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Sector-Level Analysis of the Impact of Brexit on the EU-28

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Contents

List of Tables and Figures

Executive Summary

This report presents a **sector-level impact analysis of Brexit** on each of the EU-28. By using our Global Network Model (GNM), we **dig deeper** than most existing studies on brexit and consider the sector-level effects in every EU country in terms of **value added and in job losses, both** in the case of a **soft** as in a **hard brexit**. In addition, we focus on **fifteen** different economic **sectors** and compare Brexit-outcomes for the EU-28 member states. In doing so, this report goes beyond the study by Vandenbussche et al. (2017) that only considered aggregate EU country-level results. In the report, we first explain the **methodology** and underlying **assumptions** of the **Global Network model**. Then we explain the simulations and the resulting numbers. Subsequently, we present the **results** both at the **aggregate** country-level as well as the **sector-level**. We interpret the results with special attention to the position of Belgium.

The findings in this report clearly show that the perception that brexit only affects Western-European countries that are geographically close to the UK, is not true. Countries like Poland, Sweden, Slovakia, the Czech Republic, Romania and Hungary also show substantial job losses. This should not come as a surprise, given the presence of network effects in European global value chains. Therefore, brexit is an **EU wide story**.

The losses that the EU-28 face under a **soft brexit** are significantly **smaller** than under a **hard brexit**. A soft brexit for the **EU-27** implies a loss of **0,38%** of its **GDP** and around **280 000** jobs lost, while for the **UK** 1.2% of GDP and around **140 000 jobs** would be lost. A **hard brexit** for the **EU-27** implies a loss of **1,54%** of its **GDP** and **1 200 000 jobs lost**, while for the **UK 4,4%** of its **GDP** and around **525 000 jobs** would be lost. Short-term **losses** will only be **minimized** if a **soft brexit** future relationship is pursued like the one the EU has negotiated with Turkey or Norway. An FTA-model would also limit trade barriers. However, in the latter case non-tariff barriers would remain a serious hurdle for many companies and a serious stepdown of current arrangements within the European single market. When we take a look at other EU- member states Ireland, The Netherlands, Denmark, France, Germany, Sweden, Portugal, Poland, the Czech Republic, Cyprus, Malta and Hungary are also hit hard in relative terms. With a job loss of 526.830 the United Kingdom is hit the hardest in relative as well as in absolute terms.

We find **Belgium** to be amongst the **most badly affected** countries in the EU-27 relative to its size. For many sectors we find Belgium to belong to the **top 3** of the most affected countries in the EU-27. This holds both under a **soft Brexit** scenario as well as a **hard Brexit** scenario. This conclusion is independent of how we measure the losses.

For a **hard Brexit**, with WTO tariffs in place and corresponding non-tariff measures, the aggregate short-term impact for **Belgium** would be a loss of **2,35%** of its GDP. This would correspond to **42 000 jobs** lost for **Belgium**. These losses are expected to result from a no deal scenario with the UK. Of the 42 000 jobs lost in Belgium, **28 000** would be lost in **Flanders** (which corresponds to 1.06% of the Flemish working population), 10 000 in Wallonia and about 4000 in Brussels.

In the case of a **soft Brexit** scenario, without a change in tariffs but with an increase in non-tariff measures, the aggregate short-term impact for **Belgium** would be a loss of **0.58% of GDP**. The corresponds to **10 000 jobs** lost **for Belgium**. This would be the outcome under a future relationship with the United Kingdom that is similar to the one that the EU currently has with **Norway** and/or **Turkey**.

In terms of sectors, a **hard Brexit** would have a disastrous effect on the European **Food and Beverages** sector with over 112 000 jobs that would be lost for Europe as a whole. The Food sector is the most heavily affected sector in **Belgium** with job losses amounting up to 4500 jobs. Also in Ireland, Poland, the Netherlands and Denmark this sector will be significantly hit.

A **hard brexit** would also have a major impact on **EU-27 Textiles** industry with nearly 130 000 jobs lost. Also the **Belgian Textiles** industry would be hit hard. One in 7 jobs in that sector risks being lost. Other member states that would be severely impacted include Italy and Portugal.

For **Pharmaceuticals, Chemical and Petroleum products**, a hard brexit is expected to cost the EU around €14 billion of value added. For **Belgium**, the loss in value added in these sectors would be around €1,3 billion. Given that the petro-chemical cluster in Antwerp is considered to be one of the most important engines of the Belgian economy, it is safe to say that Brexit threatens to lower the overall growth of the Belgian economy. In the Netherlands, Poland, France, Italy and Germany this sector would also be hit hard.

Not just goods sectors, but also **services sectors** would be badly affected. Goods and services are often bundled and traded as one integrated package. Trade barriers on goods therefore also negatively impact the services embedded in them (and vice versa). This study confirms the strong link between goods and services and predicts a substantial loss for the Belgian employment in Administrative & support activities, Legal & Accounting services and Retail activities. In the **Retail sector**, Belgium ranks first in Europe with more than 2400 jobs lost in case of hard Brexit.

The results in this study are obtained by using the **Global Network model** (GNM) (KUL, 2017). The EU is modelled as a network economy to trace the global value chains between countries. The model considers **both direct trade** to the UK as well as **indirect trade** via third countries to the UK. It provides a more complete picture than the traditional gravitas models used in many other studies which only look at direct trade effects. The focus is on the **trade impact** of Brexit and the **network tissue** that is **lost** under Brexit. This makes the model inherently a **short-term one**. It predicts the trade destruction effects of Brexit by sector, before trade diversion takes place. We do not make speculative guesses about the new network tissue that can be formed in the future. The underlying assumption is that it takes time to find new suppliers and customers in the event of Brexit and supply chain disruptions. The model also assumes that factors of production such as labor and capital do not move in the short-run.

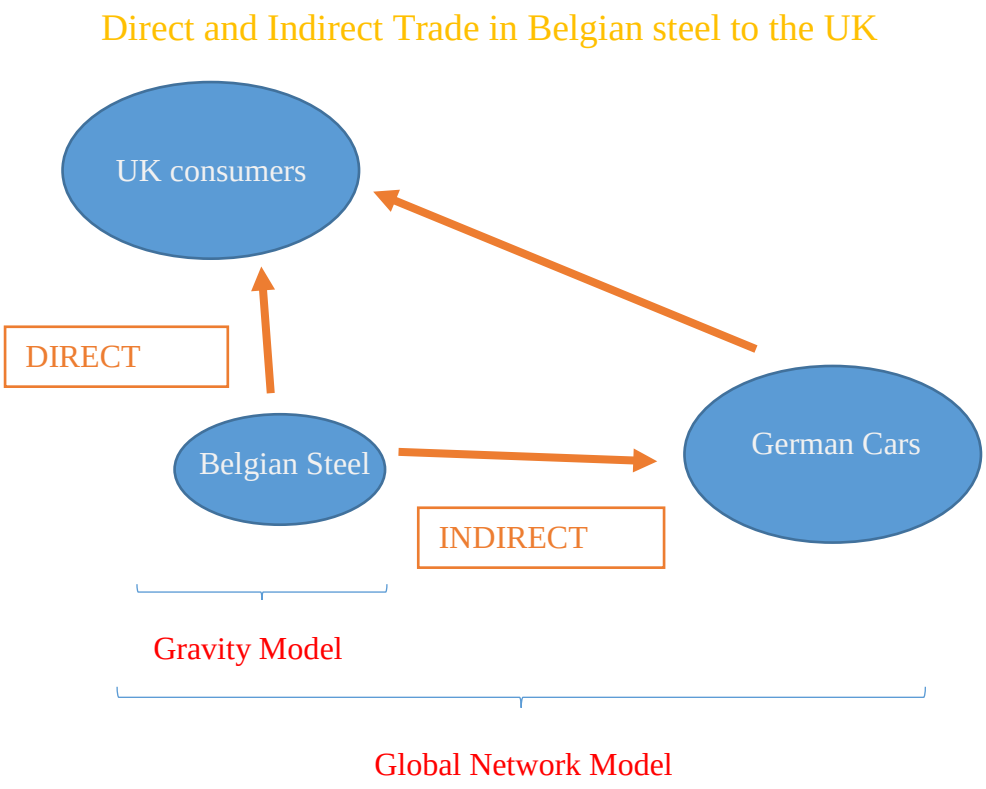
Global Network Model

In this paper we use the Global Network Model (GNM), developed at the KU Leuven (henceforth KUL, 2017) to assess the economic effects of Brexit and other trade shocks. This model has a number of specific characteristics that we explain below. We start by explaining some of the most critical assumptions of the theory model and continue with details on the empirical implementation.

I.1. Assumptions of the Model

1) the model is a **global input-output model** at sector level. It takes all exports and imports between **sectors** into account rather than just looking at exports and imports between countries. For example, for a **sector** like Belgian steel, it studies both the direct export of steel to the UK but also the steel exported to Germany and used in German cars which are then shipped to the UK. This is illustrated in **Graph 1** below. It should be kept in mind that steel is just used here for illustrative purposes, since in reality, the MFN tariff on steel is currently very low and zero for many finished and semi-finished steel products. But that is not the case for many other products with similar value chain input-output linkages, such as in the food or chemical sector.

Figure 1: Global Network Model



2) The Global Network model assumes that the output of each sector can trade with the UK either **directly or indirectly via "third countries".** Thus, the Brexit impact can come via any of these two channels. The **direct impact of Brexit** on Belgian steel exported to the UK, comes from the UK tariff on steel. But Belgian steel is used in the production of German cars. Therefore the Brexit impact on Belgian steel can also come from the UK tariff on German cars, which is an **indirect Brexit effect**. Similarly when Belgian steel is used in French aircrafts, the Brexit effect on Belgian steel can also come via the UK tariff on French aircrafts. And when Belgian steel is used in Spanish bicycles, it is also subject to the UK tariff on bicycles. So ultimately the Brexit impact on Belgian steel is not only a function of the UK tariff rate on steel but of every tariff rate on sectors that use Belgian steel.

3) This makes the Global network model much more complex than a gravitas model that only considers direct trade between countries and that only considers the UK tariff rate on Belgian steel to predict the Brexit impact on Belgian steel. In the KUL (2017) we show that the **average indirect impact of Brexit e.g. via third countries** varies by country but goes up to 50% of the total Brexit impact at country level and lies around 70% of the total Brexit impact at country-sector level. In this report we always present **the sum** of the direct and the indirect Brexit impact.

4) **Tariffs (WTO**) and the tariff equivalent of **non-tariff measures (NTM)** are defined at sector level, which makes it possible to model protection per sector, which varies considerably. Sectors are defined at NACE 2 digit level (rev.2) or a slightly higher level of aggregation. Under Brexit, protection is assumed to be the same on both sides of the channel.

5) The model KUL (2017) considers trade in **added value** rather than gross export values, because only added value in a sector also represents **domestic jobs**. By looking at added value in a sector, we retain the contribution of each sector to the value chain.

6) The Global network model (KUL, 2017), takes into account both trade in both **goods and services**. While goods are subject to tariffs, **services are not subject to tariffs** within the World Trade Organization (WTO). Still service sectors are also exposed to Brexit. In the Global network model, we show that services are used as an input in many goods sectors. Whenever services are included in goods, services àre subject to WTO tariffs. We will show that the Brexit impact is important for service sectors too.

7) The model assumes that each sector can have more than one supplier of intermediary products (**Armington assumption**). Thus a sector like German cars, can source steel from several countries. Other theory models are often less realistic on this account (Caliendo and Parro, 2016) and assume that steel is always sourced from the cheapest country (**Ricardian assumption**). The Global Network model follows as closely as possible what is going on in the **World Input-Output data** (WIOT) which shows that steel can be sourced from various countries.

8) The Global network model is designed to capture the **short-term impact of trade** shocks. It highlights the network tissue that is destroyed under Brexit and how many

job losses this involves. Tariffs by the UK, will make European products more expensive, so there will be less demand for them and less exports from the EU-27 and vice versa. A reduction in EU-27 exports will result in production losses and job losses in the network of EU-27 sectors and similarly for the UK. We assume **equal tariff rates in each sector on both sides** of the channel.[1]

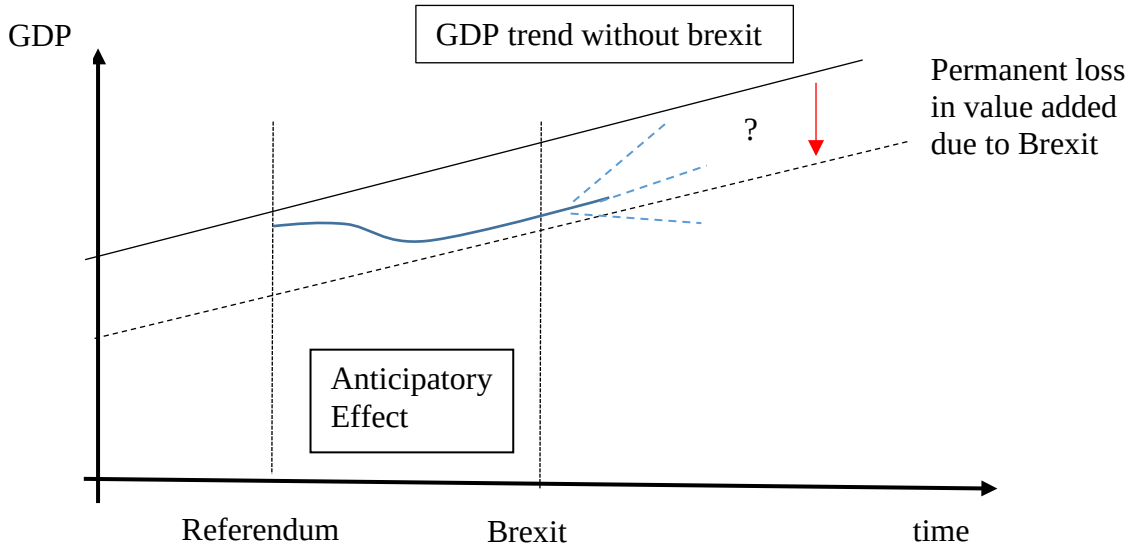
9) The Global network model does **not speculate about new network fabric** that can be created after the Brexit. If EU-27 companies loose UK customers in certain sectors, new customers will have to be found, which always takes some time. And the same for finding new suppliers. New customers and suppliers can come from their own country or from other countries (**trade diversion**). The negative economic impact will decrease over time, but it would be highly speculative to predict how long that would take. Because we do not know which new network linkages will be formed and how long this process takes, the Global network model predicts the short-term Brexit impact of the lost network fabric. It does **not take into account migration** of people, investment and **capital mobility**, the evolution of the **exchange rate** or the mitigating policies that governments can pursue in the face of Brexit.

