Three regions, three economies ?

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Introduction

Are the production structures in the Flemish, Walloon and Brussels Regions interconnected, or conversely, do they tend to function independently of one another ? Is there significant trade between the three regions ? Up to now, very few studies have examined these questions in depth [1], yet they are relevant in various respects.

As a result of the successive transfers of powers in which the Sixth State Reform marked an important step, regional powers have been extended. Substantial areas of economic policy, particularly in regard to regulation and the labour market, are now delegated to the regions. Moreover, the organisation of the production chains is a central focus of the economic literature. Analysis of that subject permits a better understanding of globalisation, which has major economic implications. However, it obliges economists to develop new analysis tools and explore new databases. This article uses detailed data on Belgian firms and the interregional input-output table, and refers to recent research conducted at the Bank on the organisation of value creation chains [2]. While the often complex techniques used do have their limitations, and the results are subject to a margin of error, this approach nevertheless helps to describe, compare and assess the complementarity of each region's production structures.

The first part of the article examines trade relations between Belgian firms. It describes the organisation of the domestic production network, concentrating on trade in intermediate goods and services between firms. That yields various findings which appear to be new. For instance, the probability of a trading relationship between two firms is in inverse proportion to the geographical distance between them. In that regard, it is notable that, even in a small country like Belgium, geographical distance is a key determinant of trade. Taking account of that aspect and a series of economic factors, we assess the relative importance of interregional barriers [3]. Expressed in kilometres, they provide a simple and easily interpreted way of measuring any difficulty in establishing a trading relationship with a firm located in a different region. Finally, we identify sub-networks of closely interconnected firms, with emphasis on their geographical extent and their influence on interregional trade.

The second part of the article quantifies trade between the regions. It presents the contribution of each region to domestic demand and to the exports of the other two regions. It also establishes the scale of the interregional market as an outlet for each region's value creation, and highlights the striking contrast between the destinations of exports from Flanders and those from Wallonia. Finally, it describes the position of each region and the length of the production chains to which they belong. A final discussion concludes the article.

1. Interregional trade

In order to gain an understanding of any regional barriers to trade, we analyse the data on trade between Belgian firms. Those data originate from the individual customer

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(1) See Avonds *et al.* (2016) and IWEPS (2016) for a presentation of the macroeconomic results based on the interregional input-output table for 2010.

(2) See Dhyne *et al.* (2015), Dhyne and Duprez (2015), and Duprez (2014).

(3) Although there are obviously no tariff barriers to trade between the regions, cultural or regulatory factors can nevertheless hamper trade between firms located in two different regions. That is the type of factor that we mean by the term interregional barriers.

base declarations submitted to the tax authorities[1]. For each firm (defined by its VAT number) those data comprise the annual total of all transactions with any other Belgian firm during a given year. These data are available for the period 2002-2014. They provide very interesting information and can be used to produce a microeconomic picture of the organisation of the Belgian production network by describing trade relations between customers and their suppliers. However, they only offer information on relations between Belgian firms, and not relations with firms located abroad. Nor do they tell us anything about goods or services supplied by firms to households or the government. The analysis of interregional trade in this first part therefore concentrates on trade in intermediate goods and services between firms, disregarding goods and services that firms supply to meet final demand. Also, the analysis is based solely on observation of the existence of a trading relationship between two firms, regardless of the amounts of the transactions. In this article, we opt for the macrosectoral approach developed in the second part for analysing the amounts, the goods and services destined to meet final demand, and links with other countries.

1.1 Geography of trade

Nowadays, production processes are highly fragmented, and firms specialise in particular production segments. For the earlier production stages in which they are less proficient – the production of commodities or components, and support services – they make intermediate purchases from suppliers. Economic theory tells us that the costs incurred in finding a supplier depend on geographical factors (the distance between the two firms), economic factors (the size and sector of activity of the two firms), cultural factors (whether the firms have a common language), and regulatory factors (differences in legislation that may limit market access)[2].

TABLE 1 NUMBER OF INTRA- AND INTER-REGIONAL RELATIONSHIPS
(in thousands, 2014)

	Customer's region		
	Flanders	Wallonia	Brussels
Supplier's region			
Flanders	5 043.4	569.5	386.8
Wallonia	264.0	1 165.7	163.3
Brussels	557.0	312.5	389.4

Source: Own calculations.

In order to determine the influence of geographical factors on trade, we considered the economic relationships within a very large group of firms[3]. In 2014, that group comprised 321 824 companies, of which 63 % were located in Flanders, 24 % in Wallonia and 13 % in Brussels (see left-hand panel of chart 1 for a depiction of the geographical location of the firms)[4].

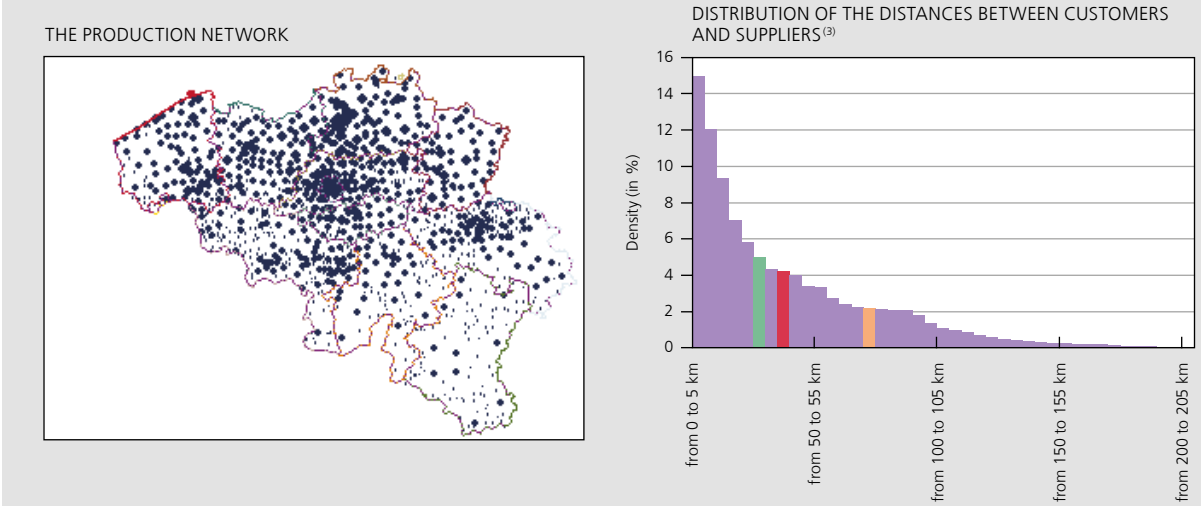
In 2014, 8.9 million bilateral trading relationships were observed (see table 1). Of those, 24 % involved firms located in different regions. Brussels had the largest proportion of relationships with another region. However, relationships between Flanders and Wallonia are certainly not insignificant. Overall, while the bulk of trade takes place within one region, 49 % of Belgian firms are involved in at least one interregional sale.

Although the number of trading relationships appears high, it nevertheless represents only 0.01 % of the potential number of trading relationships that firms could theoretically establish. If every company traded with all other companies, there would be almost 103.6 billion relationships. Obviously, a company normally has only a small number of business customers (and suppliers), as its production capacity is finite. Moreover, a firm forms part of a network involving only a specific group of companies. A firm specialising in heavy metallurgy is hardly likely to have an advertising agency among its customers. More specifically, only 10 % of firms have more than 100 business customers. At the other end of the spectrum, more than 10 % of firms have only one business customer. The median firm has a portfolio of five business customers[5].

