, the second following Bussière *et al.*'s model (2013), uses import intensity-adjusted aggregate demand, the last one also introduces the GVC variable, which is supposed to capture the trade openness linked to the fragmentation of global output.

In the first model, the elasticity of trade relative to activity obtained is much greater than unity, which suggests that the high coefficient also captures the upward trend in the trade openness ratio. The explanatory power of this model is 35%.

As in Bussière *et al.* (2013), but over a wider panel, the alternative model using only weighted total demand has a better explanatory power (45%) than the model using only GDP as an indicator of demand.

Finally, in the third model, the GVC indicator stands out significantly and further improves the quality of the adjustment (54%) compared to the first two models. In this model, the long-term elasticity of global demand weighted for imports is spontaneously close to unity.

The model for imports used is therefore:

$$\Delta \ln(M_{i,t}) = \alpha_i \underset{(-9,76)}{-0,25}\Delta \ln(M_{i,t-1}) + \underset{(9,79)}{1,04}\Delta \ln(DGP_{i,t}) + \underset{(4,63)}{0,28}\Delta \ln(DGP_{i,t-1}) + \underset{(12,92)}{0,06}\Delta GVC_{i,t} + \varepsilon_{i,t}$$

Period of estimation: 1995Q3 – 2016Q3
R^2: 54%

$M_{i,t}$: imports of country i in quarter t;
$M_{i,t-1}$: imports of country i in quarter t–1;
$DGP_{i,t}$: import intensity-adjusted aggregate demand of country i in quarter t;
$DGP_{i,t-1}$: import intensity-adjusted aggregate demand of country i in quarter t–1;
$GVC_{i,t}$: GVC indicator of participation in value chains, moving average of order 5.

The model takes account of the two indicator variables for the United Kingdom in 2006, which reflect the fits and starts in this country's imports.

As is often the case in macroeconomic import equations, the price variable appears to be poorly significant or completely insignificant. This may be due to the fact that, by construction, the GVC indicator captures the variations in domestic market share which can be partly explained by price-competitiveness effects.

As the model is based on panel data, a fixed effects model has been used. The latter is validated empirically against a random error model (using a Hausman test), which reveals the presence of individual effects specific to each country.

The R^2 in the equation amounts to 54%, which reflects a relative difficulty in capturing the quarterly ups and downs of each of these countries. However, the model does show very well the annual changes in global imports (apparent R^2 in annual data of 95%). ■

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The halt in the process of value chain integration is the main reason for the slowdown in the trade openness ratio of the global economy

A panel data model to quantify the contribution of the factors to the slowdown by country

In order to quantify the contribution of the different factors to the slowdown in world trade, imports are modelled for a panel of countries representing approximately 70% of global trade. The model that adjusts best to the data is the one that uses as economic determinants of imports, an indicator of import intensity-adjusted aggregate demand and an indicator of participation in value chains.

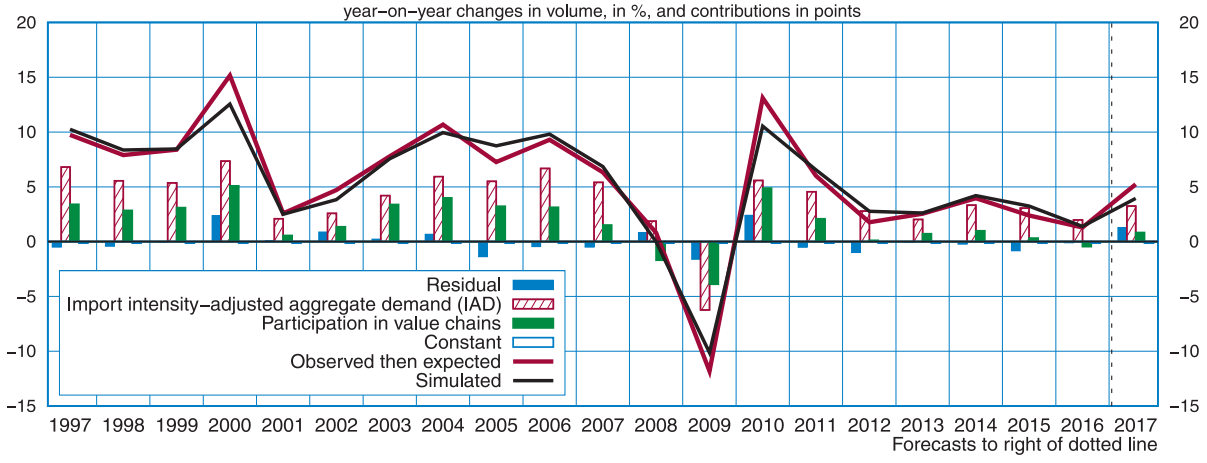
In the model used, the long-term elasticity of IAD for global imports is close to unity and the additional contribution of participation in value chains is significant. This model allows the slowdown in global imports to be tracked quite closely (*Graph 10*).

