The Geography of Trade in Goods within the European Union: Intensification of Trade between Old and New Member States over 20 Years

Adel Moutaabbid, Olivier Simon*

The trade openness of European Union (EU) Member States shows that trade in goods are mainly directed to their other European partners. Germany stands as the preferred partner, particularly among new EU Member States. To a certain extent, the same is true for France in respect of Spain and Italy. New EU members, which tend to be very open but economically smaller, account for a much smaller share of intra-European trade in goods.

The pattern of trade in goods, which has been relatively steady over the last 20 years despite the increasing openness of European economies, is not surprising but simply points out the fact that two Member States tend to trade to the extent that they have a significant weight in intra-European trade. It is more interesting to examine whether or not the same two countries trade more than their trading weight alone might suggest. Herein lies the notion of relative trade intensity analysed in this study. On average over the period 1994 2016, the intensity of intra European trade in goods is mainly determined by geography, with the existence of trade clusters (Western European, Nordic countries, Baltic countries, Central Europe and the Mediterranean countries of South-Eastern Europe), at the intersection of which can be found certain countries, notably Germany. However, the evolution of trade intensity over the last 20 years shows closer links between geographically distant countries, in particular between Eastern and Western Europe, in a context of successive EU enlargements over the period.

Free movement of goods is one of the founding principles of the European Union (EU). The principle was first implemented at the end of the 1960s[1], with the creation of a customs union between Member States, and regulates the EU internal market. The resulting increase in trade results in economic gains [Mayer *et al.*, 2018]. In addition, the creation of the eurozone (€Z) in 1999, which now includes 19 of the 28 EU Member States, make trade easier between countries sharing the same currency.

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* Adel Moutaabbid, Olivier Simon, Insee.

1. The Treaty on the Functioning of the EU, which emerged from the Treaty of Rome signed in 1957, is one of the EU's founding texts. Articles 26, 28 and 34 to 36 deal with the free movement of goods. The customs union within the EU means that trade in goods between Member States is not subject to customs duties on imports or exports nor to other taxes having equivalent effect.

Against this background, this study aims at depicting the sie and the structure of trade in goods between EU Member States over the last 20 years. Over the period, the EU has faced many changes as a result of both successive enlargements – in 2004 and then between 2007 and 2013, with many countries from Eastern Europe in particular joining the union – and the enlargement of the €Z. Therefore, the aim here is to illustrate how EU membership has led to an intensification of trade in goods between Member States, particularly among the most recent members.

The data used are from the Organisation for Economic Co-operation and Development's (OECD) BTDIxE[2] database, which provides information on import and export flows by type of goods and by trade partner (bilateral flows) for around 100 countries. For the 28 EU countries, the BTDIxE database covers most Member States between 1994 and 2016, allowing to build indicators of trade openness or indicators of the intensity of trade in goods. To make easier the analysis of the results, and unless otherwise stated, the 28 EU countries are also singled out depending on whether they are historical or new EU members and whether they joined the €Z or not *(Box 1)*.

Trade Openness in 2016 show that EU Member States mainly trade with Other EU Partners

In 2016, the trade openness rate[3] of the four main members of the €Z (Germany, France, Italy and Spain) ranges between 21 and 24 GDP points for France, Italy and Spain, reaching 35 points in the case of Germany *(Figure 1)*. The other historical members of the €Z, *i.e.* smaller countries in terms of size and economic size, are clearly more open, with an openness rate of 48 GDP points on average. New EU members, which are also mostly small in size, have even higher openness rates, with an average of more than 65 points for countries belonging to the €Z and an average of more than 50 points in the case of non-€Z countries. Lastly, among historical EU members outside the €Z, the United Kingdom has an average openness rate of 20 points, while Denmark and Sweden are more open (28 points on average). The contribution of exports and imports to the openness rate reflects the potential imbalance in the external balance of goods of the countries considered, with, for example, a surplus for Germany and Italy and a deficit for France, Spain and the United Kingdom.
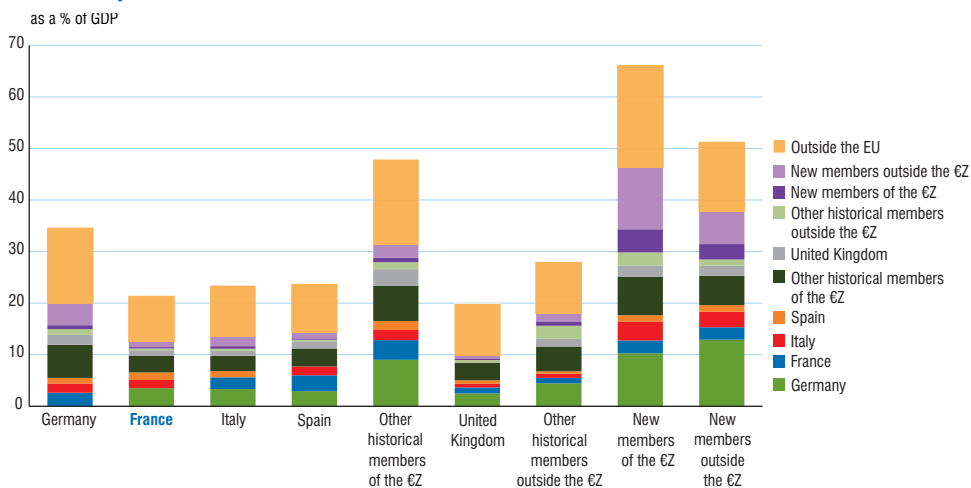
The trade openness rate of EU members mostly concerns trade with other EU members, except for the United Kingdom, which is as open to the EU as it is to the rest of the world. Among the main €Z countries, openness to the EU (hereinafter termed "intra-EU openness") accounts for nearly 60% of trade openness and nearly 65% among all historical EU members (except for the United Kingdom). It accounts for over 70% among all new EU members. In addition, the structure of traded products can vary depending on whether trade openness relates to intra - or extra - EU trade *(Box 3)*.