Analysis of the geography of trade is also highly informative (see right-hand panel in chart 1). Even in a small country like Belgium, we find that economic relationships are heavily concentrated. For instance, 15 % of the observed relationships concern firms located less than 5 km apart, or even based in the same municipality in almost half of cases. More generally, the median and average distances observed are 25 km and 38 km respectively. Only 10 % of relationships involve a distance of more than 92 km. By comparison, in Belgium the theoretical average distance between two firms selected at random would be 72 km,

(1) See Dhyne *et al.* (2015) for a description of this database.
(2) This approach based on gravity equations has hitherto been used mainly in the analysis of international trade flows. Here we apply it to domestic relationships.
(3) This group consists of firms registered both with the Central Balance Sheet Office and the Bank's Central Balance Sheet Office. Firms which do not have an address in Belgium and firms subject to VAT which do not file annual accounts were excluded.
(4) The geographical location of firms is based solely on the post code of their registered office. However, that criterion is imperfect since it introduces a bias, increasing the relative importance of the Brussels region to the detriment of the other two regions.
(5) Only firms in our sample are considered as customers. Trading relationships with foreign firms or households are therefore disregarded.

CHART 1 GEOGRAPHICAL LOCATION OF BELGIAN FIRMS[1] AND DISTRIBUTION OF TRADING DISTANCES[2]
(2014)



Source: Own calculations.

(1) The analysis only considers firms registered with the Central Balance Sheet Office for which we have the post code of the registered office and the sector of activity at the 2-digit NACE Rev2 level. The location of the firms is based solely on the post code of their registered office. That criterion introduces a bias, increasing the relative importance of the Brussels Region to the detriment of the other two regions.

(2) The distance between customers and their suppliers is measured as the crow flies. For two firms located in the same municipality, that distance is set arbitrarily at 0, because the firms' location is based on the post code of the companies and not on their full address. Each bar represents a 5 km interval (the 0-5 km interval therefore covers relations between firms in the same municipality and between firms located in municipalities less than 5 km apart).

(3) The green bar indicates the median observed distance (25 km), the red bar indicates the average observed distance (38 km), and the brown bar indicates the theoretical average distance for trade organised at random (72 km).

while the longest distance found in our sample – namely between Ostend and Aubange – is 277 km.

In order to assess the impact of the geographical dimension on relationships between firms, we used a Probit equation to model the probability of a relationship between two firms. This type of modelling allows us to quantify the relative importance of regional barriers to trade between firms, while taking account of the firms' location. This control is in fact crucial. The average distance between suppliers and customers is 32 km if the relationship involves two companies based in the same region, whereas it is 82 km if one of them is located in Flanders and the other in Wallonia. That additional distance may be part of the reason for the lower incidence of interregional relationships.

On the lines of the gravity equations used in international economics, we first modelled the probability that two firms will trade with one another according to a set of geographical characteristics, namely the distance between them, a variable indicating whether the two firms are located in the same municipality, and a number of variables indicating the regions involved[1] (see table 2).

However, the geographical dimension is not the only factor in the organisation of the domestic production network. Moreover, if distance alone were taken into account, that would not explain any asymmetry of relations between two regions. Economic factors are also in play. In a second specification, we added economic aspects of the supplier firms and the customers, such as their respective size, their respective sectors of activity, a variable indicating whether they are active in the same sector and a variable defining whether there is any financial involvement between them[2].

Specifications (1) and (2) were estimated on the basis of a sample of 132 981 firms each employing at least one paid worker in 2014. The results confirm that geographical distance has a significant effect on the probability of a trading relationship between two companies. The farther apart they are, the lower the probability of trade between them. Similarly, firms located in different municipalities, active in different sectors or having no financial links are significantly less likely to trade with one another.

(1) The intraregional relationship of the supplier's region is taken as the reference.

(2) We would point out that we do not control for whether the firm has an establishment in another region, nor do we consider the productive efficiency of the supplier or customer. However, the firm's size does permit an indirect – albeit imperfect – control for these two characteristics, as large firms more often have multiple establishments, and are generally more productive.

TABLE 2 ESTIMATED PROBABILITY OF A TRADING RELATIONSHIP

(between supplier *i* and customer *j*, average marginal effects × 1000 [1], 2014)

	(1)	(2)	(3)	(4) *i* and *j* in industry	(5) *i* in support services
Distance between *i* and *j* (km)	–0.007***	–0.007***	–0.005***	–0.014***	–0.005***
i and *j* not in the same municipality	–2.033***	–1.992***	–1.960***	–5.053***	–1.278***
i in Flanders, *j* in Wallonia [2]	–0.144***	–0.145***	–0.055**	–0.096	–0.139***
i in Flanders, *j* in Brussels [2]	–0.245***	–0.238***	–0.150***	–0.266	–0.159***
i in Wallonia, *j* in Flanders [2]	–0.427***	–0.485***	–0.150***	–0.617	–0.244***
i in Wallonia, *j* in Brussels [2]	–0.359***	–0.392***	–0.072**	–0.351	–0.110
i in Brussels, *j* in Flanders [2]	0.046**	–0.002	0.028	–0.433	0.020
i in Brussels, *j* in Wallonia [2]	0.190***	0.148***	0.154***	–0.015	0.176**
Size of *i*	–	0.220***	0.225***	0.557***	0.198***
Size of *j*	–	0.156***	0.159***	0.652***	0.148***
i and *j* not in the same sector of activity	–	–0.300***	–0.239***	–2.734***	–0.663***
No financial link between *i* and *j*	–	–301.8***	–278.3***	–	–
i and *j* not in the same sub-network in 2014	–	–	–0.377***	–0.725***	–0.314***
i and *j* not in the same sub-network in 2013 and in 2014	–	–	–0.232***	–0.911***	–0.198***
Sectoral binary variables of *i* and *j*	No	Yes	Yes	Yes	Yes
Pseudo R^2	0.059	0.200	0.225	0.202	0.216

Source: Own calculations

(1) Supplier and customer sizes are measured as the log of employment in full-time equivalents. The sector of activity is defined according to the 2-digit NACE Rev2 nomenclature. The existence of a financial link means that one of the two firms (supplier or customer) has a stake in the other. The sectoral binary variables concern the sectors of activity of the supplier and the customer considered separately. To estimate the Probit regression, we made a random selection of pairs of firms that do not trade with one another and added them to our sample of observed relationships. We used the adapted econometric techniques to correct the sampling bias introduced by that methodology (see Manski and Lerman, 1977). The symbols ***, ** and * indicate that the average marginal effect is significant at 1, 5 and 10 % respectively.

(2) Taking as the reference the intraregional relationship of *i* (the supplier). This barrier is an estimate of the effect that a firm in a given region experiences when selling to a firm in one of the other two regions.

These different variables reflect search costs which increase with the geographical or economic distance between suppliers and potential customers. However, those costs are lower for larger firms.