The slowdown in the trade openness ratio is largely due to stagnation of international production fragmentation

The econometric contributions of the two determinants can be compared from one subperiod (2000-2011) to the next (since 2012): this serves to compute their respective contributions to the slowdown in global imports since 2012, and therefore that of the trade openness ratio excluding the geographical composition effect.[3] The geographical composition effect accounts for just over a third of the slowdown in the trade openness ratio observed since 2012. The halt in the integration of global value chains accounts for a larger share, a little under half (45%). The change in the composition of demand has a considerably lower influence as it accounts for only about 15%. The contribution of global demand to the slowdown in the trade openness ratio therefore seems to be moderate in view of its strong contribution to the slowdown in world trade.

3. The contribution of the composition of demand is obtained by deducting the growth in GDP from the econometric contribution of import intensity-adjusted aggregate demand (IAD). In the model, the changes in the trade openness ratio (and the contributions to these changes) are considered excluding geographical composition effects, insofar as they have been calculated with a weighting fixed over time.

10 - World imports, observed and simulated variations with the model used



Scope: 19 countries of the modelling (*Box 2*)
Source: quarterly national accounts, IMF and OECD data, calculations by authors

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However, the results are more mixed at country level (*Table 2*). In China, the slowdown in the trade openness index, which has been large, can be explained mainly by the reversal in its participation in value chains, but the composition of demand has also played a more marked role than on average (approximately 20% of the slowdown). In Russia and Australia, the composition of demand accounts for a third of the slowdown in the trade openness ratio. In the countries in the Eurozone, the trade openness ratio slowed less, in particular because their involvement in global value chains continued to grow, contrary to the global trend. This is the case of the Netherlands, France, Spain and especially Portugal, and it has been accompanied for Spain and Portugal by a sharp gain in their export performances over recent years.

In 2017, the trade openness ratio of the global economy is expected to increase for the first time since 2011

For 2017, the model suggests a clear acceleration in world trade in 2017 (+5.9% as an annual average), under the effect of a marked upturn in investment, especially in China and the United States. Furthermore, participation in value chains is expected to cease weighing down on world trade, as is suggested by the recent recovery in foreign processing trade in the Chinese customs data (*Graph 9*).

In 2017, world trade is therefore expected to accelerate more sharply than world activity (+3.5%). Even if it remains lower than its average between 2000 and 2011, this increase is expected to lead to a marked increase in the trade openness ratio (+0.7 points), for the first time since 2011. ■

Table 2 - Share of demand factors and of value chains in the slowdown of openness ratios between 2000-2011 and 2012-2016

in points

Countries	Slowdown (–) or acceleration (+) of openness ratio (annual average, in points)	Weighted total demand (composition effect)	Participation in value chains	Unexplained
All the countries of the modelling	**–0.6**	**–0.1**	**–0.4**	**–0.1**
United States	–0.1	0.1	0.0	–0.1
United Kingdom	0.0	0.1	0.0	–0.1
Austria	–0.1	0.2	–0.2	–0.1
Denmark	–1.0	0.0	–0.9	0.0
France	0.3	0.1	0.3	–0.1
Germany	–0.1	0.0	–0.1	0.0
Italy	–0.2	–0.1	–0.1	0.0
the Netherlands	0.6	0.2	0.6	–0.2
Sweden	0.0	0.2	0.0	–0.1
Canada	–0.4	–0.3	–0.4	0.2
Japan	0.1	0.1	0.1	0.0
Finland	–0.2	0.1	–0.1	–0.1
Portugal	1.2	0.2	1.1	–0.1
Spain	0.4	0.2	0.3	–0.1
Australia	–1.1	–0.3	–0.8	–0.2
Mexico	0.1	0.1	0.1	–0.1
Russia	–2.3	–0.7	–1.4	–0.7
China	–1.8	–0.4	–1.4	–0.1
Poland	0.5	–0.1	0.3	0.3