10) The prediction of the Global Network model is a **loss-loss situation** for both the UK and the EU-27. It predicts an **economic contraction as shown in Graph 2**. Brexit will decrease the overall output of a country (GDP) which boils down to a shrinking of the economy compared to a counterfactual situation without Brexit. How much and how quickly the economy will recover from the impact, will depend on many factors including those outside the model. Our model is not a dynamic model and does not predict year by year effects. Instead it predicts the drop in GDP that will occur under Brexit compared to a counterfactual without Brexit.

Example: Belgian value added will drop by 2,35% as a result of Brexit. This can be interpreted as a shrinking of the Belgian GDP with 2,35%. It is as if Belgium would start on a GDP growth path that is 2,35% lower than without Brexit. The economy will grow again afterwards, but how much time is needed to overcome the shrinking of the pie is unclear and will depend on the mitigating factors such as the extent of migration, the foreign direct investment flows, the migration, the exchange rate response, government tax policies etc. But these mitigating factors lie outside the Global network model and will not be taken into account here.

[1] The United Kingdom has put forward a temporary tariff regime that would apply in the event of a 'no deal'. This regime would apply for up to 12 months. Under the temporary tariff regime, 87% of total imports to the UK by value would be eligible for tariff free access. Given the Most-favored Nation (MFN) principle of the WTO, this tariff regime would equally have to apply to both the European Union as to other third country trading partners of the UK such as the United States and China. The EU has always maintained that it will not change its tariff regime. The introduction of the UK temporary tariff regime will inevitably result in the destruction of network tissue between the EU27 and the UK, but might also create new network tissue for the UK with other trading partners. The trade shock would no longer be bilateral. As the Global network model is especially designed to capture the network destruction in the event of a bilateral trade shock - even though it can calculate what happens in "outside" countries as a result of the bilateral trade policy – it is less well-equipped to study multi-lateral trade shocks. The latter would entail making predictions about the formation of new network tissue over time which is highly speculative.

Figure 2: GDP evolution with and without Brexit



11) In the Global Network model there are **no winners from Brexit** at least not in the short-run. But the model does not exclude that there can be winners in the longer term. The reason is that trade flows will shift which may benefit either domestic suppliers or suppliers outside the EU. For example, if before Brexit, fish is imported from the UK, after Brexit, fish may well come from Vietnam instead which makes Vietnam a winner of Brexit. Another example is the import of financial services. Before Brexit, the EU-27 mainly imported financial services from London, but after Brexit, this could shift to Frankfurt and Paris instead. This trade diversion would benefit Germany and France. However, in this study we focus on the short-term impact of Brexit, e.g. before trade diversion has taken place.[2]

12) The global network model assumes **complete pass-through of tariffs into domestic prices**. We point out that our results vary linearly with the trade elasticity i.e. doubling the trade elasticity in every sector, doubles the value added losses from Brexit and as such results depend monotonically on the value of the trade elasticity.

13) The Global network theory model starts from a **number of standard assumptions** that are generally accepted in the academic literature on trade models. It models a **Demand side** of the model summarized and visualized in Appendix A.1. It also models a **Supply side** of the model, which is summarized and visualized in Appendix A.2. By bringing together the demand side, the supply side of the model and market clearing conditions, a market equilibrium can be derived. The model thus generates an

[2] Most existing studies on trade policy find trade diversion effects to be relatively small compared to trade destruction effects. Using different gravity specifications, Magee (2008) finds estimates of the trade diversion effects of regional agreements to be small and their significance to depend on the specification used. Similarly, Soloaga and Wintersb (2001) find evidence of export diversion in a minority of FTAs, as only 2 out of the 9 FTAs analyzed had substantial trade diversion. Therefore, the trade diversion effects of trade policy are likely to be relatively small.

analytical solution with an algorithm that predicts what the losses in added value will be if a trade partner introduces WTO tariff rates at its external border. The analytical solution of the model, given in Appendix A.3. provides us with an algorithm that can be taken to the empirical WIOT data to make predictions on the Brexit impact.

14) The Global network model takes into account **all upstream input-output** relationships when calculating a Brexit impact. The information of upstream inputs is summarized in the **Leontief coefficients**, which empirically are available in the Input-output Tables. As a result, the estimates of the KUL (2017) study can be regarded as more accurate than in other studies that only use technical coefficients. This is also confirmed by a study of the National Bank that made a comparison of Brexit studies (Biscari, 2019).

The **distinction between Leontief and technical coefficients** can be made on the basis of an example.

Example: Suppose the German steel sector uses Belgian aluminum rims. Assume that the aluminum for the production of the rims comes from the UK. A technical coefficient analysis only takes into account the use of Belgian steel in German cars, while a Leontief coefficient takes into account all upstream steps in the value chain, including the fact that English aluminum is used in German cars.
Modelling and using Leontief coefficients makes our analysis more accurate than other models.

Contextualization in the fisheries sector: it is important to point out that the trade impact as calculated in this report does not take into account the possible closure of access to British waters. In such a scenario, the impact for the sector would be substantially much higher than what is stated in this report

Contextualization with regard to the impact of the automotive sector: Based on the WIOT (2016) version, we work with figures from 2014. As a result, we cannot take into account the latest developments in recent years. This may result in an under-estimation of the effects on the automotive sector in Belgium. Since end of 2014, Ford Genk closed just like other companies in the sector. This resulted in production losses. Part of that production ànd employment has been relocated to Spain. The actual job loss from Brexit in the Belgian automotive sector may therefore be lower than what we report here because we cannot take into account events that happened after 2014. For Spain the job losses in the car sector may therefore be higher than what we report here for the same reason.[3]

[3] We refer to the latest numbers of the European Automobile Manufacturing Association (ACEA) (https://www.acea.be/publications/article/acea-pocket-guide)

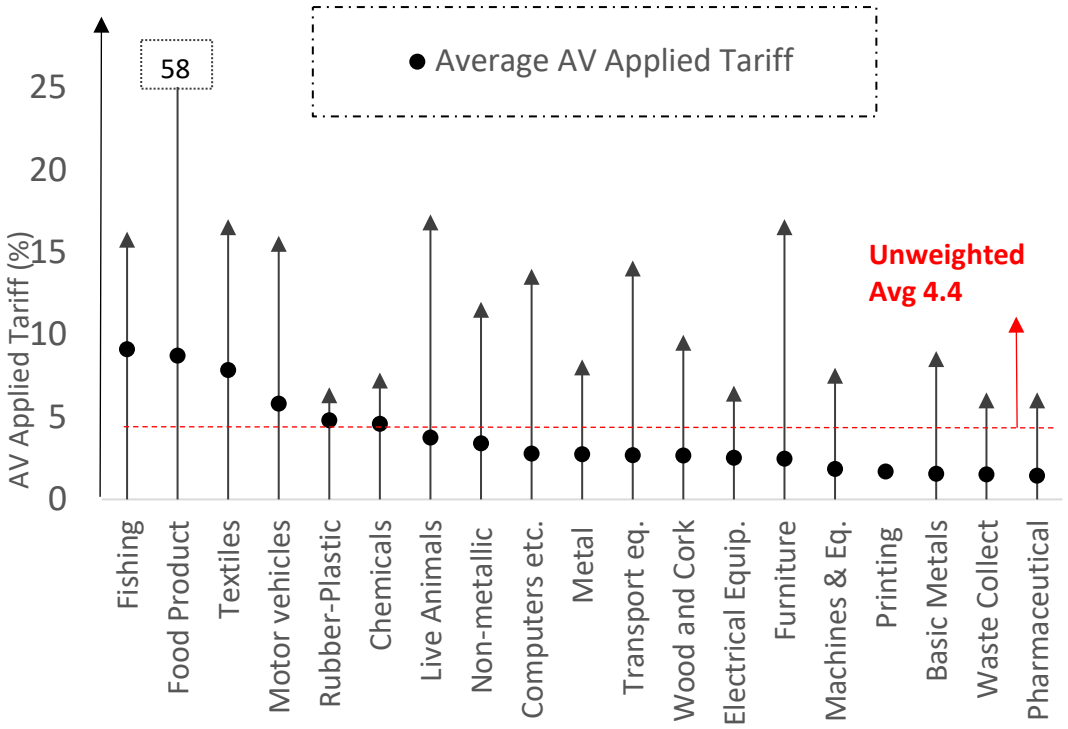
I.2. Empirical Implementation

When applying our model to the data, we use the most recent public data on input-output relationships between sectors. We use the **World Input-Output Tables (WIOT)** where the most recent release dates from 2016. These data consist of **43 countries and 56 sectors**, with each EU member state being included separately in the database. The latest year available is **2014** which is what we use. There is currently no indication that a newer version is coming soon. While there are other input-output data sets than WIOT around, such as GTAP or EORA-MRIO, each of them has its advantages and disadvantages. For example, GTAP has been developed historically to monitor trade in agriculture and still provides great detail on agricultural sectors but less detail is provided on industrial sectors and services than in WIOT. The data available in the EORA input-output tables is available for several countries, but the latest data dates from 2012, while WIOT is more recent. Also EORA features only 26 sectors, while WIOT has 56 sectors and is more detailed.

The following set of parameters are required to estimate the algorithm that can be derived from our theory model as given in Appendix A.3. This algorithm then allows us to calculate the reduction of value added resulting from tariffs:

i) The magnitude of **WTO tariffs** in every sector which we obtain from the WTO website and which are the same tariffs that apply to the US trade with the EU. The graph below gives an overview of average applied tariffs by sector, where the bands around the averages given by the line segments, show the ranges of tariffs that applies to individual products in that sector. These **MFN tariffs** are the tariffs that are currently imposed on goods traded between the United States and the EU, for instance. Graph 3 presents the unweighted current MFN tariffs according to WTO rules in the sectors contained in the WIOD database. These are the MFN tariffs from the EU perspective, i.e. those that the EU imposes on imports from abroad. In the “hard" Brexit scenario, we assume EU-UK and UK-EU trade to be subject to an increase in the trade tariffs on goods from 0% to the unweighted average MFN tariff which ranges from 0% in some sectors (Mining and quarrying, Forestry and Electricity and Gas) to 9.1% in the case of Fishing products.

Figure 3: World Trade Organization (WTO) Tariffs[4]



ii) The magnitude of **Non-tariff measures** e.g. border controls, product and other standard divergences that may arise under Brexit. We consider two Brexit scenarios, **an optimistic ("soft Brexit")** and a pessimistic ("hard Brexit") scenario, shown in Table 1.

Table 1: Tariffs and Non-Tariff Measures Brexit Scenarios.

	Soft Brexit	Hard Brexit
Tariffs	Unchanged	MFN Tariff
Non-tariff barriers	2.77%	8.31%

Note: The scenario is based on Dhingra et al. (2017) and Berden et al. (2009).

[4] The upper (lower) level of the line segments corresponds to the highest (lowest) tariff imposed within the HS6 classified in a Nace rev. 2 sector. The red dotted line marks the unweighted average tariff of all the HS6 products when the European Union reports a tariff under the Most-Favoured nations (MFNs). Tariffs are collected using the Integrated Data Base (IDB). This database contains information on the applied tariffs at the Harmonized System (HS) level for all the WTO members. We use the RAMON correspondence tables to classify the equivalent Combined Nomenclature (CN) to the respective CPA 2008 codes which are then corresponded into the NAC rev 2 sectors of WIOT.

In the "**soft Brexit" scenario**, the UK continues to belong to the EU Single Market or Customs Union and we assume tariffs to be unchanged to what they are today between the EU and the UK which is zero. For the non-tariff barriers to trade (NTBs) , we assume them to increase by 2.77%.

The soft Brexit scenario in our model can usefully be compared to the case of **Norway** (which belongs to the European Economic Area, EEA) and to the **case of Turkey** (which forms a customs union with the EU-27). Even though, in both regimes, not all tariffs with the EU are currently zero.[5] Therefore we can consider our soft Brexit scenario, as a case that is the best possible scenario for the UK if they go ahead with Brexit. A soft Brexit case would be one with an ambitious future relationship between the EU and the UK. Based on our Global network model we simulate such a scenario assuming that all tariffs are going to continue to be zero. If the UK leaves the EU with such a deal than there are likely to be additional tariffs/quotas and border checks, just like it is the case in the EEA and in the Customs Union with Turkey today.