The different interregional binary variables estimate the scale of the barriers to interregional trade. For ease of interpretation, their impact on the probability of the formation of trading links can be converted into additional kilometres implicit in the crossing of a regional border [1]. Except in the case of firms based in the Brussels Region, which seem able to trade more easily with firms outside their own region than within it [2], our calculations indicate that it is relatively harder for a company to find a customer in another region. Let us consider the case of a Flemish supplier and two identical potential customers, one Flemish and the other Walloon, which are therefore located at the same distance from the supplier and have the same economic characteristics. According to our estimates, if a Flemish supplier forms a relationship with the Walloon customer rather than the customer in its own region, that entails an implicit additional distance of around 20 km. This naturally reduces the probability of selling goods and services to the Walloon firm rather than to the Flemish firm. For a Walloon supplier, the interregional barrier is greater. According to our calculations, it comes to almost 70 km for a Walloon company wishing to sell to a Flemish firm rather than to an otherwise identical Walloon company. Finally, in the case of sales to a firm in Brussels, the interregional barriers for a Flemish firm and a Walloon company are 40 and 60 km respectively.

(1) In order to express the impact of the interregional binary variables in kilometres, it is necessary to divide the marginal effect of each interregional binary variable by the marginal effect of the distance.

(2) This result is probably influenced by the presence in Brussels of the registered offices of many firms which have establishments in the other two region.

1.2 Geography of the production systems

While the regional barriers estimated in the previous section may reflect cultural or regulatory impediments, they may equally be due to incompatibilities in the

production systems. Why would a firm in the Kortrijk district trade with a firm in the Virton district if the former is active in electronic components and the latter in timber production [1] ? Any network effects have also been ignored up to now. The relationship between two customers of the same supplier could well be easier than a relationship between two firms with no common link.

(1) Such effects are only imperfectly captured by the sectoral binary variables included in our second specification, as the sectors of activity of suppliers and customers are introduced separately and not together. These sectoral binary variables therefore reflect sectoral differences in terms of the average number of customers or suppliers, but not the fact that a relationship involving, for example, firms in branches 02 (forestry and logging) and 26 (manufacture of computer, electronic and optical products) is less probable than a transaction between firms in branches 01 (crop and animal production, hunting and related service activities) and 10 (manufacture of food products).

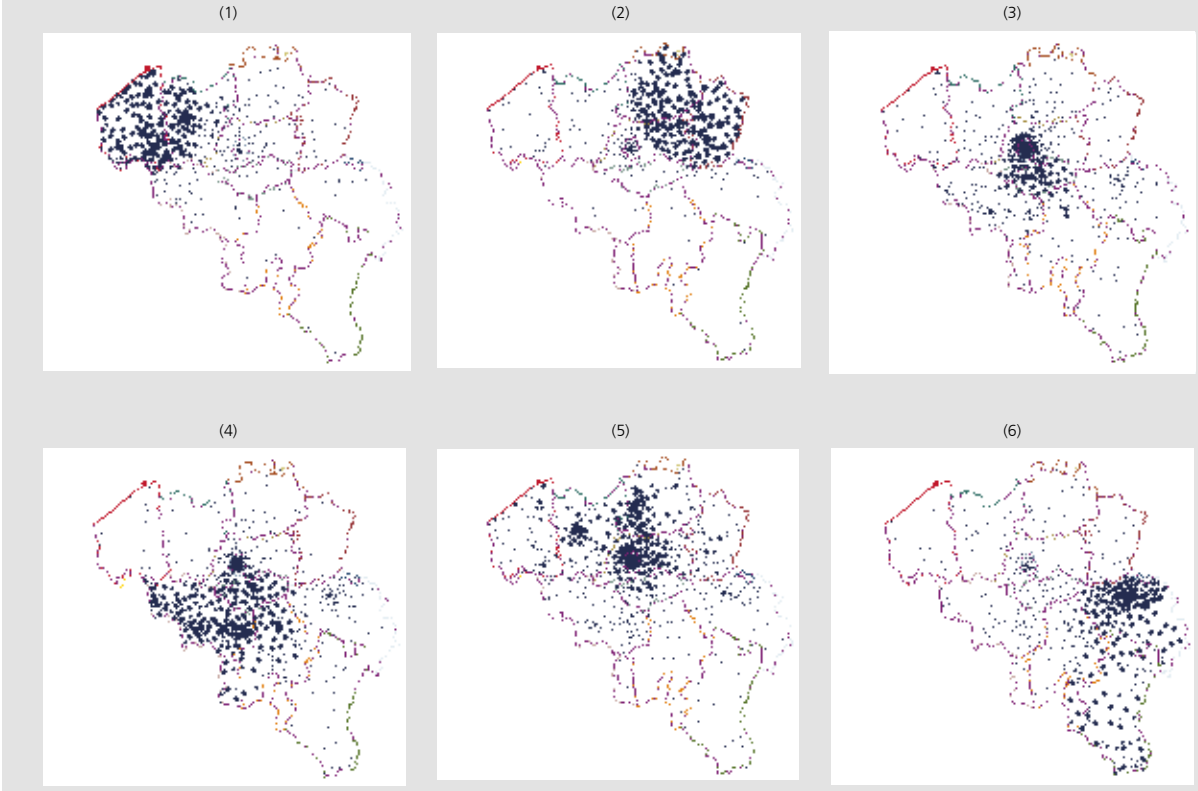
(2) 'Community detection' is the usual term. However, in order to avoid the ambiguity of the word "community" in the Belgian context, we prefer the term sub-network detection. The community detection method applied to a graph or network is similar to a data clustering technique and involves determining the best division of the network into interconnected sub-networks. By using detection algorithms, such as the Louvain algorithm, the aim is to identify subsets of individuals (in our case firms) which potentially have mutual connections. It should be stressed that two firms in the same sub-network do not necessarily trade with one another but are indirectly linked via mutual customers or suppliers, customers of customers, etc. The detailed presentation of this method is beyond the scope of this article. For full details, see Blondel *et al.* (2008).

(3) However, network effects may be connected with a degree of geographical proximity.

Network theory proposes a methodological approach which can take account of these two aspects by identifying groups of individuals or firms which are potentially more closely connected with one another. Use of the 'community detection' method [2] makes it possible to identify groups of firms for which the probability of mutual trade is above average. These groups, referred to here as economic sub-networks, imply that as well as belonging to mutual production systems the companies have indirect links, in particular, which may connect them. By definition, the methodological approach disregards the geographical dimension of trade in that it takes no account of the geographical distance between the firms [3].

Before describing the results, it is worth specifying that the economic sub-networks are obtained on the basis of the links observed for a given year. For 2014, the application of this method identifies a total of 18 sub-networks. However, that number may vary from year to year. In order to isolate the structural component, we defined the sub-networks for 2013-2014 as sub-sets

CHART 2 THE SIX MAIN ECONOMIC SUB-NETWORKS [1]
(2013-2014)



Source : Own calculations.
(1) On the basis of the Louvain community detection algorithm applied to relationships observed in 2013 and in 2014.

of firms belonging to the same sub-network in both 2013 and 2014. We also repeated the exercise for the whole period 2002-2014. It emerges that the main sub-networks for 2013-2014 are found fairly systematically throughout the observation period.

By way of illustration, chart 2 shows the six main sub-networks for 2013-2014. Altogether, they represent 64 % of employment and 60 % of value added in our sample of firms, and half of exports. Sub-networks (1), (2) and (5) consist mainly of Flemish firms. Sub-network (1), the largest, comprises 40 507 firms of which 97 % are located in Flanders (mainly in West Flanders and East Flanders). Sub-network (2) contains 39 504 firms of which 99 % are Flemish (more specifically, from the provinces of Antwerp and Limburg). Sub-network (5), which contains 28 247 firms, consists of 75 % Flemish firms, 20 % Brussels companies and 5 % Walloon firms (it mainly covers the province of Flemish Brabant, part of the provinces of Antwerp and East Flanders, and the Brussels Region).

