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Keywords: technological progress, telecommunications, deflators

JEL classification: R11; R15; F62

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Abstract

The nature of international trade has changed in the first decade of the 21st century. Many production processes have become organized in internationally dispersed supplier networks, so-called global value chains (GVCs). This tendency has implications for the competitiveness of countries and regions. This paper uses the regionalized world input-output tables from the EUREGIO-database, for 2000 and 2010. These give quantitative descriptions of the world production structure, and the linkages between regions and countries regarding the sourcing of raw materials, parts, components and (business) services. Linking regional data on employment by industry to these tables allows us to quantify differences in the extent to which UK regions were contributing to GVCs. It also presents indications of changes in regional competitiveness and numerical evidence on regional Brexit risks for regional employment.

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1. Introduction

The nature of international trade has changed dramatically over the past twenty years. Transportation costs continued to fall. China and countries in Eastern Europe became much more open to trade and foreign direct investment. Most importantly, however, new internet-based technologies allowed for previously unknown ways of organizing production. Communication over long distances has become much easier than before and inventories and logistics can be monitored and managed from anywhere in the world. Consequently, large firms have opportunities to slice their production processes of final products up into activities, each of which can be performed in places where the activity-specific quality-to-price ratios are highest. Routine production of standard components, for instance, can be done in a low wage country or region, while very specific financial services can be produced in a country or region where the required knowledge is amply available. Trade is still driven by comparative advantage, but this so-called "second unbundling" (Baldwin, 2006), "international fragmentation of production processes" (Jones and Kierzkowski, 1990) or "emergence of global value chains" (Gereffi et al., 2005) has had profound implications for the economic performance of regions and countries, for better or for worse.

In this paper, we focus on the implications of the emergence of global value chains (GVCs) for regions in the United Kingdom. Two broad strands of research could provide insightful results. First, there is a long tradition of deep analyses of specific value chains, which are considered on a case-by-case basis. Prominent examples are Gereffi (1999) and Dedrick et al. (2010), who analysed GVCs for apparel and iPods, respectively. These studies tend to devote a lot of explicit attention to the ways in which GVCs are governed by lead firms, and the implications of this for the extent to which supplying firms, regions or countries could use their contribution to the GVC as a springboard for further development. With respect to opportunities in GVCs for regions in specific, the conceptual article by Humphrey and Schmitz (2002) is a seminal one within this strand of literature. The second strand of literature takes a macro-perspective. It uses much more aggregated data contained in global input-output tables, often complemented with satellite data on employment and the use/compensation of other production factors. The main advantage is that the usual question marks regarding the extent to which conclusions from case studies can be generalized are avoided, because these tables provide information on all industries (disaggregated into 'country-industries', like "Chinese electronics manufacturing" and "UK financial services") and the value of transactions between these. The main downside is that there is much less depth in the data, which implies that studies tend to have a more descriptive character. Still, the data allows for testing hypotheses derived from theories (e.g. Antras and Chor, 2013; Fally and Hillberry, 2015).

Since the objective of this paper is to quantify the changes in economic performance of all UK regions defined at Eurostat's NUTS2 level rather than the performance of a single region (or industries therein), we opt for the macro-oriented input-output approach. Until recently, the data required to do such analysis for regions were not available, since global input-output databases like the World Input-Output Database (WIOD, Timmer et al., 2015), Eora (Lenzen et al., 2013), EXIOBASE (Tukker et al., 2013) and OECD-TiVA (OECD, 2018) do not provide data at subnational level. This has changed with the EUREGIO database (Thissen et al., 2018), the construction of which took WIOD as the point of departure, but geographically disaggregated most EU countries into NUTS2 level regions. This disaggregation is a data-intensive procedure, which implies that some industry-detail is lost. Regional economies are split up into 14 industries. For some of our analyses, we complemented the EUREGIO data with employment data from Levell (2018), which are based on Labour Force Surveys. The data is available for the period 2000-2010, which covers the pre-crisis period during which the GVC revolution was at its most intense.

The rest of the paper is structured as follows. In Section 2, we briefly illustrate the ways in which we approach GVCs in an input-output context. We also provide figures about the importance of GVCs for economic activity in each of the UK 37 regions, and how this changed between 2000 and 2010. In Section 3, we quantify the extent to which the economies of UK regions depend on GVC activities. Section 4 is devoted to analyses of changes in the international competitiveness of UK regions. We argue (in line with Timmer et al., 2013) that conventional indicators of competitiveness based on gross exports are meaningless in networks of GVCs, and we provide an alternative. Section 5 pays attention to the potential consequences of one of the main threats to the competitiveness of most UK regions, Brexit. We quantify the shares of regional employment that are at risk due to Brexit, following methods proposed by us in Chen et al. (2018). We throw some light on the differences in regional risk levels between two scenarios: First, membership of a customs union or a free trade agreement with the European Union would imply that trade in goods would remain relatively unaffected, whereas trade in services would be hampered seriously. If such agreements could not be struck, economic activity associated with exports of goods would also be exposed to Brexit-risks. This is the second scenario that we study. Section 6 concludes.