Germany is the preferred partner for other EU members, with a particularly high rate of openness compared to other EU Member States of similar size *(Figure 2)*. This is in line

2. Bilateral Trade in Goods by Industry and End-use Category
3. Half-sum of imports and exports of goods, expressed in GDP percentage points *(Box 2)*. The trade openness rate considered in this case differs from the usual openness rate, which includes not only trade in goods but also trade in services and is therefore higher. In the case of France, the trade openness rate for goods and services totalled 30% of GDP in 2016.
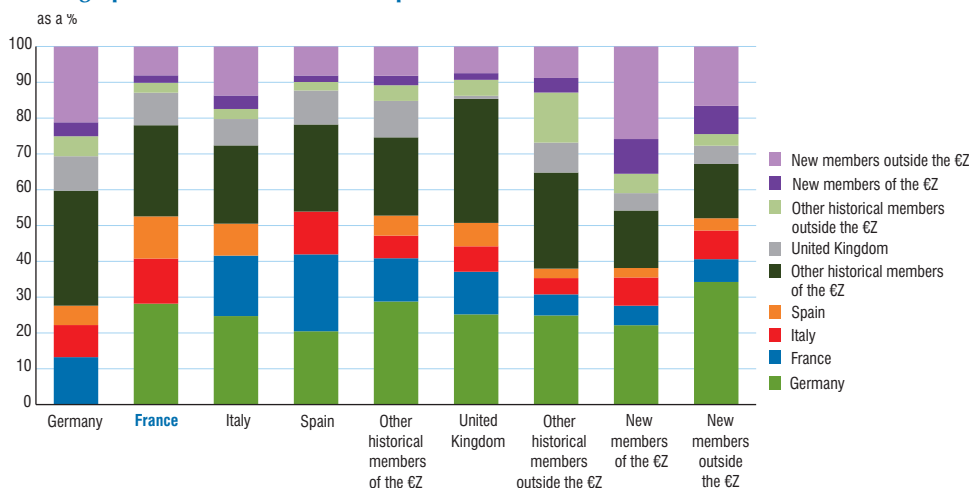
1. Trade Openness Rate (Trade in Goods) in 2016

as a % of GDP

Legend (top to bottom):
- Outside the EU
- New members outside the €Z
- New members of the €Z
- Other historical members outside the €Z
- United Kingdom
- Other historical members of the €Z
- Spain
- Italy
- France
- Germany

Reading Note: In 2016, the trade openness rate of new Eurozone (€Z) members averaged 66 percentage points of GDP, including 20 percentage points directed to partners outside the EU.

Notes: the trade openness rate refers to the half-sum of imports and exports of goods (including intra-zone in the case of a geographical zone) relative to GDP.

Sources: OECD, BTDIxE database and national accounts, authors' calculation

2. Geographical Structure of Trade Openness (Trade in Goods) with EU Members in 2016

as a %

Legend (top to bottom):
- New members outside the €Z
- New members of the €Z
- Other historical members outside the €Z
- United Kingdom
- Other historical members of the €Z
- Spain
- Italy
- France
- Germany

Reading Note: in 2016, the rate of trade openness of new Eurozone (Z€) members to France stood on average at 5% of their rate of openness to the EU.

Notes: the trade openness rate refers to the half-sum of imports and exports of goods (including intra-zone in the case of a geographical zone) relative to GDP.

Sources: OECD, BTDIxE database and national accounts, authors' calculations.

with the frequently cited fragmentation of the value chain[4] linked to globalisation as regards German firms [Marc and Patier, 2016]. In the case of France, openness to Germany in 2016 accounted for nearly 30% of its intra-EU openness, compared to lower percentages recorded for Italy, Spain and the United Kingdom but comparable to other countries, with some even recording higher rates (nearly 35% on average for non-€Z EU member states). Albeit to a lesser extent than Germany, France represents a major trade partner for historical €Z members: in 2016, the rate of openness to France represented 13% and 12% of the intra-EU trade openness of Germany and the United Kingdom respectively, 17% and 21% of the intra-EU trade openness of Italy and Spain and 12% of the intra-EU trade openness of other historical €Z members.

France, Italy and Spain have a strong mutual openness, which represents 25% of the intra-EU opening in the case of France and Italy, and more than 30% in the case of Spain. For its part, Germany is found to be less open to France, Italy and Spain than to other historical EU members, particularly in the €Z. Germany is also very open to new EU members outside the €Z – and so more than France, Italy and Spain. On the other hand, mutual trade between new EU members are important: mutual openness among these countries accounts for more than 35% of intra-EU trade openness in the case of new €Z members and nearly 25% for new members outside the €Z.