How to read it: the trade openness ratio (excluding the geographical composition effect) fell by an annual average of 0.6 points between the subperiods 2000-2011 and 2012-2016, for all the 19 countries included in the model. –0.1 point of this dip is accounted for by weighted total demand, –0.4 points by participation in value chains and the remaining 0.1 point remains unexplained.
Source: calculations by authors

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Appendix - The participation in value chains indicator (GVC) and import intensity-adjusted aggregate demand (IAD)

This report uses two main indicators, the participation in value chains (GVC, for global value chains) on the one hand and import intensity-adjusted aggregate demand (IAD) on the other. Both are taken from the same source, the inter-country input-output (ICIO) tables disseminated by the World Input-Output Database (WIOD2) and Johnson and Noguera (2017). The first indicator mainly uses the part of the ICIO tables concerning intermediate consumptions, whilst the second mainly relies on the composition of final demand.

This appendix illustrates how these indicators are constructed based on a simplified model of the world economy, with two economies, indexed "1" and "2", and for each of them a single sector producing a single product ("1" and "2"). This product may be used for final demand or as an intermediate consumption. The notations used here are close to those of Koopman, Wang and Wei (2014), who propose a unified theory of the GVC indicator.

To understand what the GVC and IAD indicators add, it can be useful to compare the results in the simplified case where there is no trade in intermediate products (international trade therefore concerns only finished goods): in this case, the GVC indicator is zero and the IAD corresponds to domestic demand.

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Input-output table (IOT) and inter-country input-output (ICIO) table

As the treatment of the items of domestic demand is symmetrical, the simplified model below presents only private consumption, but the presentation would be the same for investment or public consumption. By separating the domestic or foreign origin of the intermediate consumptions and final consumptions, the IOT for country 1 can be written as follows:

IOT of country 1	Output	Final demand	
		Consumption	Exports
Domestic products	$a_{11}x_1$	y_{11}	e_{12}
Imported products	$a_{21}x_1$	y_{21}	/
Value added	v_1x_1		
Output	x_1		

We have the following accounting relationships:

(1) Output x_1 is the sum of all intermediate consumptions and value added: $x_1 = a_{11}x_1 + a_{21}x_1 + v_1x_1$ with a_{ij} the technical coefficients associated with the production of product x_1.

(2) Country 1's imports from country 2, m_{12}, are the sum of the imports used as inputs for production, and the imports used directly for final consumption, namely $m_{12} = a_{21}x_1 + y_{21}$.

(3) Symmetrically, by reading the IOT for country 2, country 1's exports are the sum of the exports used for the production process and the exports consumed directly, namely $e_{12} = a_{12}x_2 + y_{12} = m_{21}$. In the customs data as in the national accounts, imported inputs are assumed not to be directly re-exported.

(4) The total consumption of country 1 is the sum of the consumption served by domestic products and that served by imported products, namely $y_1 = y_{11} + y_{21}$

(5) Finally, country 1's GDP is equal on the one hand to the value added and, on the other, to the final demand less imports, namely: $v_1x_1 = (y_{11} + y_{21}) + e_{12} - m_{12}$

By combining equations (1) and (5) with the definition of demand components (2) to (4), the resources and uses balance is obtained for product 1, the total output of product x_1 broken down into its use as intermediate consumptions or as final consumptions with, each time, a breakdown according to domestic or foreign origin, namely:

(6) $x_1 = a_{11}x_1 + a_{12}x_2 + y_{11} + y_{12}$.

The two IOTs of country 1 and country 2 can be combined in an inter-country input-output (ICIO) table. In its simplest form, the value added or international trade can be deduced from the other lines in the table and are not shown. The first line in the table represents the resources and uses balance for product 1, the second that of product 2.

ICIO	Intermediate consumption		Final demand	
	Product 1	Product 2	Country 1	Country 2
Product 1	$a_{11}x_1$	$a_{12}x_2$	y_{11}	y_{12}
Product 2	$a_{21}x_1$	$a_{22}x_2$	y_{21}	y_{22}
Output	x_1	x_2		

Import intensity-adjusted aggregate demand (IAD)

The construction of the import intensity-adjusted aggregate demand (IAD) aims to take into account the import content of the different factors in demand. It is sufficient to reason at the level of a given country's IOT.

The output of product 1 necessary to meet the total final demand for product 1 given by equation (5) can be rewritten in the following form:

(7) $x_1 = a_{11}x_1 + y_{11} + (a_{12}x_2 + y_{12}) = a_{11}x_1 + y_{11} + e_{12}$

from which it can be deduced

(8) $x_1 = \frac{y_{11} + e_{12}}{1 - a_{11}}$

where (8) corresponds to the transformation using the Leontief inverse matrix in the case of a scalar (as there is only one product in the model).