Sub-networks (4) and (6) are predominantly Walloon. Sub-network (4) comprises 32 402 firms of which 80 % are located in Wallonia (more specifically in the provinces of Hainaut, Walloon Brabant and Namur), 15 % in Brussels and 5 % in Flanders. Sub-network (6) contains 22 961 firms of which 98 % are Walloon (mainly in the provinces of Liège and Luxembourg). Sub-network (3) is dominated by Brussels. It comprises 33 608 firms of which 60 % are located in Brussels, 15 % in Flanders and 25 % in Wallonia. However, we would point out that each sub-network includes large Brussels firms which play a key role in establishing links between the different regions. We would also mention that while all the sub-networks have their own particular geographical territory, they differ relatively little in terms of economic structure. By way of information, only sub-network (1) features a relative dominance of industrial firms (particularly in textiles and the manufacture of machinery and equipment).

The geographical dimension of the economic sub-networks is particularly marked. The barriers to interregional trade estimated in section 1.1 therefore partly reflect that segmentation of the production structure. On the basis of the economic sub-networks identified, links between a firm located in West Flanders and another firm in Limburg seem just as unusual as links between a firm in West Flanders and another firm in Walloon Brabant. We therefore effected a third estimation using two additional variables to take account of the influence of membership of an economic sub-network (see table 2). The first variable indicates whether the customer and the supplier belong to the same sub-network in both 2013 and 2014, while the second specifies whether that applies only in 2014. This latter variable therefore takes account of new links formed in 2014.

The results of the third specification confirm the importance of economic sub-networks, as we find that the distance increases by around 120 km if the supplier and the customer do not belong to the same sub-network either in 2013 or in 2014. Membership of the same sub-network in 2014 but not in 2013 already implicitly increases the distance by 75 km. Membership of the same economic sub-network apparently does much to facilitate trade.

The fact that economic sub-networks are taken into account affects the estimation of regional barriers (see chart 3). The Flanders-Wallonia and Wallonia-Flanders barriers are now estimated respectively at 10 and 30 km. These barriers are only half as great as those calculated in section 1.1. However, the relative handicap suffered by Walloon suppliers is still considerable in view of the country's size.

So far we have analysed the interregional barriers in general. However, the question is whether they affect all sectors of activity to the same degree or whether,

CHART 3 ESTIMATION OF BARRIERS TO INTERREGIONAL TRADE

(expressed in additional kilometres, 2014)

Source : Own calculations.

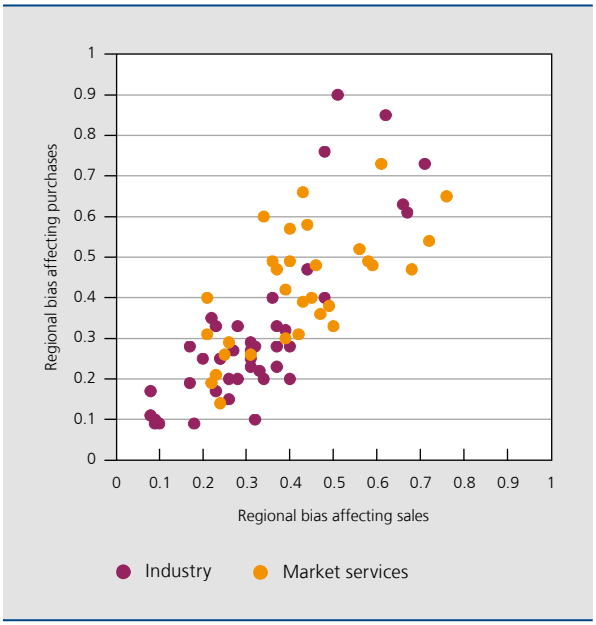
conversely, there are characteristics specific to certain types of traded goods or services. To answer that question we made two additional estimations (see table 2). Specification (4) was estimated solely on the basis of relations between industrial firms, whereas (5) only considers relations in which the supplier is active in the support service branches[1]. The first sub-sample covers trade involving mainly transfers of goods between firms, while the second covers intangible trade for which the cultural barriers are likely to be more important, as such trade involves a greater degree of interpersonal relationships.

The results of specifications (4) and (5) display marked contrasts. In the case of purely industrial relationships there is no longer any significant interregional barrier. While some coefficients have a high value, that value never differs significantly from 0. Conversely, in the case of suppliers of support services, the barriers are still considerable.

We conducted an additional test to check whether a regional bias affects the consumption of certain specific products. For that purpose, we used sectoral data from the interregional input-output table for 2010. For each branch of activity, we compared the actual regional breakdown of sales with a theoretical breakdown that neutralised any regional bias. We conducted the same exercise for purchases. Ultimately, each branch of activity has a dual indicator of regional bias: one for (intermediate and final) sales, and one for (intermediate) purchases. The higher these indicators, the greater the regional bias.

In general, the results of this exercise are in line with the econometric results obtained for specifications (4) and (5) in table 2. The regional bias is greater in the service branches than in the industrial branches (see chart 4)[2]. Differences in legislation, culture and language are probably more of an impediment for service providers than for manufacturers, whose products are more universal. For example, car manufacturing, textiles and the food industry are highly integrated, whereas the regional bias is relatively considerable in the case of accommodation, information services, legal and accounting activities, and other specialist and technical activities. However, there are some evident exceptions. The wholesale trade, employment-related activities, and maritime or road transport are relatively well integrated. Conversely, as regards industry, the extraction, treatment and distribution of water and the production, transport and distribution of electricity are highly regional in character, but so are glass manufacturing and the pharmaceuticals industry.

CHART 4 REGIONAL BIAS BY BRANCH OF ACTIVITY[1]



Source: Own calculations based on tables produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

(1) The regional bias is constructed by the following method. For each pair *i–j* (*i* is the supplier branch of activity, *j* the customer branch of activity or final demand), the interregional input-output table provides a regional breakdown in the form of a matrix [3X3]. The regional bias of each pair (*i,j*) is the ratio between (1) the square of the sum of the differences between the observed regional breakdown and a theoretical regional breakdown and (2) the variance of the nine components of the regional breakdown matrix. The theoretical breakdown is constructed by modelling the regional breakdown of purchases (sales) of branch *j* concerning branch *i* on the regional breakdown of production *i* (sales by *j*). For a branch of activity *i*, the regional bias in the case of sales is the weighted sum of the biases (*i,j*) weighted by the importance of branch *j* as a customer. For a branch of activity *j*, the regional bias in the case of purchases is the weighted sum of the biases (*i,j*) weighted by the importance of branch *i* as a supplier.

2. The three regions in the value chains

So far, we have not examined a number of elements such as goods and services supplied to final demand (households or the government) in the various regions, the value of trade between the regions, and the regions' economic relations with foreign countries. The purpose of this section is to address these points, primarily on the basis of the interregional input-output table for 2010[3]. In order to position the domestic production segment in global value chains we have also used the WIOD's world input-output matrix for 2010. This global macroeconomic framework enables us to define the position of the regions in global value chains.

(1) In specification (4), we consider industrial customers only, so as to ensure that the inclusion of transport or trade firms does not influence the results. In specification (5), we take account of all potential customers.

(2) It is worth noting that, in general, the branches of activity where sales are affected by a substantial regional bias also display a strong regional bias in their purchases (see chart 4), as we find that most of the points are concentrated around a 45° line. We therefore refer to a regional bias with no distinction between purchases and sales.