Inside the EEA, for some products and sectors, **tariffs/quotas and border checks** still exist. For example, the **Fishery and Agricultural** sector are covered by separate bilateral agreements between the EU and Norway, with trade liberalization occurring only gradually. Bilateral tariffs between the EU and Norway still exist for cheese, meat, fruits amongst others. Should the **UK** withdraw from the EU, it will also leave the EEA. If it wishes to stay in the internal market, it could opt to **re-join EFTA** and become an **EEA member** through EFTA. The EEA incorporates the four freedoms of the internal market (free movement of goods, people, services and capital) and related policies (competition, transport, energy, and economic and monetary cooperation). The EEA agreement also includes policies strictly related to the four freedoms: social policies (health, safety at work, labour laws); policies on consumer protection, the environment, statistics and company law; and a number of flanking policies, such as those relating to research and technological development.

What EEA does not cover are the common agricultural policy and fisheries policy of the EU. It does also not cover a common trade policy nor a common foreign and security policy. Justice and home affairs are also separate from that in the EU and EEA members do not participate in the economic and monetary union.

This **option** is considered **unlikely** for the UK, because as a member of the EEA, the UK would then have to accept EU legislation (such as freedom of movement), payments to the EU and the (indirect) jurisdiction of the Court of Justice of the European Union, which at this point does not seem what the UK wants.

[5] For some products and sectors, tariffs/quotas and border checks still exist within these agreements. For example in the EEA-area tariffs continue to exist in the fishery and agricultural sector. For more details on the EU-Turkey customs union relationship see the following article by Professor Catherine Barnard https://ukandeu.ac.uk/explainers/eu-turkey-customs-union/.

The customs union with Turkey is incomplete in the sense that it mainly covers industrial goods, it does not cover most agricultural goods nor services, nor coal & steel nor public procurement. In the case of Turkey that forms a customs union with the EU, there are zero tariffs on trade with the EU in industrial products, but there is a common external tariff on the outside borders.

One of the main differences between the Norwegian model and the Turkish model is that Norway (Switzerland to a certain extent) unlike Turkey accepts the free movement of people. But Norway (Switzerland) are more autonomous over their trade policy, which Turkey is not. Turkey has a similar external tariff on the outside borders than the EU external tariff. And when it comes to Free trade agreements (FTA) concluded by the EU with third countries, the customs union with Turkey is a-symmetric. This means that a country like Canada recently, that concludes an FTA with the EU, automatically gets access to the Turkish market but not the other way round. Turkey does not automatically get access to the Canadian market. For this reason a **customs union like the one with Turkey** also seems **unlikely** as a scenario for the UK to agree to, unless the EU would agree to a more comprehensive customs union with a bigger role for the UK in future EU trade negotiations.

Another possibility is that the UK opts for an **FTA** with the EU. That would be the lowest form of economic integration with the EU. This could take time to negotiate as well. It would mean that the UK no longer is part of the EU single market, but would have tariff free access (full or partial) to the EU market and vice versa. All other policy areas such as competition policy, justice, migration, trade policy etc. would be separate.[6] An FTA-model would normally eliminate most tariffs and therefore limit the trade shock of brexit significantly. However, as the NTB's would still be substantial and potentially higher than under an EEA/CU model, it would deliver a **less optimal economic result** in comparison with a Norway or a Turkey model.

In our Global Network model, we cannot distinguish between the Norway case or the Turkey case, because we do not model migration or any other policy besides trade policy. The free mobility of people, is one of the main delineations between the models even though other differences exist. Thus we consider them to both correspond with the **soft Brexit** scenario. The **Global network model** is a trade model which assumes that factors of production such as labor and capital do not move. In the soft brexit scenario we assume tariffs to remain what they currently are and non-tariff barriers (NTB) to be small.

The magnitude of **NTBs** used in our study, come from the London School of Economics (**Dhingra et al**. 2017). They base their estimate on the EU commission (Berden et al., 2009) where the current NTBs on EU-US trade, are assumed at 20.4%. Half of these NTBs are "reducible barriers" if the US would enter in an FTA

[6] The content of every Free Trade Agreement tends to be different but in most cases, it only involves free-er exchange of goods and services between the partners with lower or zero tariffs in place.

with the EU. Dhingra et al.(2017), assume that for the EU-UK trade, NTBs are one quarter of the non-reducible tariff equivalent of NTBs which amounts to 2.77%.

In **a "hard" Brexit scenario**, the UK leaves the Single Market and trade between the EU-27 countries and the UK by default falls back to World Trade Organization (WTO) rules as shown in **Graph 3**. Similar to Dhingra et al. (2017), we assume that under a "hard" Brexit, NTBs rise to a tariff equivalent of 8.31%. These NTBs include "border measures" (such as customs procedures) and "behind-the-border measures" that result from domestic regulations and standards.

The **soft** Brexit and **hard Brexit** scenarios used in this report are summarized in **Table 1**. Allowing for sector heterogeneity in non-tariff barriers (NTB) as in Berden et al. (2009) indicates that **NTBs in some sectors** are lower than what we assumed but in some sectors are higher. We will discuss this based on **Table 2** below.

iii) Every sector is characterized by **trade elasticities** e.g. how sensitive EU-27 exports to the UK are to a price increase resulting from UK tariffs. The trade elasticities that we use in the Global Network model were obtained from (Imbs and Méjean, 2017) and are listed in Table 2. Whenever we face a missing value in Imbs and Méjean (2017), we impute the average trade elasticities across countries for which we do observe values at a sectoral level. We thus obtain trade elasticities for sixteen different manufacturing sectors, which together with the WTO tariffs are reported in **Table 2.** For sectors where all information is missing, we simply turn to the most common value for the trade elasticity used in the literature which is -4. This value is at the lower end of all estimates that circulate in the literature. But given that we analyze trade in value added rather than gross flows and that our data are at sector-level and not at product-level, we prefer to use this **lower-end estimate** of the trade elasticity for sectors where no trade elasticity is available. This renders our results into lower bound estimates.

The first column of Table 2 lists the sectors of the WIOT database. These sectors correspond to NACE 2 (rev2) digit sectors, but are slightly more aggregated. In Appendix B, we list a complete sector level correspondence between the WIOT sector codes and the NACE 2 sector codes, together with their description.

Column (2) in Table 2 lists the average **applied WTO tariff per** WIOT **sector** which are averaged over all products belonging to that sector and which are used in our simulations.
Column (3) gives the maximum tariff in that sector, while column (4) gives the minimum tariff in that sector, usually zero.
Column (5) gives the **trade elasticity per sector** and columns (6) and (7) give the **NTB**s in the soft Brexit, and hard Brexit respectively that we used to simulate the outcomes of our model. We do not distinguish between sectors, but have used the average NTB that applies across all sectors. The main reason is that data on NTBs are difficult to obtain and are missing in some sectors. This

can be seen column (8) and (9) in Table 2. There we report what is available for NTBs in terms of sector heterogeneity both for soft and hard Brexit scenarios respectively. But there are many sectors where data cannot be found. The data that we retrieved are from a study by Berden et al. (2009). Due to the scarcity of data on NTBs at sector-level, we decided to take an average that is set equal across all sectors.

But it is clear from Table 2 columns (8), (9), that in some sectors the NTBs can be different than what we have used in the simulations. Especially in **Food and Beverages**, **NTBs** can be expected to be **higher than the average** that we have used in our simulations, which is why we indicate these NTBs in red in Table 2.

Based on this we conclude that for the sector Food and Beverages, the Brexit impact that we present is likely to be a lower bound of the true effect which may be larger. But for other sectors **NTBs can be substantially lower** than what we have assumed. These sectors are indicated in green. These sectors are Wood (C16), Paper (C17), Pharma (C21), Computers (C26) and Electrical equipment (C27).[7]

iv) From the WIOT data we also obtain the **Leontief coefficients** that capture all upstream input-output linkages for every sector. This information is needed to calculate **how much of the added value each sector in every EU-27 country will lose when the UK introduces WTO rates**. It is important that this also captures how much the UK loses due to its own rates.
Example: If the UK produces aluminum for Belgian car rims, a UK tariff on the export of Belgian car rims to the UK, will lead to a fall in Belgian demand for English aluminum and hurt the UK. Due to the **global value chains** that run across different European countries, **UK import rates against EU-27 exports will also damage English sectors.** This adds to the damage that English sectors suffer from Brexit and will be added to our calculations. And vice versa for the EU-27.

Finally, we arrive at a total Brexit effect per sector in the EU-28. We then aggregate all sector losses to the level of each EU-28 country to arrive at a loss of added value per EU member state.

[7] Please turn to the Sector Legend Table at the end of document to see the exact name of the sectors.

Table 2: Parameters used to simulate the Global Network Model (KUL, 2017)

	WTO			Imbs & Méjean (2017)	Dhingra et al. (2017)		Berden et al. (2009)		Konings & Murphy (2006)
WIOT sector	Average Applied MFN Tariff (%)	Max Applied MFN Tariff (%)	Min Applied MFN Tariff (%)	Trade Elasticity	NTM soft Brexit (%)	NTM hard Brexit (%)	NTM soft Brexit (%)	NTM hard Brexit (%)	Employm. Elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A01	3.75	17.30	0	-4.0	2.77	8.31	.		0.57
A02	0.00	0.00	0	-4.0	2.77	8.31	.	.	0.57
A03	9.11	16.25	0	-4.0	2.77	8.31	.	.	0.57
B	0.02	0.85	0	-4.0	2.77	8.31	.	.	0.57
C10-C12	8.73	57.60	0	-6.3	2.77	8.31	8.1	24.4	0.57
C13-C15	7.86	17.00	0	-11.9	2.77	8.31	2.2	6.7	0.57
C16	2.67	10.00	0	-5.0	2.77	8.31	1.2	3.6	0.57
C17	0.15	6.36	0	-4.9	2.77	8.31	1.2	3.6	0.57
C18	1.70	1.70	1.7	-5.1	2.77	8.31	.	.	0.57
C19	0.38	1.97	0	-7.8	2.77	8.31	.	.	0.57
C20	4.60	7.70	0	-5.7	2.77	8.31	2.8	8.4	0.57
C21	1.45	6.50	0	-5.7	2.77	8.31	1.6	4.7	0.57
C22	4.81	6.80	0	-5.1	2.77	8.31	2.8	8.4	0.57
C23	3.41	12.00	0	-4.9	2.77	8.31	2.8	8.4	0.57
C24	1.56	9.00	0	-6.1	2.77	8.31	1.8	5.4	0.57
C25	2.75	8.50	0	-8.1	2.77	8.31	1.8	5.4	0.57
C26	2.79	14.00	0	-11.3	2.77	8.31	0.8	2.4	0.57
C27	2.54	6.90	0	-4.0	2.77	8.31	0.8	2.4	0.57
C28	1.85	8.00	0	-9.9	2.77	8.31	.	.	0.57
C29	5.82	16.00	0	-4.0	2.77	8.31	3.3	9.8	0.57
C30	2.69	14.50	0	-4.0	2.77	8.31	3.3	9.8	0.57
C31_C32	2.48	17.00	0	-7.4	2.77	8.31	.	.	0.57
D35	0.00	0.00	0	-4.0	2.77	8.31	.	.	0.57
E37-E39	1.53	6.50	0	-4.0	2.77	8.31	.	.	0.57

Notes: 1) These values were used in the simulations of the model; 2)To obtain average tariffs per sector, we corresponded HS6 product codes to CPA product codes and then we corresponded CPA codes to NACE 2 codes; 3) see Sector _legend Table at the back for Nace correspondence of WIOT sectors; 4) Service sectors are not listed but have a trade elasticity of -4, tariffs and NTBs do not apply; 5) The Employment elasticity used for the service sectors is 0.33.

v) To make our estimations we also need **Employment elasticities** e.g. this will tell us how much of the value added in each sector that is lost due to Brexit, represents job losses. This elasticity measures the proportionate drop in employment after a 1% decrease in value added production. In theory, Hamermesh (1986) argued that a production function characterized by constant returns to scale, like ours, has an employment elasticity of 1. If this was true that it would suggest that job losses are proportional to production losses e.g. a 2% loss in value added would also imply a 2% loss of jobs.

However, this seems refuted by existing empirical evidence in the literature. Konings and Murphy (2006) using European firm level data, estimate employment elasticities with respect to value added for manufacturing and non-manufacturing sectors. They find **employment elasticities** to range between **0.57 and 0.72** in manufacturing sectors and find the average employment elasticity in non-manufacturing sectors to be 0.33. Given our focus on European data, we use the lower bound of these sectoral estimates. This implies that for every 1% drop in domestically produced value added as a result of Brexit, we assume employment to go down by **0.57 % in manufacturing and 0.33% in non-manufacturing sectors**. The values of these employment elasticities are shown in the last column of **Table 2**. The Brexit results on employment depend linearly on the choice of the employment elasticity. Thus, once we have obtained the relative drop in employment from the decrease in production, we compute the **absolute number of jobs lost** by multiplying by the country-sector's total employment base.

I. Discussion of Results

II.1. Aggregate Results

We start by giving a summary of the **aggregate impact of Brexit**, on respectively Belgium, the EU-27 and the UK. We focus on the worst case scenario of hard Brexit, but the corresponding numbers for the soft Brexit case can be found in the Tables below. These numbers have already been reported elsewhere (KUL, 2017) but we include them here to start with results on the aggregate picture.