Box 1

Country Data and Groups

The OECD's Bilateral Trade in Goods by Industry and End use Category (BTDIxE[1]) is a database providing information on the value of annual flows of imports and exports of goods for about 100 countries – the 34 OECD countries and a selection of non-OECD countries – broken down by type of goods traded, country of origin or destination and type of use (final consumption, intermediate consumption, investment). The data are built using the United Nations Com trade database and OECD historical series (International Trade by Commodity Statistics, ITCS).

The 28 EU Member States are gathered, as appropriate, into five groups of countries, according to their date of accession to the EU[1] and their membership of the eurozone (€Z). A distinction is made between *(map)*:
– historical members of the €Z, including Germany, France, Italy, Spain, Austria, the Benelux countries (Belgium, Luxembourg, the Netherlands), Finland, Greece, Ireland and Portugal. These countries are founding members of the EU

and have belonged to the union since its establishment in 1993 (with the exception of Austria and Finland, which joined in 1995). They subsequently joined the eurozone upon its creation in 1999 (2001 for Greece);
– historical members of the EU outside the €Z (Denmark, the United Kingdom and Sweden). These countries have been EU members since 1993 or 1995 but did not subsequently join the eurozone;
– new members of the EU and €Z: Baltic countries (Estonia, Latvia, Lithuania), Mediterranean countries (Cyprus and Malta) and Central European countries (Slovenia and Slovakia). These countries have been new members of the EU since 2004 and subsequently joined the eurozone between 2007 (Slovenia) and 2015 (Lithuania);
– new EU members outside the eurozone, mainly located in Eastern Europe (Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Hungary). These countries joined the EU in 2004 or later but do not belong to the eurozone.

1. http://www.oecd.org/trade/bilateraltradeingoodsbyindustryandend usecategory.htm
2. The EU was established on 1 November 1993, the date of entry into force of the Maastricht Treaty. Therefore, a Member State's accession to the EU cannot have occurred before 1993.

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4. Fragmentation of the value chain is a mode of production that favours the outsourcing of part of production and the use of foreign subcontractors, thus leading to an intensification of trade flows (imports of inputs, re-exports, etc.).

Box1 (continued)

The European Union in 2018

Norway

Sweden
1995

Finland
1995 1999

Denmark
1993

Estonia
2004 2011

Latvia
2004 2014

Lithuania
2004 2015

Ireland
1993 1999

United Kingdom
1993

Netherlands
1993 1999

Belgium
1993 1999

Luxembourg
1993 1999

Germany
1993 1999

Poland
2004

Czech Rep
2004

Slovakia
2004 2009

Austria
1995 1999

Hungary
2004

Romania
2007

France
1993 1999

Switzerland

Slovenia
2004 2007

Croatia
2013

Bulgaria
2007

Italy
1993 1999

Spain
1993 1999

Portugal
1993 1999

Greece
1993 2001

Malta
2004 2008

Cyprus
2004 2008

Notes: for each country, the date of entering into the European Union and, where applicable, to the eurozone is indicated. The different colours denote historical members of the eurozone (dark green) as opposed to historical EU members outside the eurozone (light green), as well as new eurozone members (dark pink) as opposed to new EU members outside the eurozone (light pink) and the EU's major trade partners (dark grey).

Trade Openness steadily increased in the last 20 Years, Driven by New EU Members

The hierarchy of openness rates remarked in 2016 has remained relatively steady over the past 20 years, with smaller countries showing a higher level of trade openness (Figure 3). Thus, in 1998, the countries that subsequently joined the EU already had high rates of openness, as did historical and small members of the future €Z. On the other hand, the openness rates of the major €Z countries stood at around 20 points.