(3) This table was produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

However, the macroeconomic analysis does have its limitations. The results obtained at macrosectoral level are subject to a margin of error since we consider that production within each branch of activity is perfectly homogenous (see annex). Moreover, the world input-output matrix is not an official statistic, and its construction entailed some trade-offs[1]. In addition, the interregional input-output table is only available for 2010, so that the set of results presented in this section only concern the year 2010. We therefore cannot comment on any recent developments, although tests on the microeconomic data used in the first part seem to indicate that the organisation of the production chains is relatively stable.

2.1 Origin of the goods and services in the three regions

The first question concerns the origin of the goods and services consumed (or invested[2]) in the three regions. There are various ways of tackling this question. We can try to identify the suppliers of those goods and services, but given the fragmentation of production chains we know that it is not necessarily these direct suppliers who contribute the most to the manufacturing of their products. In some cases, they only act as a trade intermediary, reselling products that they have bought in. Even if that is not the case, the producing suppliers do not create the whole of the value of their products. In order to make them they first buy intermediate goods and services (commodities, energy, components, support services, etc.) from other firms. That is evident from the number of trading relationships (see part 1). In this part, rather than focusing on just the direct suppliers, we shall look at all the (domestic or foreign) producers who have been involved in making the products consumed or invested.

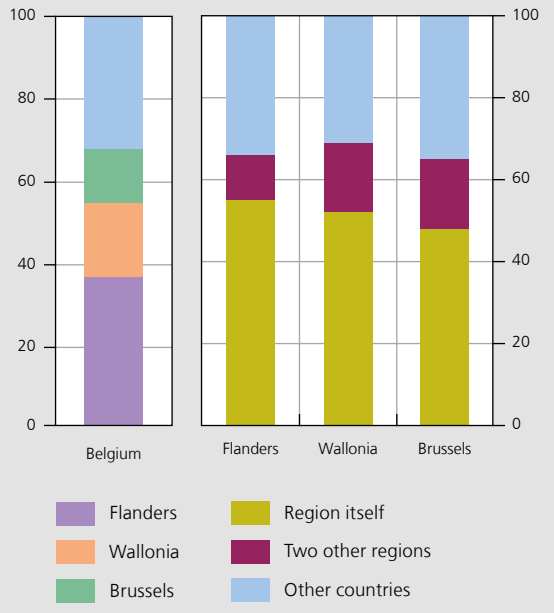
For each of these successive producers we can assess their contribution, i.e. the value that they have added to the end products. That value added is what generates income and employment for firms. The reasoning applies equally to individual firms and to groups of companies within a region or country[3]. The total contributions of foreign countries and of each region are thus obtained by simply aggregating the value added of the firms. We shall use that criterion to measure their respective participation in domestic final demand. We would point out that this approach to some extent disregards the specific content of the products in question. In fact, when buying a mobile phone, a household consumes copper, oil, chemical activities, assembly activities, trade services, transport and logistical services, advertising services, etc.

A large proportion of the value of the goods and services consumed or invested in Belgium comes from other countries, as their contribution actually amounts to 33 % (see chart 5), a figure that includes the value of the imports of end products consumed or invested without further processing. It also includes the value of the intermediate imports used in domestic production processes meeting Belgian final demand. The rest of the value consumed or invested in Belgium is created in Belgium. The contributions of the Flemish, Walloon and Brussels Regions to Belgian domestic demand amount to 37 %, 18 % and 13 % respectively.

The regional approach enables us to go a step further in assessing the contributions to each region's final demand. In comparative terms, Flemish domestic final demand is the biggest consumer of value added produced

CHART 5 REGIONAL CONTRIBUTIONS TO DOMESTIC FINAL DEMAND

(in %[1], 2010)



Source: Own calculations based on tables produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

(1) Excluding taxes on products minus subsidies.

(1) The world input-output matrix is not validated by national statistics institutions. Inconsistencies with national statistics therefore cannot be ruled out.

(2) By definition, domestic final demand includes final consumption expenditure of households, non-profit institutions (NPIs) and governments, as well as investment (gross fixed capital formation).

(3) In economics, one of the most commonly used aggregates is GDP, which is equal to gross value added at basic prices (€ 326.5 billion in Belgium in 2010) plus taxes on products minus subsidies (€ 38.6 billion in 2010). However, all the results presented in our analysis concern value added only, and take no account of taxes on products minus subsidies.

in its own region (55 %), against 52 % for Wallonia and 48 % for Brussels. Nonetheless, the final demand of each region is based to a significant extent on value from the other two regions. The contributions of the Walloon and Brussels Regions amount to 11 % of final demand in Flanders, compared to 34 % for other countries. The other two regions therefore represent almost a quarter of the external value consumed or invested by Flanders, the remaining three-quarters coming from foreign countries. For Wallonia and Brussels, one-third comes from the other two regions compared to two-thirds originating from abroad.

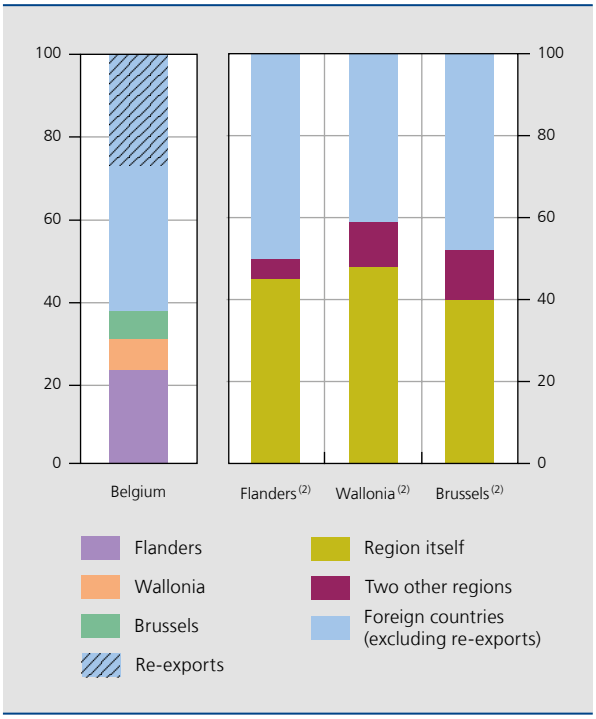
Not all Belgian production is consumed in Belgium. Part of it is exported to other countries. To assess the participation of the various regions in exports, we shall here analyse their contributions in terms of value added. Admittedly, there are alternative indicators for assessing the role of the various regions in exports. Traditionally, exports are allocated according to the regions that dispatch the products abroad. However, owing to the fragmentation of the production chains, that indicator must be interpreted with caution, because a region may serve as the transit point for a product leaving Belgian territory. That has a particular influence on exports by Flanders, because the two main gateways to foreign markets – the port of Antwerp and Zaventem airport – are located in the Flemish Region. Another option which avoids these gateway effects entails considering the region in which the exported goods are produced. Once again, the criterion is imperfect because it identifies the region that effects the final domestic stage in production, yet to make products destined for the rest of the world, a region's firms use inputs originating from other regions or countries. To take account of indirect participation in exports, we use the concept of each region's value added contained in Belgian exports, regardless of the exporting region [1] and the nature of the exported products.