In terms of output losses, **Belgium** loses about **2,35%** of its **value added** in production, while the **EU-27** as a whole loses about **1.54%** of its **GDP** due to a hard Brexit. The loss for the **UK** under a hard Brexit would be **4.47%** of its **GDP**. For **Belgium** this corresponds to absolute job losses of **42 000 jobs**, while for the **EU-27** as a whole the job loss would amount to **1 200 000 jobs** lost and for the **UK** at worst **526 000 job** losses would result from a hard Brexit.

Table 3: Output losses under Brexit for EU-27, Belgium and UK

Brexit scenario	Output loss (in % of GDP)		
	Belgium	**EU-27**	**UK**
Soft Brexit	0.58%	0.38%	1.21%
Hard Brexit	2.35%	1.54%	4.47%

Table 4.a.: Job Losses under Brexit for EU-27, Belgium and UK (absolute numbers)

Brexit scenario	Job Losses (absolute numbers)		
	Belgium	**EU-27**	**UK**
Soft Brexit	10 000	284 000	140 000
Hard Brexit	42 000	1 200 000	526 000

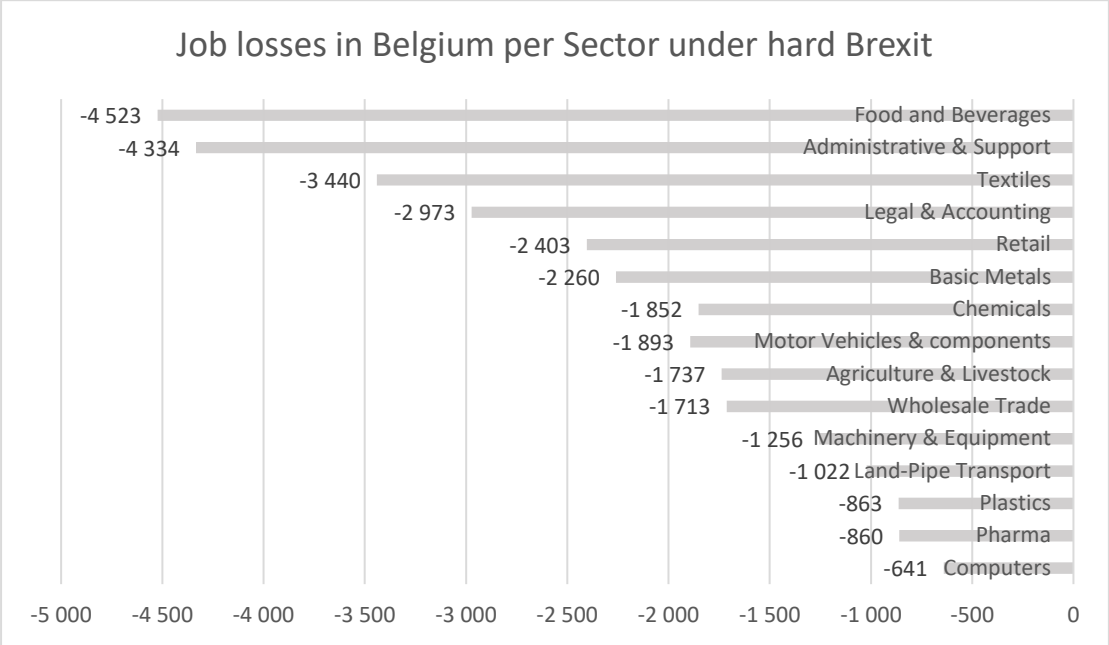
Table 4.b.: Job Losses under Brexit for EU-27, Belgium and UK (relative job losses)

Brexit scenario	Job Losses (in % country employment)		
	Belgium	**EU-27**	**UK**
Soft Brexit	-0.22%	-0.15%	-0.45%
Hard Brexit	-0.93%	-0.62%	-1.71%

Notes: numbers are rounded to thousands. Source: Vandenbussche et al. (2017) CEPR working paper, London.

We rank **Belgian job losses** for the fifteen **most affected sectors** under **hard Brexit**. This gives a better overview of the losses for each sector and how they can be ranked.

Figure 4 : Ranking of Sectors in Belgium – Job Losses Hard Brexit



Source: Vandenbussche, Connell and Simons, Vives-KU Leuven discussion paper.

For completeness we also break down the job losses for Belgium to the level of the **regions**. To obtain results for the different Belgian regions, ideally we would need regional input-output data at sector-level with an international dimension e.g. with linkages in production to other foreign sectors. However this information was not available to us. We used an alternative approach for this purpose. To obtain results for **Flanders, Wallonia and Brussels** we consider the number of employees by region and by sector as a share of the total Belgian population[8]. In the food sector for example, Flanders represents about 70% of the Belgian production because 70% of Belgian workers working in the Food sector, are located in Flanders. The employment share by region and by sector was obtained from EUROSTAT. While this information is available for Belgium, for many other European countries it is not reported, therefore a general breakdown of our result by regions in Europe is not possible.

The job losses by region that we find this way for regions in Belgium are shown in Table 5. Not surprisingly, the **largest** share of the Belgian **job losses** take place in **Flanders**. Of the 42 000 Belgian job losses under hard Brexit, about 28 000 jobs will be lost in Flanders which corresponds with about **1.06%** of the **Flemish working population**. Wallonia comes second with 10 000 job losses under hard Brexit and the remaining 4 000 jobs will be lost in Brussels.

[8] As a source for these numbers we use the Eurostat database for the year 2010.

Table 5: Job Losses in Hard Brexit – By Region in Belgium

	Job Losses	
	Soft Brexit	**Hard Brexit**
Brussels	-1 000	-4 000
Flanders	-6 500	-28 000
Wallonia	-2 500	-10 000
Belgium	-10 000	-42 000

Source: Vandenbussche et al. (2017), VIVES discussion paper.

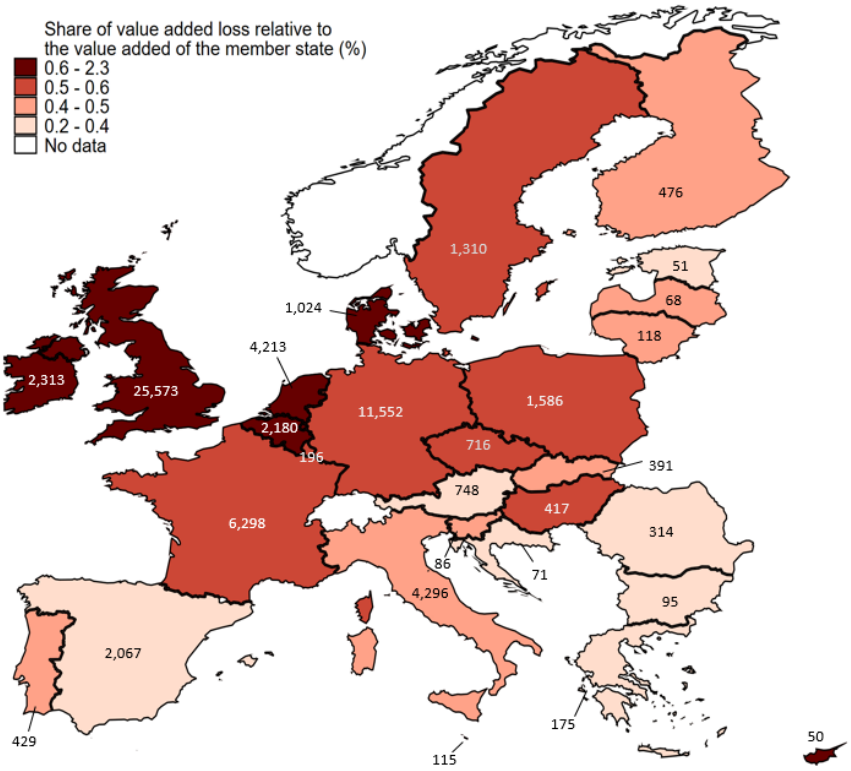
II.2. Results by EU Country

Map of Europe

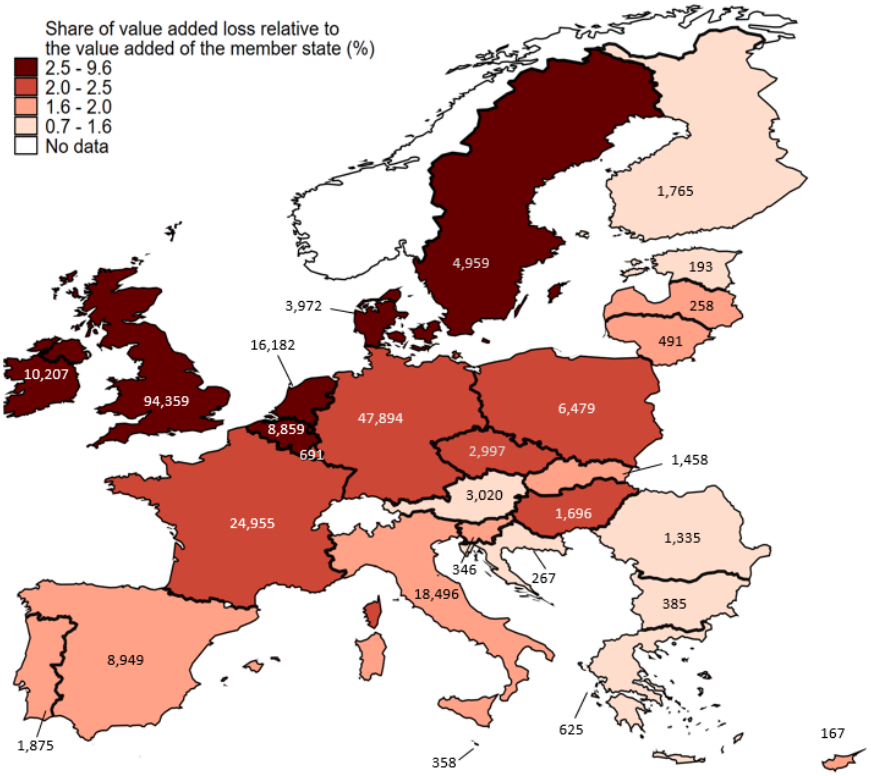
We now **aggregate job losses** for each EU-28 country and **visualize** them on a European map. We start by showing **value added** losses for soft and hard Brexit in **map 1.a and 1.b** respectively.[9] Subsequently, we show **job losses** under soft and hard Brexit per EU country in **maps 2.a and 2.b** respectively. These maps clearly show that in each case Belgium belongs to the most affected countries, shown by the darker color on the map.

[9] The WIOT data are in dollars. We have applied an annual exchange rate of the year 2014 on which the analysis is based (e.g. 1$ = 0.75188 euros).