3. Trade Openness (Trade in Goods) Between 1994 and 2016

as a % of GDP
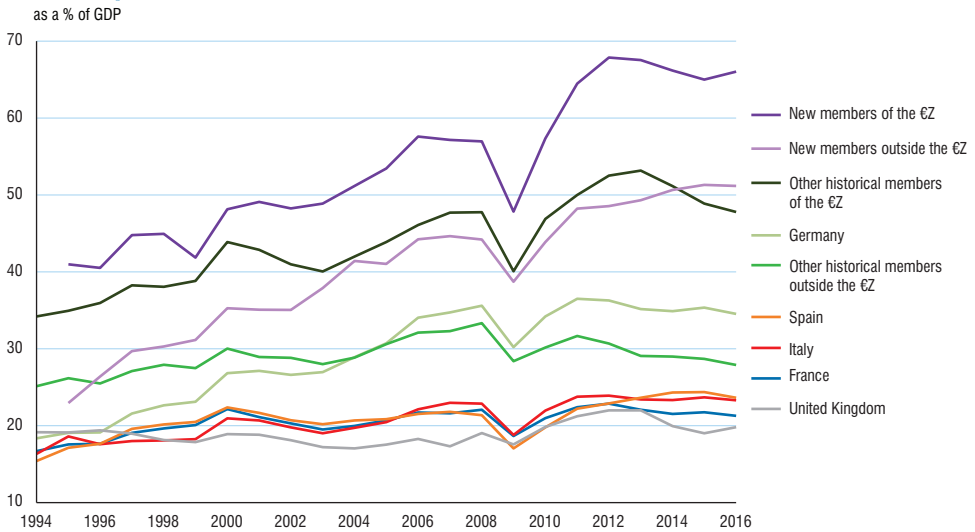
Reading Note: in 2016, Germany's trade openness rate was 35 percentage points of GDP.
Notes: the trade openness rate refers to the half-sum of imports and exports of goods (including intra-zone in the case of a geographical zone) relative to GDP. In the case of the other historical members of the Eurozone, Luxembourg was absent from 1994 to 1998. For new Eurozone members, overall GDP is missing for 1994. For new EU members outside the Eurozone, overall GDP is missing for 1994 and Bulgaria is missing for 1995.
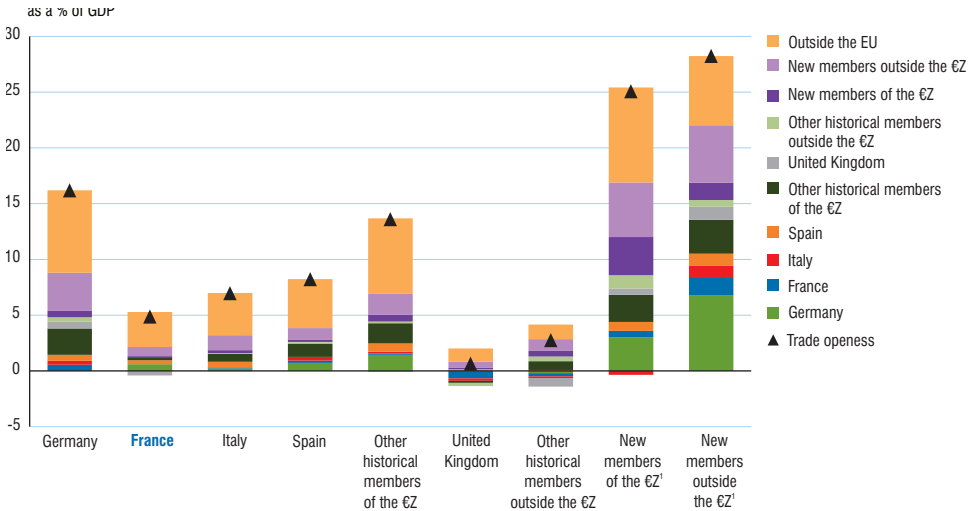*Sources: OECD, BTDIxE database and national accounts, authors' calculations..*

Between 1998 and 2016, the trade openness of EU members (or future members) increased almost continuously, except in 2009 at the beginning of the crisis. The most noticeable change concerns countries that already had a high level of trade openness in 1998, as well as Germany, the only major EU country to record an important increase in trade openness over the entire period.

Among historical EU members, the increase in trade openness recorded since 1994 is primarily the result of openness to partners outside the EU, in links with the rise of emerging countries in global trade *(Figure 4)*. The intra-EU openness of these countries increased significantly towards new EU members outside the €Z, while the mutual openness of major €Z members remained almost unchanged over the period.

Conversely, among new EU members, most of the increase in trade openness is due to intra-EU trade and, in particular, mutual trade between new EU members.

France in the European Union, 2019 edition - Insee References

4. Variation du taux d'ouverture commerciale (échanges de biens en points de PIB) selon le partenaire entre 1994 et 2016

as a % of GDP

Legend:
- Outside the EU
- New members outside the €Z
- New members of the €Z
- Other historical members outside the €Z
- United Kingdom
- Other historical members of the €Z
- Spain
- Italy
- France
- Germany
- ▲ Trade openess

X-axis categories: Germany, France, Italy, Spain, Other historical members of the €Z, United Kingdom, Other historical members outside the €Z, New members of the €Z¹, New members outside the €Z¹

1. Difference between 1995 and 2016.
Reading Note: Germany's trade openness rate increased by 16 percentage points between 1994 and 2016, including 7 percentage points with non-EU partners.
Notes: the trade openness rate refers to the half-sum of imports and exports of goods (including intra-zone in the case of a geographical zone) relative to GDP.
Sources: OECD, BTDIxE database and national accounts, authors' calculations.

The Openness of a Country to a Partner is a measure of trade size but not of their relative intensity

The trade openness rate is a measure of the extent of a country's trade in goods with each of its partners, relative to its GDP. However, it says nothing about the trade that one would expect between two countries based on *a priori* benchmarks. For example, if these countries account for a significant share of world trade, the existence of trade between them is not surprising. On the other hand, the question that arises is whether their mutual trade is greater than what a simple examination of their weight in world trade might indicate: this may be the case if, for example, they are geographically or culturally close countries, or countries belonging to an economic free trade area. In this case, the openness rate as an indicator is not suitable to answe such a question.

One way to address this issue is to consider a bilateral trade intensity index (referred to hereinafter as "relative intensity"). The index aims to measure the extent of trade in goods between two countries within a given area, based on a reference situation in which the two countries trade on the basis of their respective importance in trade in the area *(Box 2)*. A relative intensity higher than 1 means that the two countries trade more than their share in the area's trade, which may be explained, for example, by the fact that they are neighbouring countries. Conversely, a relative intensity lower than 1 means that the two countries trade less than their "weight" in the area's trade.

Hereinafter, the area of study will consist of the 28 EU Member States, plus Switzerland and Norway[5]. For example, France's trade with Spain and Italy is significantly more intense than

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5. Both countries, although not members of the EU, are nevertheless major trading partners since they are both located geographically in Europe and are also signatories to free trade agreements with the EU. For example, they are both members of the European Free Trade Association (EFTA).

with Germany and the United Kingdom over the period of the last 20 years *(Figure 5)*. Trade with the Netherlands (historical €Z member) has been significantly less intensive. The same applies to trade with Slovakia (new €Z member) and Poland (new EU member outside the €Z), although relative intensity in both cases has increased in the last 20 years.