Flanders contributes 24 % to Belgium's exports, compared to 7 % for both Wallonia and Brussels (see chart 6). With a contribution of 62 %, other countries therefore have a predominant weight in Belgian exports, even exceeding their weight in domestic demand. There are two reasons for that. First, the exports consist mainly of industrial goods, production of which involves large quantities of commodities or components from abroad. Conversely, domestic consumption is based more on services, including public services. The production of services requires fewer foreign inputs. Also, the importance of foreign countries in Belgium's exports is due to Belgium's central position at the heart of the EU and to its excellent, highly developed logistics and transport infrastructures. Belgium acts as a trade hub and, in particular, forms the gateway to the north European market via the activities of its sea ports. In practice, a significant proportion of Belgium's imports is immediately re-exported. Those re-exports simultaneously inflate Belgium's imports and (the foreign value content of its) exports [2].

Re-exports are also recorded in the regional export statistics and inflate them by a factor of around 40 % [3]. However, to obtain a more accurate picture of the exports of the three regions, we exclude re-exports, focusing solely on domestic export production. In comparative terms, Walloon export production contains the most value added originating from its own region (48 %), against 45 % for Flanders and 40 % for Brussels. The regions also rely on value created outside their territory. The contribution of

CHART 6 REGIONAL CONTRIBUTIONS TO EXPORTED PRODUCTION

(in % [1], 2010)



Source : Own calculations based on tables produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

(1) Excluding taxes on products minus subsidies.

(2) Region of production of the goods and services exported to other countries.

(1) A discussion of the role of the various stages leading up to the actual export of the product is beyond the scope of this article. For more information on producing and exporting regions, see Avonds *et al.* (2016).

(2) In the case of re-exports, the value added is due to any transport and logistical costs invoiced to resident firms.

(3) According to the regional input-output table, re-exports totalled € 50.4 billion for Flanders, € 12.5 billion for Wallonia and € 11.5 billion for Brussels. As pointed out in the IWEPS report (2016), in the input-output system imports of goods destined for re-export are imputed to the region where the flows originate, and not to the trade intermediary for whom only the trade margin received is recorded.

the other two regions comes to almost a fifth of that external value that Wallonia and Brussels include in their respective exports (the remaining four-fifths coming from abroad), compared to almost a tenth of that used by Flanders (the other nine-tenths originating from foreign countries). Although these interregional contributions are smaller than those recorded for domestic final demand, notably because more foreign components are used in the processes of producing exported industrial goods, they are still significant.

2.2 Destinations of the value added of the three regions

The preceding section aimed to define the origin of the goods and services consumed or invested. In that section, we assessed interregional trade from the point of view of the final consumers. Nonetheless, we can also analyse trade from the producers' point of view. Analysing trade from that angle amounts to identifying the final destinations of the value added created in each region. We expressly refer to final destinations, and not direct destinations. For producers of intermediate goods and services, that means that we determine the place of consumption of the finished product incorporating these intermediate components.

Obviously, a region's own market is its preferred final destination. Thus, 64 % of Walloon value added, 57 % of Flemish value added and 28 % of Brussels value added is ultimately consumed or invested in the respective regions (see table 3)[1]. Each region also responds to the final demand from the other two regions and from foreign countries. In that regard, the interregional market represents around a sixth of the value added sold by Flanders outside its region, compared to a quarter for Wallonia and over half for Brussels[2]. These shares are considerable. In the case of Flanders, the other two regions together are more important than any neighbouring country considered individually. Moreover, the importance of the Walloon market alone is comparable to that of the German or French market, and greater than that of the Dutch market. For Wallonia and Brussels, the interregional market is more important than the German and French markets together.

One peculiarity of the Brussels Region is that it exports a very large proportion of its value added to the other two regions. It also imports value added from Flanders and Wallonia, but to a much lesser degree. It therefore records a positive value added balance in regard to the other two regions (see chart 7)[3]. That is due partly to the very numerous services (financial, government, education services, etc.) that Brussels provides for the other two

(1) This table is similar to table 7 in Avonds *et al.* (2016). The differences are due to estimation of the repatriation effect in our analysis, i.e. the Belgian value added initially exported but later reimported for consumption or investment purposes.

(2) In accordance with the residence principle, household consumption expenditure is apportioned according to the household's region of residence, regardless of the place of purchase. For more information, see Avonds *et al.* (2016).

(3) For a region or country, the total balance of value added corresponds exactly to the total trade balance established on the basis of imports and exports of goods and services. However, bilateral balances may diverge depending on the approach (for more information, see Benedetto (2012), among others). Thus, in contrast to the traditional concept, the balance of value added between two countries (or regions) can neutralise the effect of re-exports or imported inputs which could inflate the exports of a country (or region).

TABLE 3 DESTINATIONS OF THE VALUE ADDED OF THE THREE REGIONS

(in %, 2010)

	Region creating the value added			
	Brussels	Flanders	Wallonia	Total Belgium
Destination of the value added[1]				
Belgium	67.9	63.3	73.0	66.5
Brussels	28.2	2.4	2.3	7.3
Flanders	27.0	56.6	6.5	39.0
Wallonia	12.7	4.4	64.2	20.2
Foreign countries	32.1	36.7	27.0	33.5
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Own calculations based on tables produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

(1) The results include an estimate of any repatriation effect, namely the amount of each region's value added which is initially exported but then re-imported for consumption or investment purposes.

regions, notably as the capital (see Avonds *et al.*, 2016). Commuter flows also play a key role. According to data from Steunpunt Werk, 238 000 Flemish residents and 133 000 Walloon residents worked in Brussels in 2010, compared to 42 000 and 23 000 Brussels residents working in Flanders and Wallonia respectively. In an interregional context, commuters contribute to the production of their place of work. However, their expenditure forms part of the final demand of their region of residence. The flow of commuters to Brussels therefore tends to create an imbalance in favour of Brussels, because it inflates both the Brussels value added and the Flemish and Walloon final demand. Incidentally, Flanders records a positive balance in relation to Wallonia. Commuter flows may likewise exert an influence, as the number of commuters travelling from Wallonia to Flanders was 20 000 greater than the number commuting in the opposite direction.

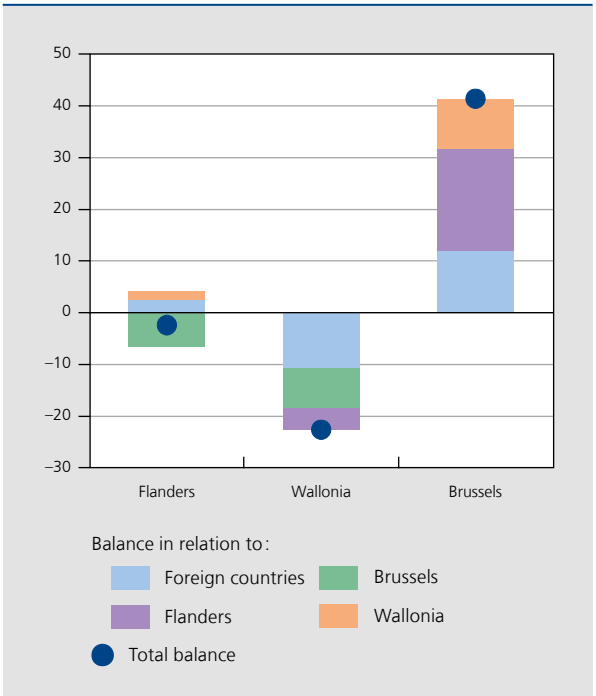
Each region also exports part of its value added to foreign countries. There are various routes via which those exports may leave Belgian territory. Part of the value added exported by a region is incorporated in its own export production. Another part crosses the Belgian frontier via the production exported by the other regions. That is the case where a region provides inputs for the export production facilities of the other two regions. Generally, the value added content then changes its form. For example, some firms provide support services the value of which is incorporated in exports of industrial products by another region.