Map 1.a.: Value added Loss per EU Member State – Soft Brexit

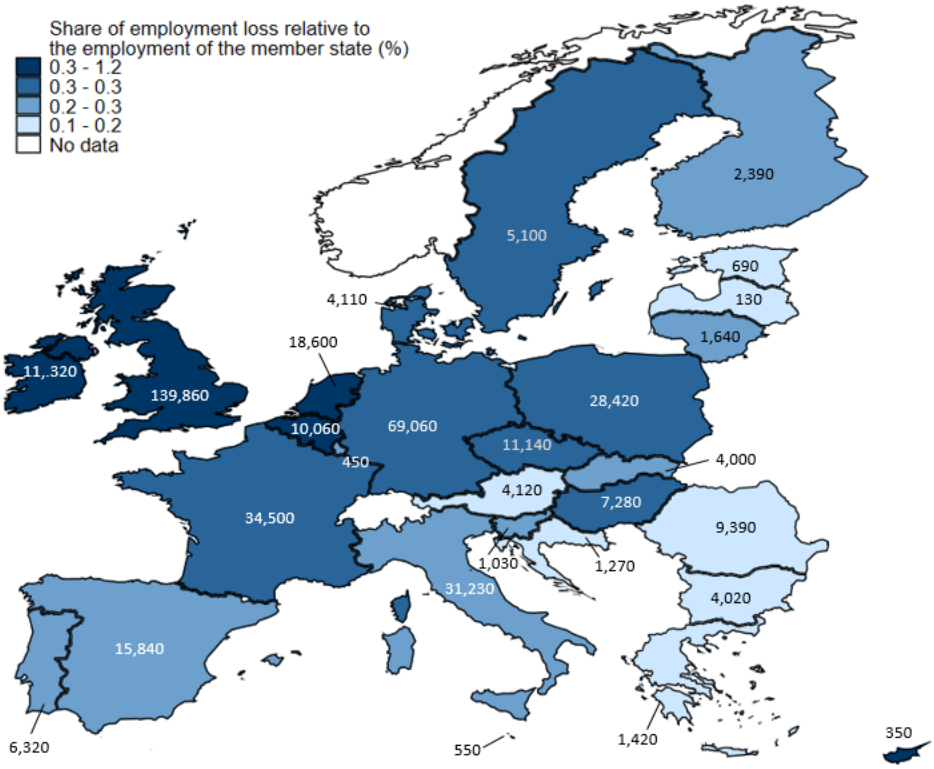


Map 1.b.:Value added Loss per EU member state– Hard Brexit

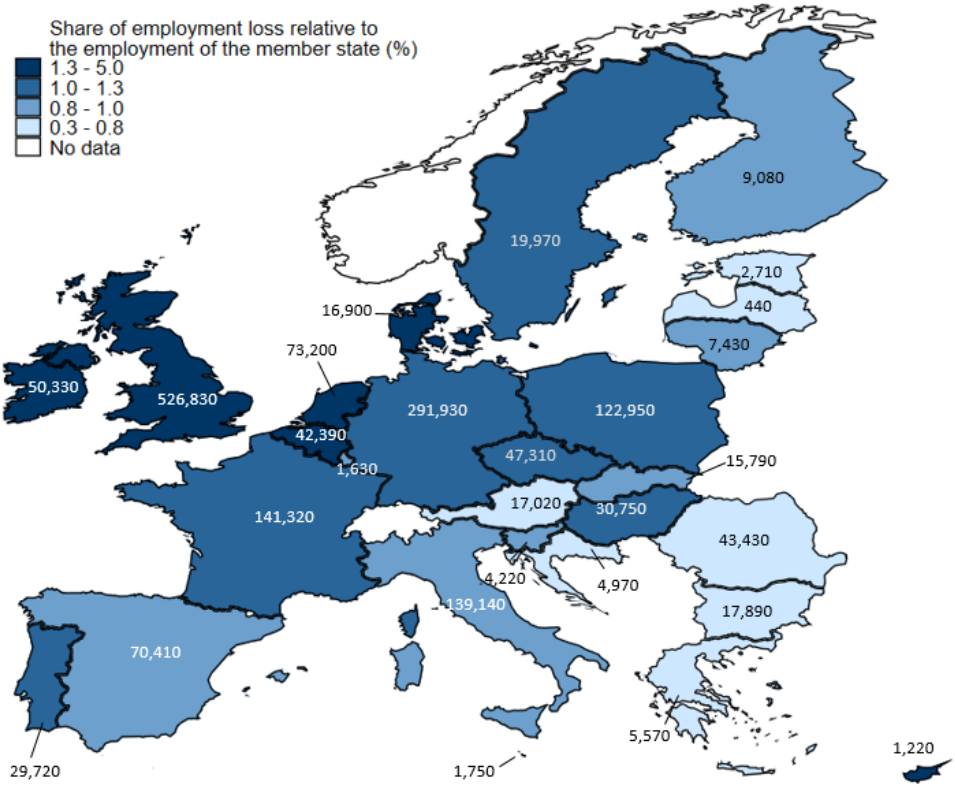


The absolute losses in value added are indicated in each member state and are expressed in millions of Euros. For Belgium, soft Brexit means an absolute loss of 2,180 million Euros and a loss of 1% relative to the total value added of the member state. Hard Brexit means an absolute loss of 8,859 million Euros and a loss of 4% relative to the total value added of the member state.

Map 2.a.: Job Loss per EU member state – Soft Brexit



Map 2.b.: Job Loss per EU member state – Hard Brexit

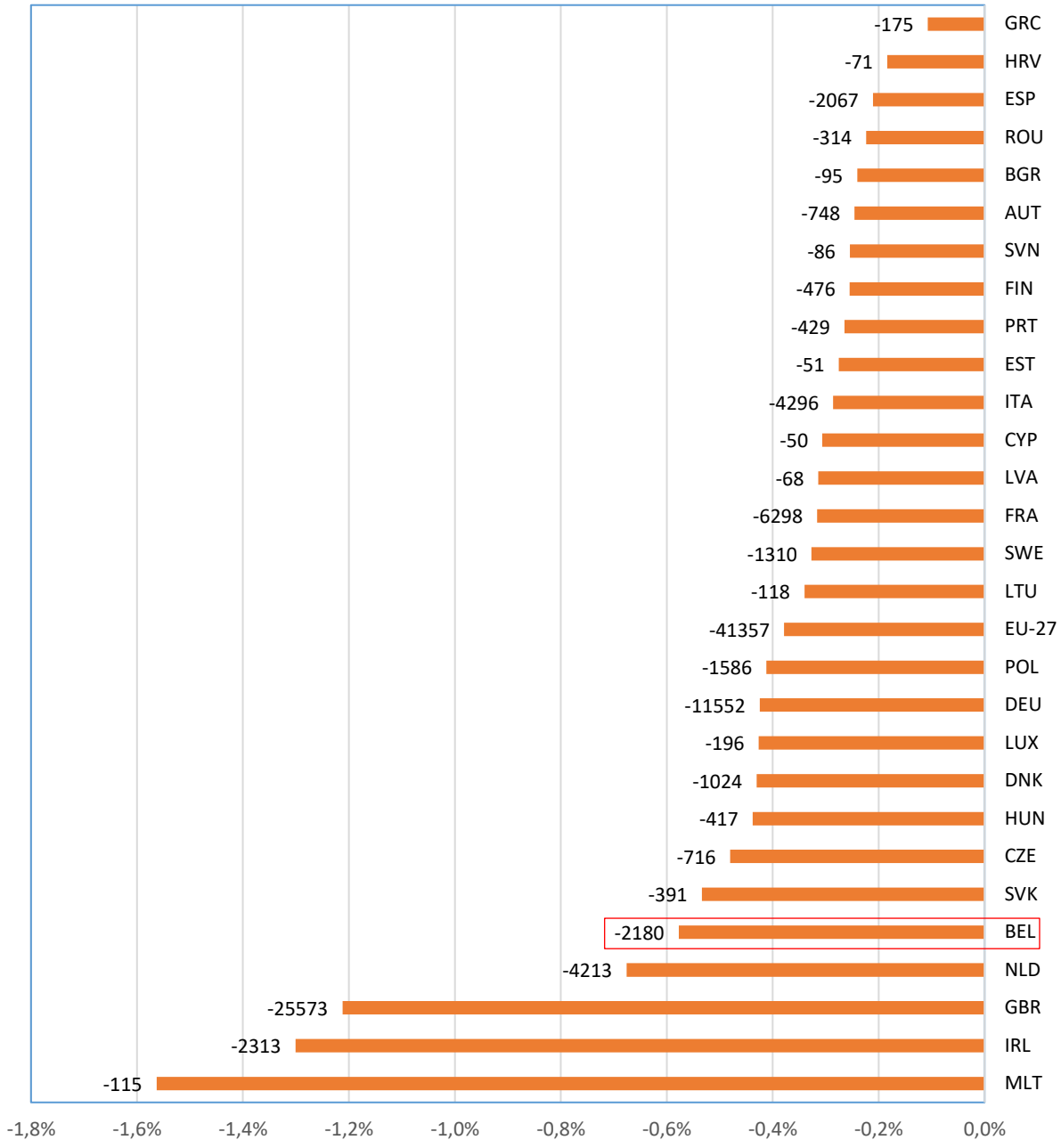


The absolute employment losses are indicated in each member state and are expressed in number of employees. For Belgium, soft Brexit means an absolute loss of 10,060 job and a loss of 0.5% relative to the total employment of the member state. Hard Brexit means an absolute loss of 42,390 jobs and a loss of 2% relative to the total employment of the member state.

II.3. Rankings of EU countries

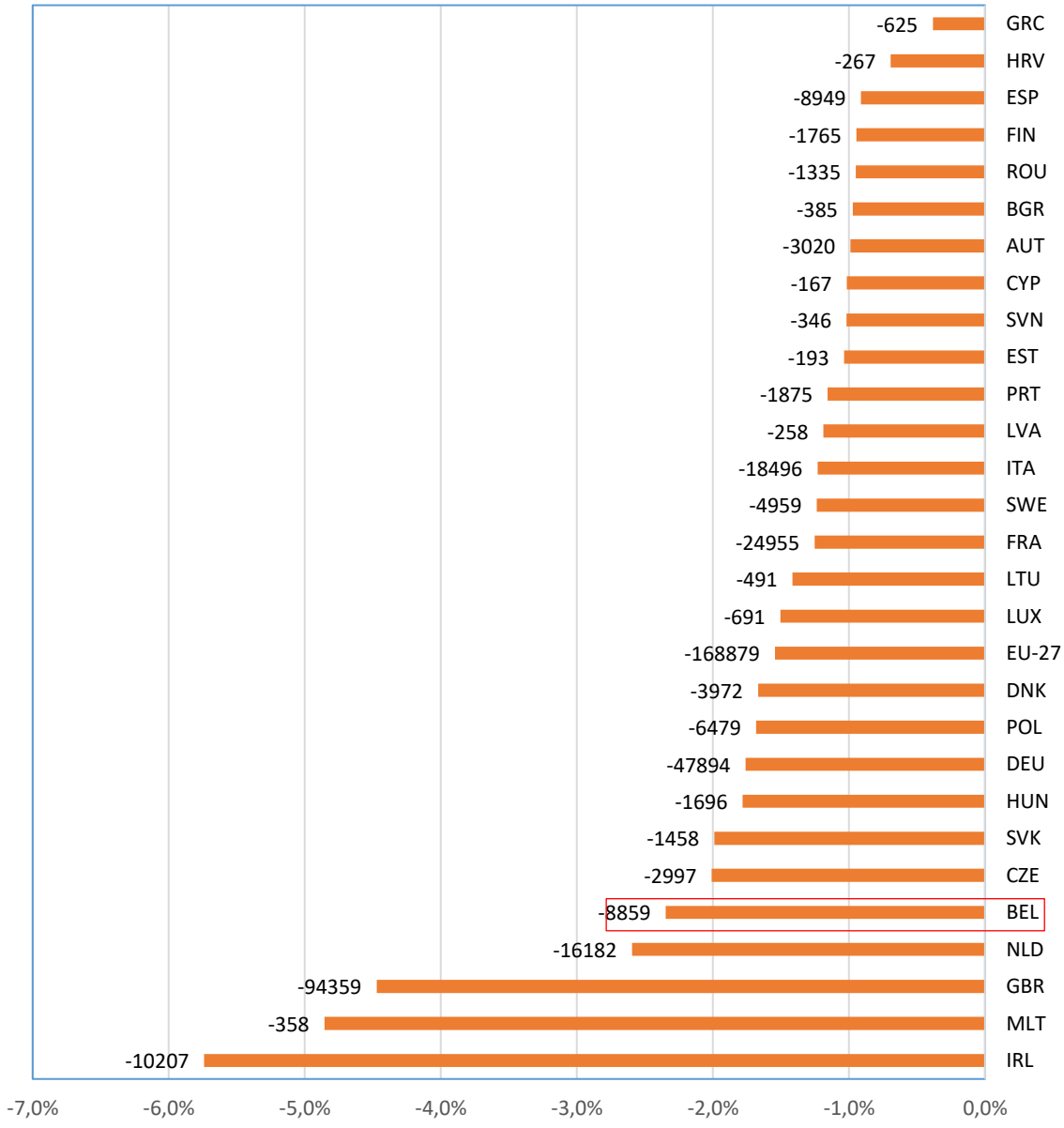
When we rank EU member states according to the loss in value added and job losses, **Belgium lists in the top 3 to 4 of most affected EU-27** member states, not including the UK (GBR). Figures 4a and 4b show the ranking of EU countries in value added losses, both in absolute numbers as in relative terms, while Figures 5a and 5b show a similar ranking for job losses both in number of persons as in relative terms (relative to the active population of each country).

Figure 5.a: Ranking Value Added Losses - Soft Brexit (% and in MIO €)



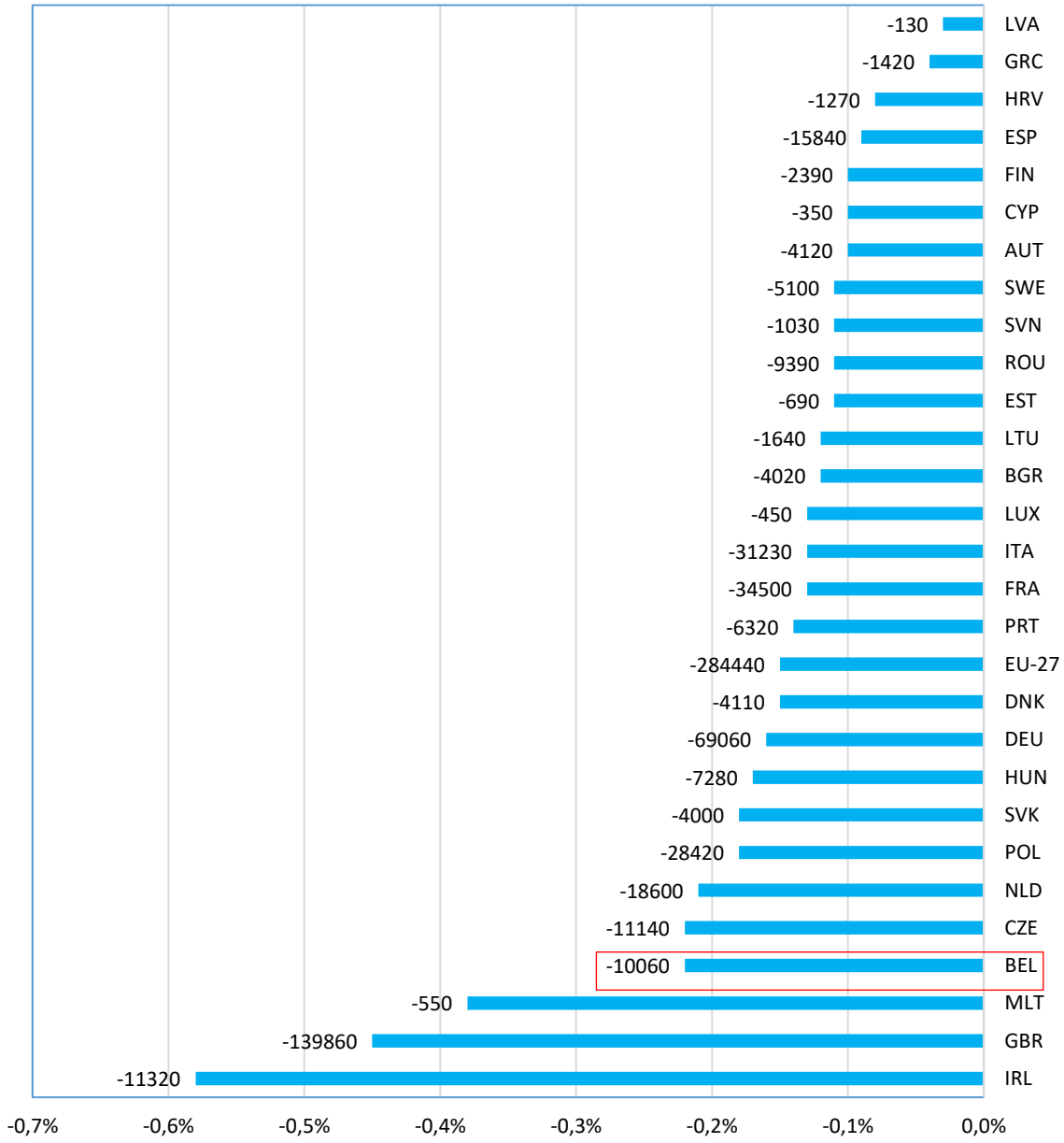
source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Figure 5.b: Ranking Value added Losses - Hard Brexit (% and in MIO €)