5. Relative Intensity of France's Trade in Goods with Some of its European Partners
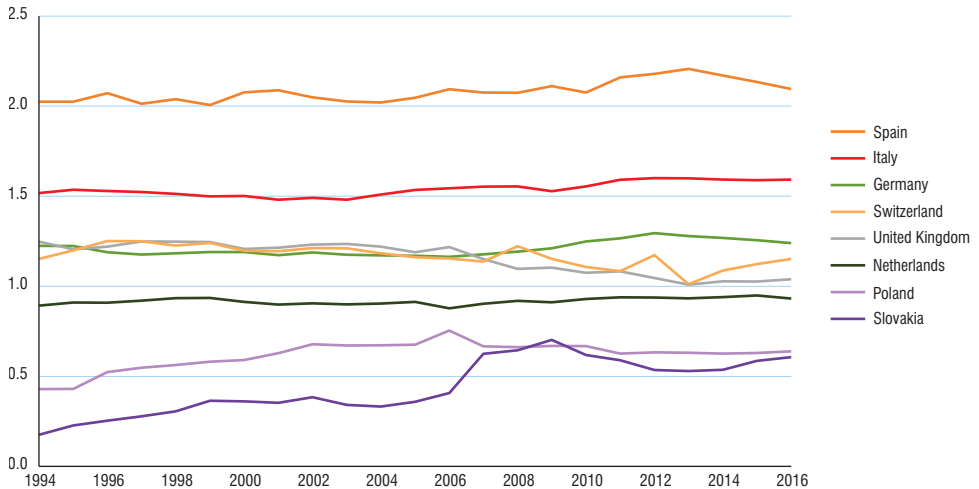
Reading Note: in 2016, the relative intensity of trade in goods from France to Germany was 1.24.
Notes: a relative intensity higher than 1 means that the two countries trade more than their weight in the area's trade. Conversely, a relative intensity of less than 1 means that the two countries trade less than what they "weigh" in the area's trade.
*Sources: OECD, BTDIxE database, authors' calculations.*

On Average Between 1994 to 2016, Relative Trade Intensity is Driven by the Geographical Proximity of Countries

We begin by focusing on the average level of relative intensity obtained each year for the 30 countries studied over the period 1994-2016. One way to easily visualise intensity is to represent it graphically, as a network of relationships *(Box 2)*. A link between two countries shows particularly intense mutual trade relations, especially if the two countries are close to each other in the network[6].

The network of average relative trade intensities from 1994 to 2016 shows clusters strongly influenced by geography *(Figure 6)*. Moving clockwise, the following distinctions can be drawn: Western Europe (including France, Germany and the United Kingdom), Nordic countries, Baltic countries, Central Europe (including Austria) and the Mediterranean countries of South-Eastern Europe. Some countries are sometimes located at the intersection of two clusters, such as Italy between the Mediterranean countries of South-Eastern Europe and Western Europe, the Netherlands and the United Kingdom between Western Europe and Nordic countries and Poland

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6. It should be noted, however, that in network representation, the position of a country in relation to another country depends not only on the relative intensity of their mutual trade relations, but also on all other relative intensities, with the latter operating as "forces" between countries. Therefore, network representation should be seen as a tool for visualising the relative intensity of trade relations between the countries studied.

France in the European Union, 2019 edition - Insee References

6. Network of Average Relative Intensities of Trade in Goods among the 28 EU Countries, Norway and Switzerland over 1994-2016
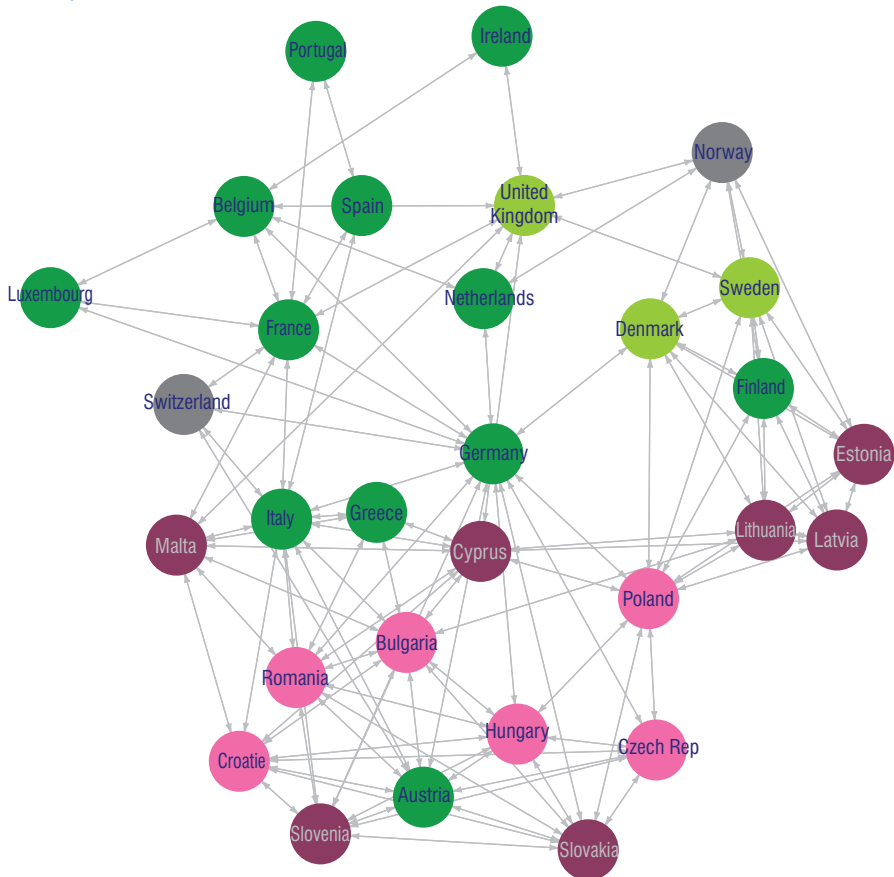
Notes: the average relative intensities are represented by a network of the 30 countries studied. The links refer to particularly high relative intensities (the highest 25% among those calculated). Thus, a link between two countries reflects a particularly high level of intensity in terms of mutual trade in goods, particularly if the two countries are close. The different country colours represent the following groups: long-standing EU members belonging to the eurozone (dark green) or outside the eurozone (light green), new EU members belonging to the eurozone (dark pink) or outside the eurozone (light pink) and countries outside the EU (grey). In addition, some countries are only partially present over the study period: Estonia (present from 1995 onwards), Bulgaria (from 1996) and Luxembourg (from 1999).
Sources: OECD, BTDIxE database, authors' calculations.