It is interesting to compare the countries of destination of regional exports. In general, trading with certain specific markets influences the dynamics of exports or their sensitivity to certain international shocks. The traditional international trade approach identifies the direct recipient of the exports, but exports to one country may in turn be rerouted to a third country, possibly after processing. The map of end recipients of exports, and hence of the exported value added that they incorporate, differs from the map of direct recipients. According to the final destination approach, some non-European countries (United States, BRICS) are more important to Belgium than the traditional approach would suggest. On average, Belgian exports thus travel almost 1 850 km before reaching their direct recipient, whereas the final consumption takes place, on average, almost 3 000 km away [1].

The final destinations of the exported value added vary from one region to another. Although these results are subject to a margin of error (see annex), a map of the final destinations shows that Flanders primarily serves markets to the north and east of Belgium, particularly Germany, the Netherlands, India, China and Japan (see chart 8). Conversely, the final domestic demand of countries to the south and west of Belgium, notably France, Italy, Spain, the United States and Brazil, is proportionately more important for Wallonia's exported value added. For the Brussels Region, the map (which is not represented on the chart) is comparable overall to the map for Wallonia. However, there are some specific characteristics. For instance, Brussels value added is destined more for the United States and the United Kingdom.

CHART 7 BALANCE OF INTERREGIONAL TRADE IN VALUE ADDED

(in % of the total value added of the region considered, 2010)



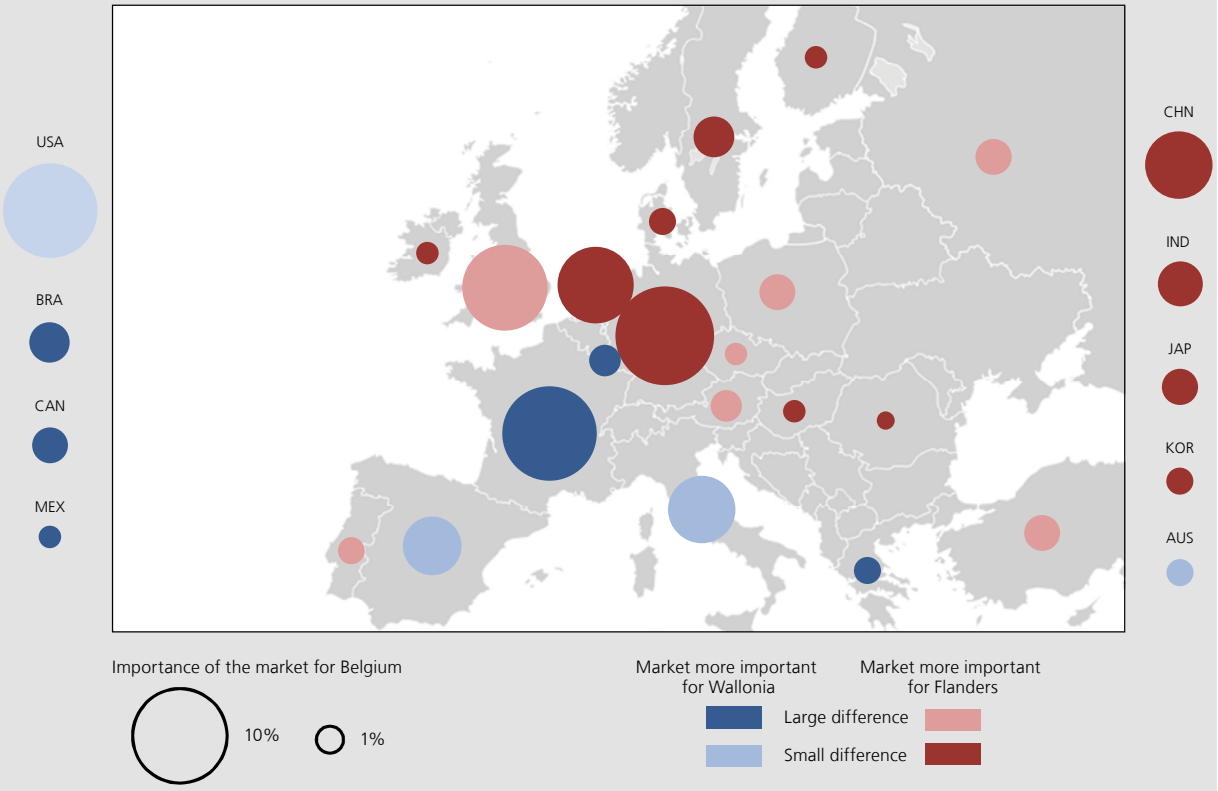
Source: Own calculations based on tables produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

2.3 Position of the three regions in the value chains

Indicators concerning the length of and position in global production chains can be used to describe the production structures of the various regions [2]. The length of the chain, i.e. its degree of fragmentation, and the position within it have a number of economic implications. If

(1) See Duprez (2014).
(2) See Dhyne and Duprez (2015) for more information on these two indicators.

CHART 8 GEOGRAPHICAL DISTRIBUTION OF EXPORTED VALUE ADDED (1)



Source: Own calculations based on tables produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

(1) The size of the disc represents the importance of the market for exported Belgian value added. The colour of the disc depends on the difference between the share of a given market in the total Wallonian exported value added and the corresponding share for Flanders. The difference is called small (large) if it is below (above) 10 %.

a region forms part of fragmented chains, that means that its firms are generally more specialised in a particular production segment. That specialisation is often accompanied by greater productivity. Also, if a region is positioned towards the end of production chains, its companies are fairly close to the final consumer. In some sectors that is a considerable advantage, as competition with foreign firms, particularly those from emerging countries, is less fierce and the margins are bigger.

On average, Flemish and Brussels firms form part of relatively fragmented chains with more than three production links. Conversely, Wallonia is more active in fairly short production chains. In terms of position, Brussels comes at quite an early stage in the production chains. Wallonia and Flanders are closer to the final consumer (see table 4).

TABLE 4 POSITION IN AND LENGTH OF REGIONAL PRODUCTION CHAINS (1)

(2010)

	Average length of the production chains	Average position in the production chains
Flanders	3.22	0.48
Wallonia	2.74	0.49
Brussels	3.12	0.45

Source: Own calculations based on tables produced in the context of the agreement between the FPB, the BISA, the SVR and the IWEPS on "Regional monetary input-output tables for Belgium for the year 2010".

(1) The average length of the production chains of which the regions form part expresses the average number of successive processing stages in making the end products. The position is an indicator ranging between 0 and 1. A value close to 0 means an initial production stage, while a value close to 1 indicates a final production stage, close to the final consumer. See Dhyne and Duprez (2015) for more information on these indicators.

Conclusion

The production structures of the various regions have their own specific characteristics. Wallonia forms part of less fragmented chains than Flanders and Brussels. Also, Brussels holds a position closer to the start of the chains, while Flanders and Wallonia are closer to the final consumer. The final destinations of the exported value added likewise vary from one region to another. The value created in Flanders is destined more for the markets to the north and east of Belgium (particularly Germany, the Netherlands, India and China), while Walloon value added is more specifically destined for countries to the south and west of Belgium (such as France, Italy, the United States and Brazil). The Brussels Region's destinations are comparable overall to those of Wallonia, although the United States and the United Kingdom represent a larger share.