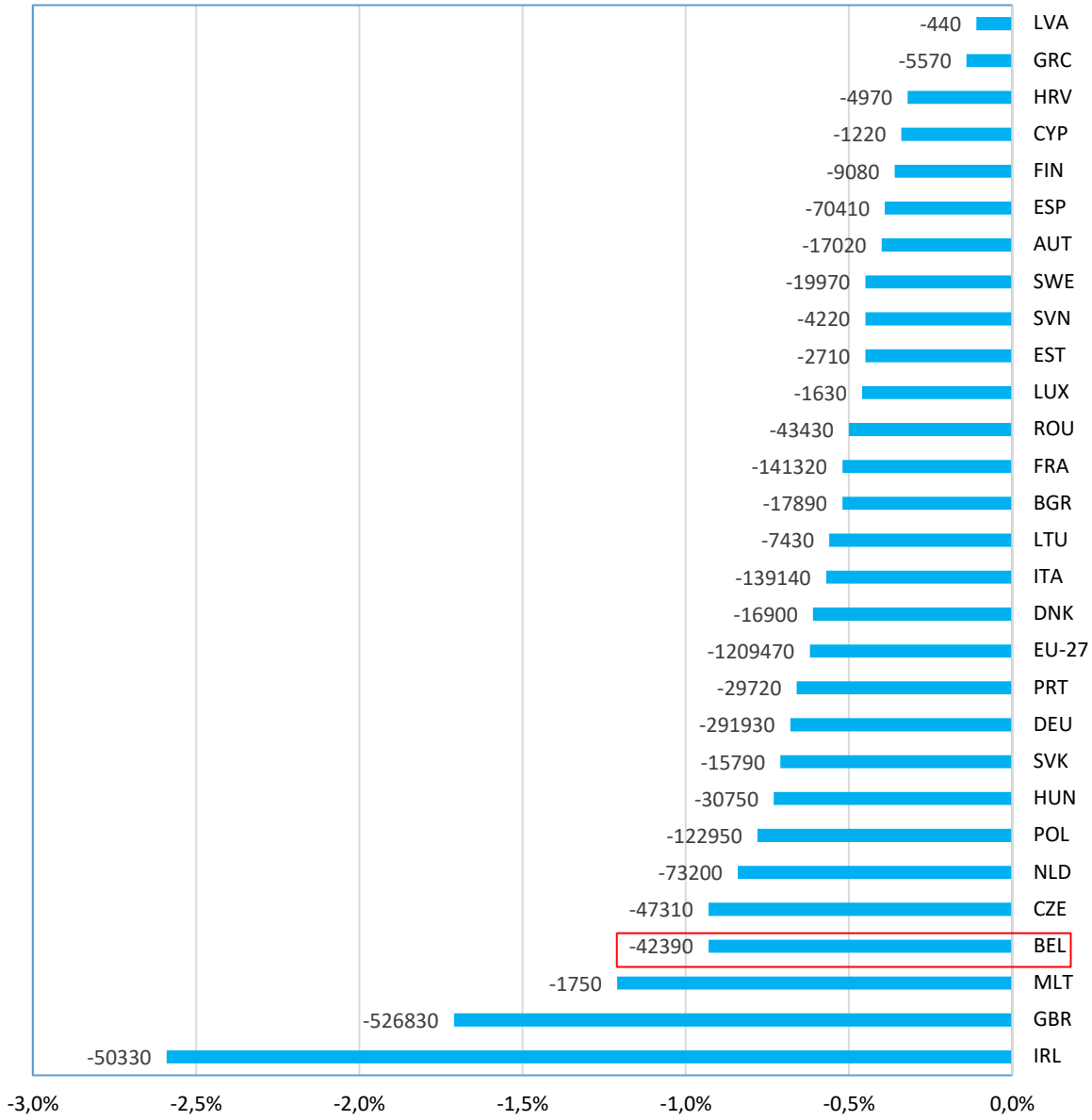
Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Figure 6.a: Ranking Job Losses – Soft Brexit (% and number of people)



Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Figure 6.b: Ranking Job Losses- Hard Brexit (% and number of people)



source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

II.4. Damage Indicators : Value added and Job Losses

Figure 7.a:Soft Brexit- VA

Member state	% VA in MS	EU-27 MS relative to EU-27 total
MLT	-1.56%	4.13
IRL	-1.30%	3.44
NLD	-0.68%	1.79
BEL	**-0.58%**	1.53
SVK	-0.53%	1.41
CZE	-0.48%	1.27
HUN	-0.44%	1.16
DNK	-0.43%	1.14
LUX	-0.43%	1.13
DEU	-0.42%	1.12
POL	-0.41%	1.09
EU-27	-0.38%	1.00
LTU	-0.34%	0.90
SWE	-0.33%	0.86
FRA	-0.32%	0.84
LVA	-0.31%	0.83
CYP	-0.31%	0.81
ITA	-0.29%	0.76
EST	-0.28%	0.73
PRT	-0.26%	0.70
FIN	-0.25%	0.67
SVN	-0.25%	0.67
AUT	-0.25%	0.65
BGR	-0.24%	0.64
ROU	-0.22%	0.59
ESP	-0.21%	0.56
HRV	-0.18%	0.49
GRC	-0.11%	0.28

Figure 7.b: Hard Brexit – VA

Member state	% VA in MS	EU-27 MS relative to EU-27 total
IRL	-5.74%	3.715
MLT	-4.86%	3.143
NLD	-2.59%	1.679
BEL	**-2.35%**	1.519
CZE	-2.01%	1.301
SVK	-1.99%	1.288
HUN	-1.78%	1.153
DEU	-1.76%	1.139
POL	-1.68%	1.089
DNK	-1.67%	1.080
EU-27	-1.54%	1.000
LUX	-1.51%	0.974
LTU	-1.42%	0.916
FRA	-1.25%	0.811
SWE	-1.24%	0.801
ITA	-1.23%	0.797
LVA	-1.19%	0.769
PRT	-1.16%	0.749
EST	-1.04%	0.670
SVN	-1.02%	0.659
CYP	-1.02%	0.657
AUT	-0.99%	0.641
BGR	-0.97%	0.629
ROU	-0.95%	0.615
FIN	-0.95%	0.612
ESP	-0.91%	0.591
HRV	-0.69%	0.449
GRC	-0.38%	0.248

source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations
Note: Losses are for each member of the EU-27, relative to EU-27 total.

Figure 8.a: Soft Brexit – Job Loss

Member state	% of total Jobs	EU-27 MS relative to EU-27 total
IRL	-0.58%	3.87
MLT	-0.38%	2.53
BEL	**-0.22%**	**1.47**
CZE	-0.22%	1.47
NLD	-0.21%	1.40
POL	-0.18%	1.20
HUN	-0.18%	1.20
SVK	-0.17%	1.13
DEU	-0.16%	1.07
PRT	-0.15%	1.00
EU-27	-0.15%	1.00
DNK	-0.14%	0.93
ITA	-0.13%	0.87
LTU	-0.13%	0.87
BGR	-0.13%	0.87
FRA	-0.12%	0.80
ROU	-0.12%	0.80
LUX	-0.11%	0.73
EST	-0.11%	0.73
SVN	-0.11%	0.73
SWE	-0.11%	0.73
AUT	-0.10%	0.67
ESP	-0.10%	0.67
FIN	-0.10%	0.67
CYP	-0.09%	0.60
HRV	-0.08%	0.53
GRC	-0.04%	0.27
LVA	-0.03%	0.20

Figure 8.b: Hard Brexit

Member state	% of total Jobs	EU-27 MS relative to EU-27 total
IRL	-2.59%	4.18
MLT	-1.21%	1.95
BEL	**-0.93%**	**1.50**
CZE	-0.93%	1.50
NLD	-0.84%	1.35
POL	-0.78%	1.26
HUN	-0.73%	1.18
SVK	-0.71%	1.15
DEU	-0.68%	1.10
PRT	-0.66%	1.06
EU-27	-0.62%	1.00
DNK	-0.61%	0.98
ITA	-0.57%	0.92
LTU	-0.56%	0.90
BGR	-0.52%	0.84
FRA	-0.52%	0.84
ROU	-0.50%	0.81
LUX	-0.46%	0.74
EST	-0.45%	0.73
SVN	-0.45%	0.73
SWE	-0.45%	0.73
AUT	-0.40%	0.65
ESP	-0.39%	0.63
FIN	-0.36%	0.58
CYP	-0.34%	0.55
HRV	-0.32%	0.52
GRC	-0.14%	0.23
LVA	-0.11%	0.18

source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations
Note: Losses are relative to the EU-27

II. Main Conclusions

- Only an ambitious future collaboration with the United Kingdom with as few as possible tariff and non-tariff barriers ("**soft brexit**"), can avoid the worst consequences of brexit. A **hard brexit** would seriously and negatively affect the economic tissue of the European economy.
- When we consider value chains rather than direct export numbers, brexit is clearly **a story of the entire European Union**. European companies are so connected in the internal market that a negative effect anywhere in the chain has a direct effect on the entire functioning of the value chain. The perception that brexit only affects Western-European countries that are geographically close to the UK, is not true.
- A hard brexit would have **disastrous** effects for the EU's **Food industry**. In that sector alone, more than more than 112 000 jobs would be lost for Europe as a whole. The Food sector is also the most heavily affected sector in Belgium with job losses amounting up to 4000 jobs. Within Belgium, the Flemish food industry would be hit most, as the UK is one of her most important export markets and brexit would bring about additional trade restrictions.
- A **hard brexit** would also have a major impact on **EU-27 Textiles** industry with nearly 130 000 jobs lost. Also the **Belgian Textile** industry would be hit hard. One in 7 jobs in that sector risks being lost. For **Italy** job losses in **textiles** would also be **dramatic** and the same for **Portugal**.
- For **Petro-chemical products, Pharmaceuticals and Chemical products** throughout the EU-27, a hard brexit is expected to cost around €14 billion of value added. For **Belgium**, the loss in value added in these sectors would be € 1.3 billion. Given that the petro-chemical cluster in Antwerpen is considered to be one of the most important engines of the Belgian economy, it is safe to say that Brexit threatens to lower the overall growth of the Belgian economy.
- In most sectors, we find Belgium to be amongst the top three to four EU-27 countries most negatively affected by Brexit. This holds both under a soft and a hard Brexit scenario. Especially in the **Retail sector**, Belgium ranks first in Europe with more than 2400 jobs lost in case of hard Brexit.
- Job losses in the Belgian **Retail sector** are predicted to be higher than in the wholesale sector. A potential reason for this is the **smaller average firm size** in the Retail sector and the greater **connectedness** of the Retail sector in the production network of goods which makes it more vulnerable to shocks. It could be the case that a lot of SMEs are affected the most. This could signify that **SMEs are the victim of brexit**. Especially since survey evidence has shown that they seem the be the least well prepared for it.
- Despite the fact that Belgian export of transport equipment to the UK accounts for more than one fourth of the total exports, it turns out that job losses in this sector are lower than feared. Only 4% of the total loss in employment under a hard brexit, would occur in this sector which comes down to about 2000 jobs.

Nevertheless the impact is not negligible and will negatively affect the competitive position of the Port of Zeebrugge – as a global car hub.

- This study confirms the importance of **trade in services** for an open economy like Belgium. In modern value chains, goods and services are often bundled and sold as one integrated package. Trade barriers on goods therefore also negatively impact the services embedded in them (and vice versa). This study confirms the strong link between goods and services and predicts a substantial loss for the Belgian employment in Administrative & support activities, Legal & Accounting services and Retail activities (Appendix B).
- On the upside, the results show that brexit would bring about only **limited job losses in certain sectors** such as Education and Scientific research that seem more shielded from trade shocks. However, if the UK no longer gets access to European research funds, the negative effects could quickly run high. In addition, we can then expect a quality loss resulting from a less intensive collaboration between Belgian and British academic institutions.