between Central Europe and the Baltic states. Germany, for its part, appears at the conjunction of the different clusters. Other countries are located at the extremities of the network, indicating trade flows concentrated in specific countries. Examples include Portugal and Ireland, probably because of their extreme geographical positions in Europe, and Luxembourg, because of the specific nature of its economy.
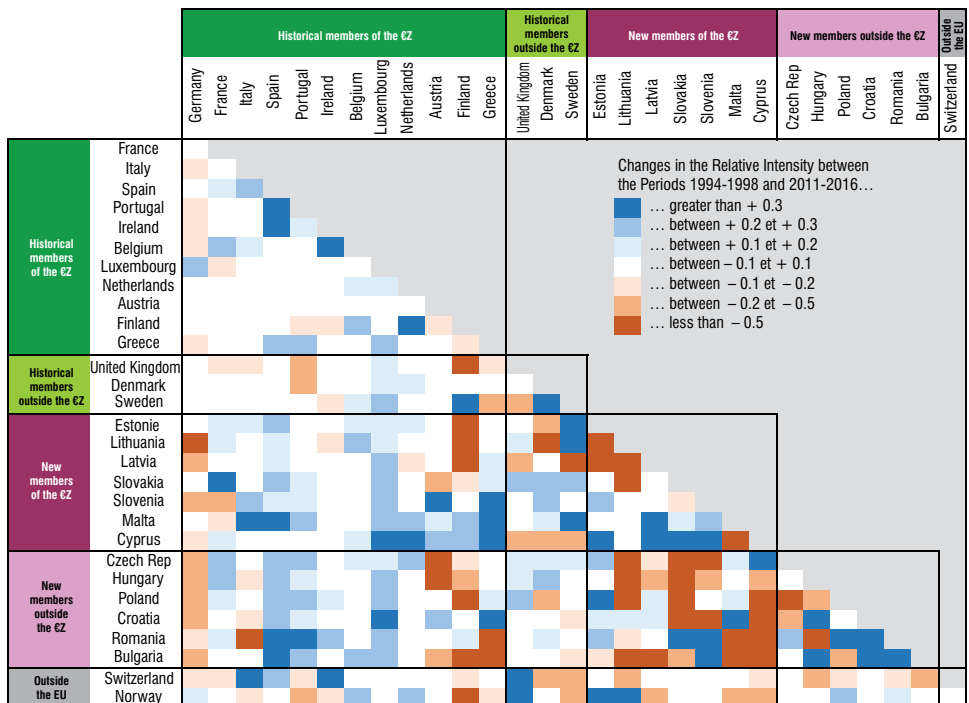
The key role of geography is not surprising at first sight since relative intensity is calculated with reference to a situation without geographical distinction. However, and interestingly, it is not the only determinant of the structure of the network represented. For example, France and Germany – *i.e.* neighbouring countries and founding members of the EU – are closest to each other in the network: while their trade relations are intense on average (intensity of 1.2 over the period 1994-2016), France has even more intense relations with Spain, Belgium and

Italy. Similarly, Germany and Austria, *i.e.* neighbouring and culturally more similar countries, are also not close to each other in the network: although their trade relations are very intense (intensity of 2.3 over the period), Austria's trade with partners such as Slovenia, Hungary and Slovakia is even more intense.

Between the 1990s and the 2010s, Trade Intensified Between EU Countries, namely Between New Members and Historical Members

The changes in relative intensity seen between the 1990s (1994 1998) and the 2010s (2011 2016) point to an increase in the intensity of trade between geographically distant new EU members and historical members *(Figure 7)*. For example, new members have increased the intensity of their trade with France, Spain and Portugal and, to a lesser extent, Belgium and the Netherlands, while trade with Germany and Austria, which are geographically and historically more "natural" partners, has declined in intensity. Among new EU members, the decline in trade intensity is particularly noticeable between neighbouring partners: the Czech Republic with Slovakia, Poland with Hungary and the Czech Republic, Slovenia with Croatia

7. Changes in the Relative Intensity of Trade in Goods among the 28 EU Countries, Norway and Switzerland between the Periods 1994-1998 and 2011-2016