The country's total imports have two components, imports of final products or "direct imports" and imports of intermediate products or "indirect imports" given by the IOT and necessary to produce product 1, namely:

(9) $m_{12}^{\text{Direct}} = y_{21}$

(10) $m_{12}^{\text{Indirect}} = \left(\frac{a_{21}}{1 - a_{11}} \right) (y_{11} + e_{12})$

For each demand component, the import content is the sum of the total imports over the sum of the final uses. For consumption, the import content of consumption is thus:

(11) $w_c = \left(\frac{a_{21}}{1 - a_{11}} y_{11} + y_{21} \right) / (y_{11} + y_{21})$

Assuming that there is no immediate re-exporting of the products imported, the imports associated with the exports are only indirect. The import content of the exports is therefore:

(12) $w_e = \left(\frac{a_{21}}{1 - a_{11}} e_{12} + 0 \right) / (e_{12} + 0) = \frac{a_{21}}{1 - a_{11}}$

Import intensity-adjusted aggregate demand is calculated as the aggregated sum of the demand components using the weight of the normalised import content:

(13) $\ln(\text{DGP}) = \frac{w_c}{w_c + w_e} \ln(y_{11} + y_{12}) + \frac{w_e}{w_c + w_e} \ln(e_{12})$

In the simplified case where there is no trade in intermediate products (case $a_{21} = 0$), the import content of exports is naturally zero, whilst the import content of consumption corresponds simply to the direct import content, namely the weight of the imported products in total consumption, $y_{21} / (y_{11} + y_{21})$. In this case, IAD is simply equal to domestic demand.

The final demand items used in the calculation of IAD are private consumption, public consumption, total investment by enterprises and general government, as well as exports. With the available indicators (*Box 1*), quarterly import intensity-adjusted aggregate demand is calculated from 1995 onwards, across a total of 26 countries. "Global" import intensity-adjusted aggregate demand corresponds to the average of the countries' IADs, adjusted for their weight in world imports in 2011.

The participation in global value chains indicator

The participation in global value chains (GVC) indicator measures the share of foreign value added in a country's exports. Indeed, the concept of trade in value added consists not of taking into account the gross trade flows that cross borders, but of measuring the added value per country along an international production chain. For example, for value added exports, it is necessary to deduct from gross exports the share of foreign inputs that enter into their production process.

Let us assume that X is the column vector (x_1, x_2) of global output in product 1 and product 2, and Y the column vector (y_1, y_2) of global consumption per product. The ICIO table can be rewritten in matrix form as:

(14) $X = AX + Y$

where A is the global matrix of technical coefficients. By rearranging this equation in this form:

(15) $X = (Id - A)^{-1} Y = BY$

the Léontief B inverse matrix appears. This indicates the output necessary to serve a given final demand, taking account of the intermediate goods entering into the production process.

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Final consumption can be separated into four components indicating the domestic or foreign origin of the final product, namely $y_{11}+y_{12}$ and $y_{21}+y_{22}$. By writing final consumptions in matrix form, four new production variables xij are defined which are the result of the following matrix product:

(16) $$\begin{pmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{pmatrix} = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \begin{pmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{pmatrix}$$

The term x_{12}, corresponds to the output of country 1 necessary to serve the total final demand of country 2 in product 1. It represents the sum of the production necessary to serve exports y_{12} including the inputs necessary to the production process of product 1, but also the products 1 that are inputs in the production process of country 2, namely: $x_{12}=b_{11}y_{12}+b_{12}y_{22}$. The total output of product 1 is $x_1=x_{11}+x_{12}$.

The value added exports vax_{12} correspond to the value added associated with this domestic production destined to serve the foreign country, namely:

(17) $vax_{12} = v_1 x_{12}$

The share of trade in value added is simply the ratio of value added exports to gross exports, namely:

(18) $vax_{12}\,(\%) = v_1 x_{12} / e_{12}$

The GVC indicator used is the complement to one of the share of the trade in value added, namely:

(19) $GVC = 1 - vax_{12}\,(\%)$

Once again, in the simplified case where the two countries trade only in finished goods, the cross technical coefficients (a_{12} and a_{21}) are zero, and the matrix of technical coefficients A is a diagonal matrix, as is the Léontief B matrix, with the coefficients $b_{ii}=1/(1-a_{ii})=1/v_i$. In this case, the gross exports, e_{12}, are equal to exports of value added, $v_1x_{12}=e_{12}$ and the share of the trade in value added is 100%. The GVC indicator is therefore zero.