Appendix A: Global Network Model

A.1. Demand Side of the Model

Analytical

The representative consumer in country k derives utility from consuming quantities of an aggregate final good F_k:

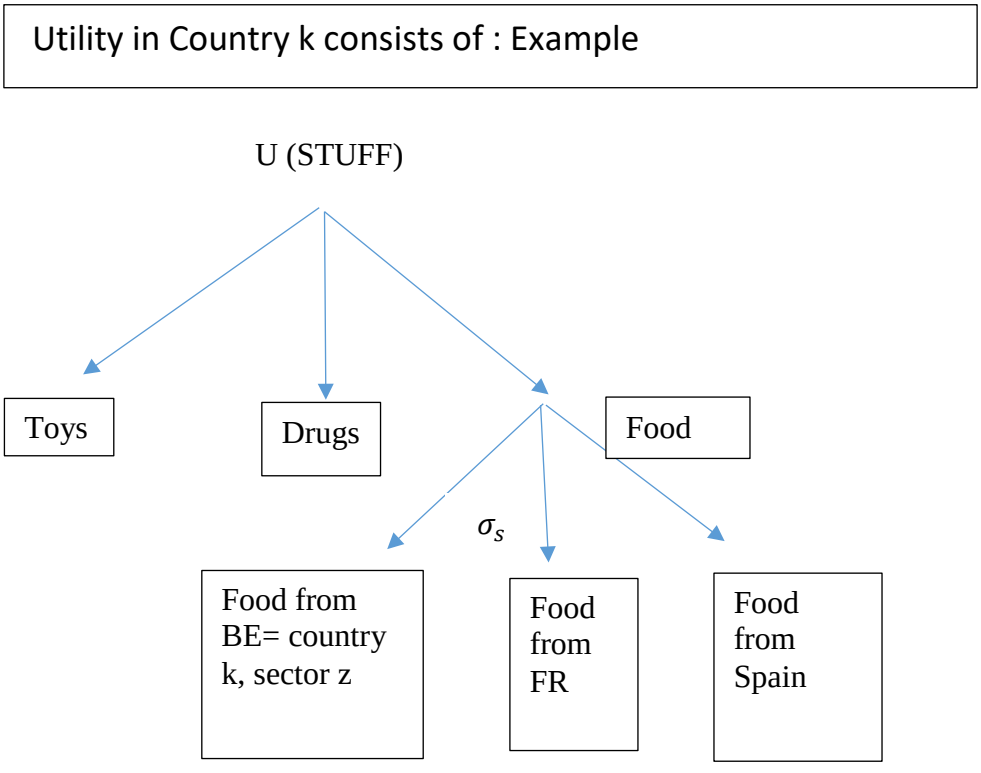
$$U_k = F_k = \prod_{s=1}^{S} [F_k^s]^{\alpha_k^s}$$

Which is a Cobb-Douglas combination of quantities F_k^s consumed of final goods from all sectors $s \in S$, with α_k^s the corresponding share in total expenditures. This sector-specific final good is a Constant Elasticity (CES) of Substitution aggregate across all countries the good can be purchased from:

$$F_k^s = \left[\sum_{i=1}^{N} (F_k^{is})^{\frac{\sigma_s - 1}{\sigma_s}}\right]^{\frac{\sigma_s}{\sigma_s - 1}}$$

Where σ_s>1 is the elasticity of substitution (for final goods) between the countries of origin N within sector s.

Visual



Source: Vandenbussche et al. (2017), KU Leuven

A.2. Supply Side of the Model

In country k sector z, output Y^{kz} is produced with a Cobb-Douglass technology that uses as inputs labor L_{kz} and intermediate inputs X_{kz}:

$$Y^{kz} = (L_{kz})^{1-\beta^{kz}}(X_{kz})^{\beta^{kz}}$$

Where β^{kz} represents the share of intermediate expenditures in total sales of country k's sector z. The intermediate goods composite X_{kz} is a Cobb-Douglas combination of intermediate goods from all sectors $s \in S$, X_{kz}^{s}:

$$X_{kz} = \prod_{s=1}^{S} [X_{kz}^{s}]^{\gamma_{kz}^{s}}$$

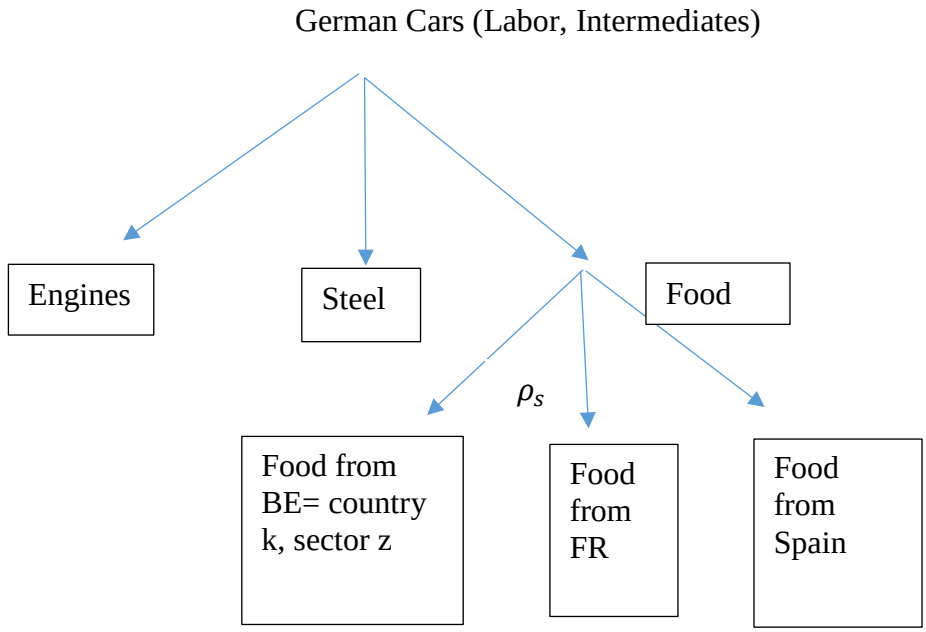
Where X_{kz}^{s} denotes the real aggregate demand of intermediates from sector s by country k's sector z, and γ_{kz}^{s} is the corresponding share in total expenditures in inputs. The sector specific intermediate good X_{kz}^{s} is a CES aggregate across all countries N the input can be purchased from:

$$X_{kz}^{s} = \left[\sum_{i=1}^{N} (X_{kz}^{is})^{\frac{\rho_s - 1}{\rho_s}}\right]^{\frac{\rho_s}{\rho_s - 1}}$$

Where ρ_s>1 is the elasticity of substitution (for intermediate goods) between the countries of origin within sector s. Note that this nested Cobb-Doubles-CES structure is similar to that of the consumer demand aggregates.

Visual

Sector Level Output and its Inputs: Example



A.3. Solution of the Model for a UK tariff on EU-27

$$dva^{kz} \approx \underbrace{-v^{kz}\sum_{s=1}^{S}(\sigma_s-1)\frac{d\tau_{UK}^{EU,s}}{\tau_{UK}^{EU,s}}L_{ks}^{kz}e_{UK}^{ks}}_{\text{direct loss}} \underbrace{-v^{kz}\sum_{i\in EU\setminus\{k\}}^{N}\sum_{s=1}^{S}(\sigma_s-1)\frac{d\tau_{UK}^{EU,s}}{\tau_{UK}^{EU,s}}L_{is}^{kz}e_{UK}^{is}}_{\text{indirect loss}}$$

The first term on the right-hand side of the formula gives the impact of UK tariffs on the direct trade between Belgium and the UK. It states that the loss of Belgian value added (dva^{kz}) in a country(k)-sector(z) e.g. *kz* (Belgian steel) depends on the share of value added in gross output of sector Belgian steel (v^{kz}); the trade elasticity in sector s that uses Belgian steel ($\sigma_s - 1$); the change in the tariffs between the EU and the UK in sector *kz* (Belgian steel) and any domestic sector *s* that uses Belgian steel ($\frac{d\tau_{UK}^{EU,s}}{\tau_{UK}^{EU,s}}$); the Leontief coefficient between a country-sector *kz* (Belgian steel) and another sector s (Belgian cars) in the same country (L_{ks}^{kz}) which is a summary of how any sector s in country k uses input z; and the intensive margin of the direct trade flow between the country-sector *ks* that uses sector *z* (including sector *z* itself) and the UK (e_{UK}^{ks}).

The second term on the right-hand side gives the impact of UK tariffs on trade from any EU-27 sector that travels to the UK e.g. via third countries (any of the other EU-27). This indirect loss from UK tariffs for the country(k)-sector(z) e.g. *kz* (Belgian steel) depends on the Leontief coefficient between a country-sector *kz* and any third country (i)-sector (s) e.g., *is* (German cars), which summarizes how every sector abroad uses Belgian steel (L_{is}^{kz}); the direct trade flow between country-sector abroad and the UK (e_{UK}^{is}). In our analysis we assume that only the tariffs between the EU-27 and the UK change($\frac{d\tau_{UK}^{EU,s}}{\tau_{UK}^{EU,s}}$), but for other countries, tariffs remain the same.

For our analysis, the formula above is applied to any sector in the EU-27 that is facing UK tariffs (1) to obtain a measure of the impact of UK tariffs.
Subsequently, we then engage in the same analysis but now assuming that the EU-27 imposes tariffs on imports from the UK (2). This results in the same formula but where UK and EU-27 now switch positions. The total Brexit effect for any country-sector is then given by the sum of (1) and (2).

Appendix B: Top 15 Most Affected Sectors under Brexit[10]

Agriculture and livestock farming					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-3768	-3,66%	IRL	-16971	-16,49%
NLD	-1085	-0,58%	**BEL**	**-1737**	**-3,06%**
BEL	**-314**	**-0,55%**	DNK	-1813	-2,97%
DNK	-326	-0,54%	NLD	-5514	-2,93%
DEU	-1755	-0,29%	DEU	-9713	-1,60%
FRA	-1921	-0,27%	FRA	-10457	-1,47%
ESP	-1678	-0,25%	ESP	-8433	-1,26%
HUN	-572	-0,22%	HUN	-3071	-1,16%
ITA	-1656	-0,20%	ITA	-9097	-1,10%
POL	-3425	-0,20%	POL	-18721	-1,09%

Food & Beverages					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-1526	-3,2%	IRL	-9314	-19,7%
BEL	**-762**	**-0,8%**	**BEL**	**-4523**	**-4,8%**
NLD	-987	-0,8%	DNK	-2274	-4,6%
DNK	-377	-0,8%	NLD	-5649	-4,4%
FRA	-2000	-0,3%	FRA	-11649	-1,8%
DEU	-2829	-0,3%	DEU	-16724	-1,8%
HUN	-361	-0,3%	HUN	-2096	-1,8%
POL	-1436	-0,3%	ITA	-7385	-1,6%
ITA	-1248	-0,3%	POL	-8363	-1,6%
ESP	-903	-0,2%	ESP	-5125	-1,2%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

[10] For these sectors we only show the most affected member states of the EU-27. Including the UK (GBR) would mean that it ranks the highest in every sector in terms of losses.

Textiles, clothing, footwear, leather goods					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-173	-3,95%	IRL	-1005	-22,93%
BEL	**-596**	**-2,48%**	**BEL**	**-3440**	**-14,33%**
NLD	-348	-2,05%	NLD	-2006	-11,80%
FRA	-1521	-1,38%	FRA	-8837	-8,03%
CZE	-651	-1,09%	CZE	-3702	-6,21%
DEU	-1596	-1,02%	DEU	-9143	-5,86%
ITA	-4779	-0,95%	ITA	-27313	-5,42%
PRT	-1830	-0,89%	PRT	-10559	-5,16%
LTU	-250	-0,86%	LTU	-1428	-4,90%
ESP	-1130	-0,77%	ESP	-6468	-4,39%

Chemicals					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
NLD	-500	-1,14%	NLD	-2230	-5,07%
IRL	-73	-0,97%	IRL	-334	-4,43%
BEL	**-408**	**-0,92%**	**BEL**	**-1852**	**-4,19%**
LTU	-54	-0,85%	LTU	-245	-3,87%
FRA	-939	-0,79%	FRA	-4281	-3,60%
DEU	-2495	-0,71%	DEU	-11315	-3,22%
POL	-532	-0,53%	POL	-2396	-2,39%
CZE	-153	-0,50%	CZE	-687	-2,26%
ITA	-551	-0,49%	ITA	-2498	-2,23%
ESP	-416	-0,45%	ESP	-1874	-2,02%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Pharmaceuticals					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
NLD	-233	-1,94%	NLD	-827	-6,89%
BEL	**-241**	**-1,05%**	**BEL**	**-860**	**-3,75%**
DEU	-1332	-1,04%	DEU	-4737	-3,70%
IRL	-158	-0,93%	IRL	-566	-3,32%
FRA	-411	-0,88%	FRA	-1456	-3,10%
ITA	-431	-0,73%	ITA	-1541	-2,60%
DNK	-131	-0,62%	DNK	-462	-2,20%
ESP	-224	-0,52%	ESP	-813	-1,89%
GRC	-60	-0,51%	GRC	-211	-1,78%
POL	-162	-0,43%	POL	-584	-1,54%