Changes in the Relative Intensity between the Periods 1994-1998 and 2011-2016…
- … greater than + 0.3
- … between + 0.2 et + 0.3
- … between + 0.1 et + 0.2
- … between − 0.1 et + 0.1
- … between − 0.1 et − 0.2
- … between − 0.2 et − 0.5
- … less than − 0.5

Notes: the positive change categories in dark, medium or light blue (or negative in dark, medium and light brown) represent approximately 30% of the most positive (respectively negative) observations. The white boxes represent the 40% of remaining changes (whether positive or negative). In addition, some countries are only partially present over the study period: Estonia (present from 1995 onwards), Bulgaria (from 1996) and Luxembourg (from 1999).
Sources: OECD, BTDIxE database, authors' calculations.

and Hungary, etc. By contrast, some new members, such as Bulgaria, Croatia and Romania, have increased the intensity of their already structurally intense trade.

In light of EU enlargements, the intensification of trade between new and distant historical members may be a reflection of the greater trade integration that has taken place over the period. This has allowed more distant trading partners to trade more between themselves, taking advantage of the free movement of goods in the EU. ∎

Box 2

Definition of Openness Rate and
Relative Trade Intensity Indicators

Trade Openness

Let A be a country (or group of countries) with country B as its trade partner. Let $X_{A->B}$ be the exports from A to B, $M_{A<-B}$ the imports of A from B and GDP_A the GDP of A. The trade openness rate of A to B, or $RaOp_{A->B}$, is defined as the half-sum of the exports of A to B and the imports of A from B, relative to the GDP of A:

$$RaOp_{A->B} = (X_{A->B} + M_{A<-B}) / (2\ GDP_A)$$

The trade openness of A, or $RaOp_A$, is the half-sum of the exports and imports of A, relative to the GDP of A, which is equivalent to the sum of the trade openness rates of A to its different partners:

$$RaOp_A = (X_A + M_A) / (2\ GDP_A) = \Sigma_{B \in R}\ RaOp_{A->B}$$

where X_A are the total exports of A, M_A are the total imports of A and R are all of A's trade partners.

Relative Trade Intensity
(Double Ratio of Relative Trade Intensities)

The definition of relative trade intensity is adapted from Freudenbreg, Gaulier and Ünal-Kesenci [1998]. We consider an area of N countries whose trade within the area can be written in the form of matrix V of size N x N as follows:

$$V = \begin{bmatrix} & & \vdots & \\ \cdots & \cdots & V_{i,j} & \cdots \\ & & \vdots & \\ & & \vdots & \end{bmatrix}$$

where, for countries *i* and *j* belonging to the area considered, $V_{i,j}$ are the trade between *i* and *j* (half sum of exports of *i* to *j* and imports *i* originating from *j*). Note that matrix V is symmetrical and with no diagonal.

The sum of the coefficients in line *i* represents the total V_i of the trade of *i* within the area while the sum of the coefficients in column *j* represents the total V_j of the trade of *j* within the area:

$$V_i = \Sigma_{j=1..N}\ V_{i,j} \quad \text{and} \quad V_j = \Sigma_{i=1..N}\ V_{i,j}$$

Lastly, the sum of the coefficients of matrix V represents total trade W within the area, meaning the total of the exports (or imports) of countries within the area towards partners in the area:

$$W = \Sigma_{i=1..N}\ V_i$$

$V°$ is defined as the trade reference matrix, or normalized matrix, in which the trade of *i* with *j* is a function of the weight of such trade in intra-area trade W and of the trade of *j* within the area:

$$V° = \begin{bmatrix} & & \vdots & \\ \cdots & \cdots & V_{i,j}^{o} & \cdots \\ & & \vdots & \\ & & \vdots & \end{bmatrix}$$

where $V_{i,j}° = (V_j / W)\ V_i$. In other words, the normalized matrix amounts to applying, to each country's trade, the same geographical structure as the one within the area. This definition is based on the principle of independence of the origin and destination of bilateral flows, as set out in the model developed by Savage and Deutsch [1960].

Box 2 (continued)

The bilateral relative intensity ratio of the trade of *i* with *j*, named here relative intensity, is the ratio of the exports of *i* to *j* at their normalized level:

$$\delta_{i,j} = V_{i,j} / V_{i,j}^{\circ} = V_{i,j} \, W / (V_i \, V_j)$$

If $\delta_{i,j} > 1$, (resp. $\delta_{i,j} < 1$) the actual trade of *i* with *j* is higher (resp. lower) than it is when solely applying the independence of origin and destination. Note that $\delta_{i,j} = \delta_{j,i}$. Moreover, relative intensity is closely linked to the intra-area trade framework used as a reference.

Implementation and Network Representation

The BTDIxE database can be used to calculate, for each year between 1994 and 2016, the relative intensity of trade for each couple within the sample of the 30 countries studied, consisting of the 28 EU Member States, Switzerland and Norway[1]. As an example, let us consider the case of France and Germany within this area. In 2016, and according to the BTDIxE database, France's trade with Germany accounted for 2.5% of intra-area trade[2], with French trade and German trade accounting respectively for 10% and 21% of intra-area trade. Therefore, a reference level of France's trade with Germany can be defined by considering that, in the benchmark situation, France's trade with Germany accounts for 21% of France's trade, or 2% of intra-area trade. In other words, France's trade with Germany is 1.25 times greater than the level of trade in the reference situation, corresponding to a relative trade intensity of 1.25 in 2016. The same result can be obtained using a calculation for Germany, thus reflecting the symmetrical nature of the index: in the benchmark situation, Germany's trade with France accounts for 10% of German trade, or 2% of intra-area trade, giving a relative intensity of 1.25.