Various authors have studied the tariff and non-tariff barriers confronting export firms (see Araujo *et al.* (2012) for Belgium). As far as we know, this article is the first to study potential interregional barriers within Belgium. For that purpose, we examined trading relationships between firms. According to our estimates, a Flemish firm faces an implicit barrier equivalent to 10 km when wishing to sell to a Walloon firm, whereas a Walloon supplier is confronted by an implicit barrier of 30 km if it wants to find a business customer in Flanders. That is also reflected at overall level. For its final consumption or its export production, Flanders is less dependent on value originating from the other two regions than are Wallonia and Brussels. The Brussels Region is a special case, to some degree. Firms there often form a link between the various economic sub-networks. They do not appear to encounter any barriers when establishing connections with firms in the other two regions. The role of Brussels as the capital providing services for the whole country, and the presence there of registered offices of numerous firms which also have establishments in the other two regions, probably make it easier to trade.

Of course, the scale of the barriers must be viewed in perspective. Economic relations between supplier firms and customer firms are determined primarily by the distance between them, regardless of their respective regions. Economic factors, such as the firms' size, their sector of activity, any financial links or their membership of the same economic sub-network, also play a crucial role. In that regard, a map of the sub-networks indicates the existence of a number of areas in which trading is more intense. In addition, interregional barriers mainly have an impact on trade in services. Legislation, language and culture are more important factors for services than for industrial goods.

The presence of interregional barriers does not prevent trade between the various regions. In Belgium, one in two firms sells to a business customer in another region. Overall, each of the three regions is involved in the exports of the other two. In addition, 6.8 % of Flemish value added is invested or consumed by households or government services in the other two regions. For Flanders, the importance of the Walloon market alone is comparable to that of the German or French market, and exceeds that of the Dutch market. For Wallonia and Brussels, the interregional market absorbs 8.8 % and 39.7 % respectively of the value added created. It is more important than the German and French markets taken together.

Finally, Belgium can take advantage of the specific characteristics of each region by limiting the interregional barriers to trade. Those barriers often have an adverse effect for suppliers and customers, as well as weakening the interregional market which represents a significant outlet. In that connection, we would stress the importance of regional policies designed to facilitate interregional trade, in particular via coordinated legislation. Worker training policies, particularly those concerning acquisition of another language, and policies that encourage mobility, are likewise important catalysts of that trade.

Annex

This annex presents the matrix calculation formulas used for the analysis in the second part of the article.

For any vector F (366X1) which gives the quantity of demand for each product/region (122 products in each of the three regions), the content in terms of value added originating from a branch/region *i* is the component *i* of the matrix E (366X1), in which:

$$E=(V^{T}\#B*F),$$

V^{T} (1X366) being the transposed vector of the coefficients of value added v_i/p_i for each product/region *i* (v_i is the value added and p_i is the production of the branch/region *i*). B (366X366) is the Leontief inverse matrix $(I–A)^{-1}$, in which I (366X366) is the identity matrix and each coefficient $a_{ij}=c_{ij}/p_j$ of matrix A (366X366) gives the quantity of products of branch/region *i* necessary to produce one unit of product of branch/region *j* (c_{ij} is the intermediate consumption by branch/region *j* of products of branch/region *i* and p_j is the total production of branch/region *j*). # is the symbol of the multiplication component by component.

To ascertain the destinations of the exported regional value added, the international exports of each branch of activity/region were divided into four categories: intermediate goods, end products, intermediate services and final services. The distinction between goods exports and services exports is derived from the interregional input-output table. Conversely, the breakdown between intermediate products and end products is not directly available. It is estimated by modelling it on the breakdown between intermediate products and end products in the case of products destined for the domestic market. For each category *y* (*y* = intermediate goods, end products, intermediate services, final services), the direct destination *d* (among C countries) of the exported value added originating from a branch/region *i* is the component (*i,d*) of matrix E^{y} (366XC), in which:

$$E^{y}=(V^{T}\#B*F^{y})*G^{y},$$

V^{T} (1X366) being the transposed vector of the coefficients of value added v^{i}/p^{i} for each product/region *i* (v^{i} is the value added and p^{i} is the production of the branch/region *i*). B (366X366) = $(I–A)^{-1}$ the Leontief inverse matrix, F^{y} (366X366) divides each product/producer region *i* into products/exporting region *j* (for a given product, the exporting region exports the production originating from the three regions). G^{y} (366XC) gives the breakdown by country of final destination (the C destinations are the countries in the WIOD world input-output matrix, shown in the columns) of an exported unit of product/exporting region.

For end products and final services, the final destination is assumed to be the direct destination, derived from the foreign trade data for goods and the balance of payments data for services[(1)]. For intermediate goods and services, the direct destination is obtained from the foreign trade data for goods and the balance of payments data for services. However, the direct destination is not the final destination.

To ascertain the final destinations of exports of intermediate goods and services, we analysed the WIOD data using the method proposed by Wang *et al.* (2013). That method makes it possible to find the final destinations by means of the following breakdown of intermediate exports of each Belgian product *i* (among the N products included in the WIOD) to a destination *r* (among the C destinations included in the WIOD):

$$(A^{r}B^{rr}Y^{rr})+\sum_{t\neq r}(A^{r}B^{rt}Y^{tt})+\sum_{t\neq r}(A^{r}B^{rr}Y^{rt})+\sum_{t\neq r,u}\sum_{u\neq r,t}(A^{r}B^{ru}Y^{ut})$$

A^{k} (NXN) is the sub-matrix that gives the intermediate use in country *k* of intermediate products exported by Belgium. B^{kl} (NXN) is the Leontief inverse matrix. Y^{kl} (NX1) is the domestic final consumption by country *l* of end products sold by country *k*.

(1) This breakdown is imperfect because the foreign trade data differ from those in the regional accounts (see Avonds *et al.* (2016) and IWEPS (2016)).The same applies to the balance of payments data.

Bibliography

Araujo L., G. Mion and E. Ornelas (2012), *Institutions and export dynamics*, NBB, Working Paper 220.

Avonds L., C. Hambÿe, B. Hertveldt, B. Michel, B. Van den Cruyce (2016), *Analysis of the interregional input-output table for 2010*, FBP, Working Paper 5.

Benedetto J. (2012), "Implications and Interpretations of Value-Added Trade Balances", *Journal of International commerce and economics*, 4(2), 39–53.

Blondel, V., J-L. Guillaume, R. Lambiotte and E. Lefevre (2008), *Fast unfolding of communities in large networks*, Journal of Statistical Mechanics – Theory and Experiments, 10.

Dhyne E. and C. Duprez (2015), "Has the crisis altered the Belgian economy's DNA?", NBB, *Economic Review*, September, 31–43.

Dhyne E., G. Magerman and S. Rubínová (2015), *The Belgian production network 2002-2012*, NBB, Working Paper 288.

Duprez C. (2014), "Value creation in exports: a diagnosis for Belgium", NBB, *Economic Review*, September, 27–42.

IWEPS (2016), *Rapport sur l'économie wallonne*.

Manski C. F. and S. R. Lerman (1977), "The Estimation of Choice Probabilities from Choice Based Samples", *Econometrica*, 45(8), 1977-1988.

Wang Z., S-J Wei and K. Zhu (2013), *Quantifying international production sharing at the bilateral and sector levels*, NBER, Working Paper series, 19677.