GVC indicators calculated from inter-country input-output (ICIO) tables have several limitations: these data are only available after a delay of several years, only cover short periods or a small number of countries and require a large mass of sector-based data. For example, the OECD's product ICIO tables only cover 1995 to 2011, with date five years apart for the first years. The database put together by Johnson and Noguera (2017) goes back to about 1970, but is only published until 2009. Finally, the WIOD2 (World Input Output Database) database stops in 2014, but covers a smaller sample of countries that those of the OECD. Depending on the countries, there are sometimes substantial differences in the GVC indicators calculated based on each of these three sources.

To overcome the difficulties specific to these sources, this report uses a simpler GVC indicator proposed by Marc and Patier (2016). It is based only on bilateral trade matrices and import ratios as a share of GDP. This indicator is very parsimonious as it requires neither a sector-based breakdown of the IOTs nor the separation of imports into intermediate products and final products, in other words it requires 5,000 times less data than a 50-sector ICIO table (the approximate size of the OECD's table for example). In spite of its extreme parsimony, the indicator used is very close to those calculated based on the three other sources (*Graph*). In particular it is very close to the results of Johnson and Noguera (2017) and the WIOD (2016), and also captures a trend close to the OECD's GVC indicator. Another advantage is that it can be produced on a quarterly basis and until the end of 2016, which represents a gain of two years on the most recent alternative indicators.

Marc and Patier's basic idea was to start from an approximate estimation of value added in exports, equal to the share of value added in GDP, and then to correct it by taking into account first of all the imported value added, then the value added exported and then returned to the country of origin. Specifically, the formula used is:

(20) $$vax(\%) = \frac{1}{1+m_i - m_i\left(\sum a_{ij}a_{ji}\frac{m_j}{1+m_j}\right)}$$

where m_i is the share of imports in the the GDP of country i and a_{ij} is the share of the imports of i destined for country j.

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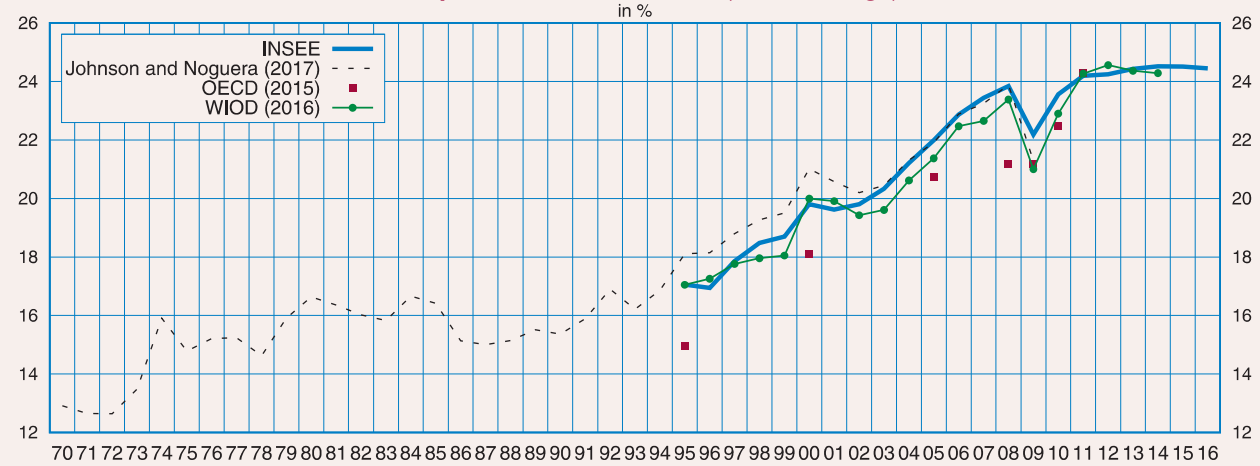
Participation to the value chains (world average)

in %



Sources: Johnson and Noguera, OECD, WIOD, calculations by authors

In the case of the two-country model presented here, $a_{12} = a_{21} = 100\%$ and the indicator used becomes simply:

(21) $$vax(\%) = \frac{1}{1 + \frac{m_1}{1 + m_2}}$$

This is based intuitively on taking the value added, adjusted by the imported value added, itself adjusted by the the exports that return to the country of origin. ■