We take the average, over the period 1994-2016, of the relative intensity of trade between the 30 countries considered, giving a total of 435 relative intensities (due to their symmetrical nature). By way of visualising these intensities, *Figure 6* shows a network representation using the algorithm of Fruchterman and Reingold [1991]. The principle of this representation, as summarised by Bahoken *et al.* [2013], involves considering countries as physical particles subject to opposing forces in pairs:
– an attractive force proportional to the square distance and the magnitude of the relative intensity of trade;
– a repulsive force inversely proportional to distance; This assumption is necessary to allow the system to achieve a "non-trivial" balance; without which, if only the attractive force existed, the particles would concentrate at a single point.

Under these assumptions, the algorithm converges towards a representation of particles that minimises the energy of the system. The representation being invariant by rotation or symmetry, it is fixed by setting initial conditions corresponding to a random placement of the countries considered: in this way, and under these initial conditions, the algorithm converges towards a stable network. In this representation, two countries being close show high relative intensities of trade between these two countries. In addition, for greater visibility, arrows have only been used to connect countries with a high average relative intensity, *i.e.* countries in the top 25% of the 435 highest relative intensities in the sample.

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1. Some countries are not present over the entire study period, including Estonia (present from 1995 onwards), Bulgaria (present from 1996) and Luxembourg (present from 1999). Thus, over the years studied, the ratios are calculated on the basis of a matrix in which the exports of the missing countries are set to zero.
2. This is defined by the sum of exports (or imports, which amounts to the same thing) from the 30 countries in the zone (the EU, Switzerland and Norway) to the other countries in the zone.

Intra-EU openness has a Product Structure Different from that of Openness Towards Non-EU Partners

The trade openness of EU countries examined here reflects the composition of external trade in goods, dominated by manufactured products, in particular machinery and other non-transport manufactured products (textiles, chemicals, metallurgy, etc.). Energy and other goods represent only a much smaller minority share *(Figure)*. Whether examining intra-EU or extra-EU openness, the composition by product is broadly similar, except for some little differences: machinery and energy weigh more heavily in extra-EU trade, corresponding, in the case of energy, to imports of fossil fuels. On the other hand, transport equipment, particularly outside the aviation industry, accounts for a greater share of intra-EU trade, as do other manufactured products.

Transport equipment (excluding aviation) weighs more heavily in the trade of Germany, Spain and new EU members, particularly with EU partners. The trade openness of Germany, new EU members and historical EU members outside the €Z is also characterised by a significant proportion of trade in machinery (to partners outside the EU).

Aerospace manufacturing weighs more heavily in the trade of France and the United Kingdom, particularly with non-EU countries.

Other non-transport manufactured products weigh more heavily in the intra-EU trade of historical €Z members, but account for a smaller share in the case of Germany.

Distribution of the Trade Openness Rate by Goods and by Trading Partner in 2016
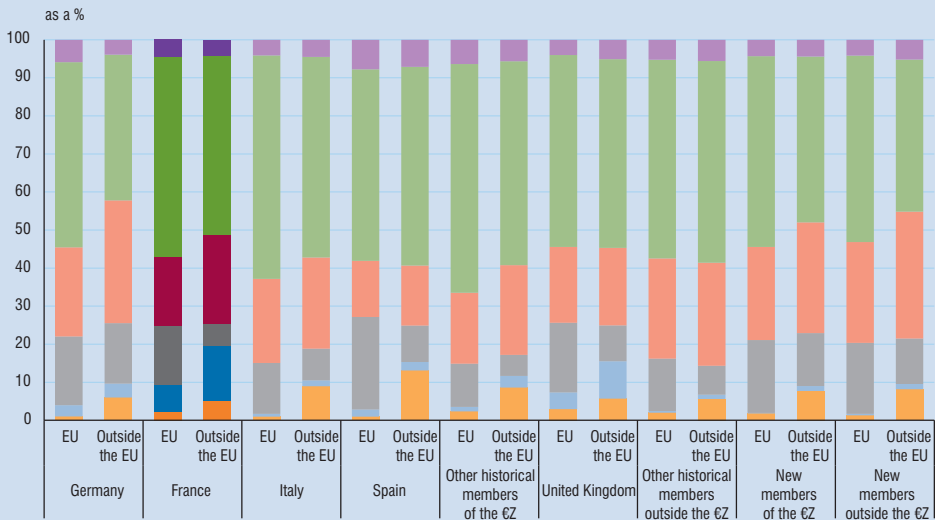
Reading Note: In Germany, 23% of the rate of trade openness with the European Union is linked to trade in machinery, while 4% of the rate of trade openness with partners outside the European Union is linked to trade in aviation products.

Notes: the product categories are based on the ISIC Rev. 4 classification and distinguish between energy (extraction of oil and other fossil fuels, production of gas, electricity, etc.), aircraft and space construction, non-air transport equipment (motor vehicles, railway and naval equipment), machinery (computers, electrical and electronic equipment, etc.), other processing products (food and beverages, textiles, clothing, paper and cardboard, wood, chemicals, pharmaceuticals, coking and refining, plastics, metal, etc.) and other goods.

Sources: OECD, BTDIxE database and national accounts, authors' calculations.

For Further Information

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