Plastics					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-195	-2,79%	IRL	-927	-13,26%
NLD	-271	-0,90%	NLD	-1237	-4,12%
BEL	**-189**	**-0,82%**	**BEL**	**-863**	**-3,75%**
PRT	-143	-0,61%	PRT	-659	-2,80%
SVK	-183	-0,59%	SVK	-823	-2,66%
DEU	-2486	-0,58%	DEU	-11344	-2,63%
FRA	-897	-0,56%	HUN	-1150	-2,51%
HUN	-253	-0,55%	FRA	-4038	-2,51%
CZE	-478	-0,55%	CZE	-2168	-2,48%
POL	-917	-0,49%	POL	-4107	-2,21%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Basic metals & metal products					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-402	-2,55%	IRL	-1615	-10,12%
NLD	-777	-0,73%	NLD	-3068	-3,16%
BEL	**-564**	**-0,69%**	SVK	-2649	-3,11%
SVK	-641	-0,67%	**BEL**	**-2260**	**-3,03%**
DNK	-250	-0,64%	DNK	-1001	-3,01%
CZE	-1532	-0,63%	CZE	-6198	-3,00%
PRT	-486	-0,57%	PRT	-1985	-2,70%
HUN	-501	-0,56%	HUN	-2050	-2,56%
DEU	-6442	-0,56%	DEU	-26171	-2,34%
POL	-2126	-0,53%	POL	-8627	-2,12%

Electronics and computer equipment, optical and precision instruments					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-478	-2,64%	IRL	-1921	-10,64%
NLD	-473	-1,82%	NLD	-1895	-7,29%
POL	-1468	-1,81%	POL	-5883	-7,25%
CZE	-784	-1,75%	CZE	-3144	-7,00%
PRT	-159	-1,60%	PRT	-637	-6,42%
FRA	-1283	-1,55%	FRA	-5139	-6,19%
BEL	**-160**	**-1,52%**	**BEL**	**-641**	**-6,11%**
SVK	-208	-1,36%	SVK	-836	-5,45%
DEU	-4463	-1,31%	DEU	-17887	-5,25%
HUN	-876	-1,16%	HUN	-3512	-4,66%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Machinery & Equipment					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-267	-2,17%	IRL	-998	-8,09%
NLD	-950	-1,20%	NLD	-3539	-4,48%
BEL	**-337**	**-1,04%**	**BEL**	**-1256**	**-3,88%**
FRA	-1477	-0,95%	FRA	-5491	-3,54%
POL	-1113	-0,80%	POL	-4220	-3,05%
HUN	-450	-0,77%	HUN	-1700	-2,91%
CZE	-980	-0,74%	CZE	-3698	-2,81%
PRT	-134	-0,64%	PRT	-505	-2,42%
DEU	-7204	0,64%	DEU	-27144	-2,40%
ITA	-2378	-0,52%	ITA	-8974	-1,95%

Motor vehicles and automotive components					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
IRL	-86	-3,03%	IRL	-419	-14,79%
BEL	**-376**	**-1,05%**	**BEL**	**-1893**	**-5,27%**
ESP	-910	-0,65%	ESP	-4546	-3,23%
NLD	-111	-0,62%	NLD	-546	-3,03%
PRT	-192	-0,60%	PRT	-957	-3,00%
FRA	-669	-0,55%	FRA	-3313	-2,72%
DEU	-4375	-0,51%	DEU	-21761	-2,55%
POL	-1203	-0,49%	POL	-5847	-2,37%
CZE	-749	-0,46%	CZE	-3684	-2,27%
ITA	-667	-0,40%	ITA	-3223	-1,93%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Wholesale trade					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
NLD	-1685	-0,35%	NLD	-6151	-1,27%
IRL	-222	-0,26%	IRL	-1057	-1,25%
BEL	**-445**	**-0,22%**	**BEL**	**-1713**	**0,87%**
FRA	-2263	-0,20%	FRA	-8602	-0,75%
DEU	-3579	-0,19%	DEU	-13753	-0,74%
HUN	-313	-0,19%	HUN	-1209	-0,72%
DNK	-305	-0,18%	POL	-3710	-0,69%
POL	-932	-0,17%	DNK	-1162	-0,68%
LUX	-29	-0,16%	CZE	-1717	-0,64%
CZE	-406	-0,15%	LUX	-108	-0,60%

Retail trade					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
BEL	**-619**	**-0,20%**	**BEL**	**-2403**	**-0,78%**
CZE	-495	-0,13%	CZE	-2127	-0.57%
POL	-1888	-0,13%	POL	-7192	-0,50%
IRL	-249	-0,13%	IRL	-820	-0,41%
LUX	-30	-0,11%	LUX	-109	-0,41%
SWE	-280	-0,11%	SWE	-1019	-0,38%
SVK	-195	-0,09%	SVK	-682	-0,33%
BGR	-205	-0,07%	ROU	-2094	-0,28%
ROU	-490	-0,06%	BGR	-843	-0,28%
DEU	-1770	-0,05%	DEU	-7894	-0,24%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Land & Pipeline transport					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
NLD	-557	-0,31%	IRL	-516	-1,16%
IRL	-109	-0,25%	NLD	-1977	-1,09%
BEL	**-245**	**-0,21%**	**BEL**	**-1022**	**-0,89%**
CZE	-295	-0,15%	CZE	-1170	-0,60%
FIN	-123	-0,14%	DNK	-353	-0,58%
DNK	-86	-0,14%	DEU	-5208	-0,58%
POL	-883	-0,14%	POL	-3569	-0,56%
DEU	-1256	-0,14%	FIN	-444	-0,52%
HUN	-190	-0,13%	ITA	-3007	-0,51%
ITA	-667	-0,11%	HUN	-734	-0,51%

Legal and Accounting					
Soft Brexit			Hard Brexit		
Country	Employment (Pers)	(% of total sectoral EMP)	Country	Employment (Pers)	(% of total sectoral EMP)
NLD	-1341	-0,39%	IRL	-829	-1,53%
IRL	-193	-0,36%	NLD	-4617	-1,35%
BEL	**-781**	**-0,22%**	**BEL**	**-2973**	**-0,83%**
SVK	-127	-0,22%	SVK	-443	-0,75%
HUN	-185	-0,18%	CZE	-709	-0,69%
CYP	-28	-0,18%	HUN	-699	-0,68%
CZE	-178	-0,17%	POL	-1541	-0,66%
DNK	-103	-0,17%	DNK	-369	-0,60%
POL	-386	-0,17%	DEU	-7715	-0,60%
DEU	-1904	-0,15%	CYP	-89	-0,57%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Administrative and support activities					
Soft Brexit			Hard Brexit		
Country	**Employment (Pers)**	**(% of total sectoral EMP)**	**Country**	**Employment (Pers)**	**(% of total sectoral EMP)**
DNK	-464	-0,36%	DNK	-1511	-1,16%
FRA	-6618	-0,32%	**BEL**	**-4334**	**-1,11%**
BEL	**-1186**	**-0,30%**	FRA	-22392	-1,10%
LUX	-66	-0,27%	LUX	-233	-0,94%
IRL	-196	-0,23%	NLD	-8523	-0,83%
NLD	-2309	-0,22%	IRL	-691	-0,81%
SVK	-183	-0,20%	SVK	-636	-0,71%
CZE	-273	-0,18%	DEU	-21117	-0,70%
ITA	-2207	-0,18%	CZE	-989	-0,67%
DEU	-5383	-0,18%	ITA	-8140	-0,65%

Source: Global Network Model, Vandenbussche et al. KU Leuven (2017), own calculations

Appendix C: NACE-WIOD Sector Legend

Nace Rev.2	NACE	Official Description (Nace Rev.2)	WIOD	WIOD Legend Short
1	A	Crop and animal production, hunting and related service activities	A01	Agriculture and livestock farming
2	A	Forestry and logging	A02	Forestry
3	A	Fishing and aquaculture	A03	Fishing and aquaculture
5	B	Mining of coal and lignite	B	Mining and quarrying
6	B	Extraction of crude petroleum and natural gas	B	Mining and quarrying
7	B	Mining of metal ores	B	Mining and quarrying
8	B	Other mining and quarrying	B	Mining and quarrying
9	B	Mining support service activities	B	Mining and quarrying
10	C	Manufacture of food products	C10-C12	Food & Beverages
11	C	Manufacture of beverages	C10-C12	Food & Beverages
12	C	Manufacture of tobacco products	C10-C12	Food & Beverages
13	C	Manufacture of textiles	C13-C15	Textiles, clothing, footwear, leather goods
14	C	Manufacture of wearing apparel	C13-C15	Textiles, clothing, footwear, leather goods
15	C	Manufacture of leather and related products	C13-C15	Textiles, clothing, footwear, leather goods
16	C	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C16	Wood and cork products
17	C	Manufacture of paper and paper products	C17	Paper and cardboard products
18	C	Printing and reproduction of recorded media	C18	Printing and Media
19	C	Manufacture of coke and refined petroleum products	C19	Petroleum Products
20	C	Manufacture of chemicals and chemical products	C20	Chemicals
21	C	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21	Pharmaceuticals
22	C	Manufacture of rubber and plastic products	C22	Plastics
23	C	Manufacture of other non-metallic mineral products	C23	Other non-metallic mineral products
24	C	Manufacture of basic metals	C24	Basic Metals
25	C	Manufacture of fabricated metal products, except machinery and equipment	C25	Non-machinery metal products
26	C	Manufacture of computer, electronic and optical products	C26	Electronic and computer equipment, optical and precision instruments
27	C	Manufacture of electrical equipment	C27	Electrical Equipment
28	C	Manufacture of machinery and equipment n.e.c.	C28	Machinery & Equipment
29	C	Manufacture of motor vehicles, trailers and semi-trailers	C29	Motor vehicles and automotive components
30	C	Manufacture of other transport equipment	C30	Other transport equipment (shipbuilding, railway stock, aeronautics…)
31	C	Manufacture of furniture	C31_C32	Furniture, medical supplies & miscellaneous manufacturing
32	C	Other manufacturing	C31_C32	Furniture, medical supplies & miscellaneous manufacturing
33	C	Repair and installation of machinery and equipment	C33	Installation of machinery
35	D	Electricity, gas, steam and air conditioning supply	D35	Electricity & Gas
36	E	Water collection, treatment and supply	E36	Water Collection Activities
37	E	Sewerage	E37-E39	Waste Collection Activities
38	E	Waste collection, treatment and disposal activities; materials recovery	E37-E39	Waste Collection Activities
39	E	Remediation activities and other waste management services	E37-E39	Waste Collection Activities
41	F	Construction of buildings	F	Construction
42	F	Civil engineering	F	Construction
43	F	Specialised construction activities	F	Construction
45	G	Wholesale and retail trade and repair of motor vehicles and motorcycles	G45	Wholesale and retail trade
46	G	Wholesale trade, except of motor vehicles and motorcycles	G46	Wholesale trade
47	G	Retail trade, except of motor vehicles and motorcycles	G47	Retail trade
49	H	Land transport and transport via pipelines	H49	Land & Pipeline transport

50	H	Water transport	H50	Water transport
51	H	Air transport	H51	Air transport
52	H	Warehousing and support activities for transportation	H52	Warehousing
53	H	Postal and courier activities	H53	Postal
55	I	Accommodation	I	Accommodation & Food serv.
56	I	Food and beverage service activities	I	Accommodation & Food serv.
58	J	Publishing activities	J58	Publishing Act.
59	J	Motion picture, video and television programme production, sound recording and music publishing activities	J59_J60	Media Production
60	J	Programming and broadcasting activities	J59_J60	Media Production
61	J	Telecommunications	J61	Telecom
62	J	Computer programming, consultancy and related activities	J62_J63	Computer Programming, consultancy
63	J	Information service activities	J62_J63	Computer Programming, consultancy
64	K	Financial service activities, except insurance and pension funding	K64	Financial Services
65	K	Insurance, reinsurance and pension funding, except compulsory social security	K65	Insurance
66	K	Activities auxiliary to financial services and insurance activities	K66	Auxiliary Financial Serv.
68	L	Real estate activities	L68	Real Estate
69	M	Legal and accounting activities	M69_M70	Legal and Accounting
70	M	Activities of head offices; management consultancy activities	M69_M70	Legal and Accounting
71	M	Architectural and engineering activities; technical testing and analysis	M71	Architectural and engineering act.
72	M	Scientific research and development	M72	Scientific Research
73	M	Advertising and market research	M73	Advertising and market research
74	M	Other professional, scientific and technical activities	M74_M75	Other professional activities
75	M	Veterinary activities	M74_M75	Other professional activities
77	N	Rental and leasing activities	N	Administrative and support act.
78	N	Employment activities	N	Administrative and support act.
79	N	Travel agency, tour operator and other reservation service and related activities	N	Administrative and support act.
80	N	Security and investigation activities	N	Administrative and support act.
81	N	Services to buildings and landscape activities	N	Administrative and support act.
82	N	Office administrative, office support and other business support activities	N	Administrative and support act.
84	O	Public administration and defence; compulsory social security	O84	Public admin and defence
85	P	Education	P85	Education
86	Q	Human health activities	Q	Health
87	Q	Residential care activities	Q	Health
88	Q	Social work activities without accommodation	Q	Health
90	R	Creative, arts and entertainment activities	R_S	Other services
91	R	Libraries, archives, museums and other cultural activities	R_S	Other services
92	R	Gambling and betting activities	R_S	Other services
93	R	Sports activities and amusement and recreation activities	R_S	Other services
94	S	Activities of membership organisations	R_S	Other services
95	S	Repair of computers and personal and household goods	R_S	Other services
96	S	Other personal service activities	R_S	Other services
97	T	Activities of households as employers of domestic personnel	T	N/A
98	T	Undifferentiated goods- and services-producing activities of private households for own use	T	N/A
99	U	Activities of extraterritorial organisations and bodies	U	N/A
N/A not included in the study				

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