2. Global Value Chain analysis using Input-Output tables[1]

Following earlier work (e.g. Timmer et al., 2013; 2014) we define a GVC as all activities required to produce a *manufactured* final product. This includes the final assembly activities, the production of parts and components, and the production of natural resources require to produce these. Next to these activities, such a GVC also includes the provision of financial and other business services to the producer of the final manufactured product and the producers

[1] Substantial parts of the exposition in this section are based on Chen et al. (2018). One of us (Los), was responsible for the methods sections in Chen et al. (2018). Miller and Blair (2009) provide an excellent, comprehensive discussion of input-output analysis in general, including explanations regarding interregional input-output tables.

of the required intermediate inputs. We do not see services as produced for final use (e.g. personal and community services) as the output of GVCs, because they tend to contain few activities produced in places distant from the location where final production takes place, so the adjective "global" is much less appropriate.

The location of activities in GVCs as defined above can basically be studied in two ways. Dedrick et al. (2010) is arguably the best-known example of a *micro*-approach. They focused on a limited number of very narrowly defined products (portable media players and notebooks of specific brands and types, assembled in China) and carefully checked the value of the components and their country of origin. Linking this type of information to data on profitability, they came up with reasonable estimates of the value capture by countries. Alternatively, one could opt for a *macro*-approach, based on global input-output tables. Johnson and Noguera (2012), Timmer et al. (2014) and Koopman et al. (2014) are among the pioneers of this approach. Its major advantage is that a much wider range of products can be taken into account and that second-round effects (e.g., the use in the components production of subcomponents produced in other industries and or countries) and beyond can be incorporated. The major downside is that stronger assumptions are needed and that estimates will be less accurate.

In our analysis of the role of UK regions in the network of GVCs, we will rely on the macro-approach. This permitted by the EUREGIO-database (Thissen et al., 2018), which contains global input-output tables with interregional detail for NUTS2-regions in most EU countries. We use the tables for 2000 and 2010, which is the most recent year for which a table is currently available.

2.1. Regionally disaggregated global input-output tables

A schematic overview of the structure of a EUREGIO table is given in Figure 1. In the figure (and throughout the paper), matrices are indicated by bold capitals, column vectors by bold lowercases and scalars by lowercase symbols in italics.[2] The order of the regions and countries in the figure has been changed for expositional reasons, without loss of generality.

The square matrix $\mathbf{Z}$ is the core of an input-output table. It contains the values of intermediate input deliveries and has $N(R_1 + R_2 + \cdots + R_C)$ rows and columns. N stands for the number of industries per region (14 in EUREGIO), C for the number of countries (41 in EUREGIO, including the UK and the Rest of the World) and R_i denotes the (country-specific) number of regions for country i. Rows represent selling industries, while columns indicate purchasing industries. For the purposes of the present analysis, it is useful to consider 16 submatrices of $\mathbf{Z}$, each with different dimensions. Let us focus on the blocks on the main diagonal (shaded) first. $\mathbf{Z}^{rr}$ is an NxN-matrix of which the typical element z_{ij}^{rr} represents the value of sales by industry i in the focal UK region r to industry j in the same region. $\mathbf{Z}^{uu}$ has $N(R_u$ -1) rows and $N(R_u$ -1) columns. The elements refer to the values of sales by industries in

[2] We will indicate diagonal matrices by a hat over the vector containing the elements on the main diagonal. Primes indicate transposition.

other UK regions to industries in regions (other than *r*) in the UK. If, for example, *r* refers to the West Midlands, $\mathbf{Z}^{uu}$ contains deliveries of industries in Cumbria to industries in Cumbria itself, but also to industries in Lancashire and Northern Ireland. Because one of our main interests is to see how UK regions relate to the EU in terms of GVCs, we split the origins and destinations of trade by the focal region (and other UK regions) into regions in other EU countries and non-EU countries. $\mathbf{Z}^{ee}$ contains the values of all transactions between industries in regions in other EU countries. Finally, the matrix $\mathbf{Z}^{oo}$ represents values of intermediate flows among industries in countries that do not belong to the EU. This includes, for example, sales of Chinese manufacturers of components used by car manufacturing plants in Japan.

Figure 1: Stylized global input-output table with regional detail

	Focal region in UK	Other regions in UK	Regions in other EU countries	Countries outside the EU	Focal region in UK	Other regions in UK	Regions in other EU countries	Countries outside the EU	Gross output
Focal Region in UK	$\mathbf{Z}^{rr}$	$\mathbf{Z}^{ru}$	$\mathbf{Z}^{re}$	$\mathbf{Z}^{ro}$	$\mathbf{f}^{rr}$	$\mathbf{F}^{ru}$	$\mathbf{F}^{re}$	$\mathbf{F}^{ro}$	$\mathbf{x}^{r}$
Other regions in UK	$\mathbf{Z}^{ur}$	$\mathbf{Z}^{uu}$	$\mathbf{Z}^{ue}$	$\mathbf{Z}^{uo}$	$\mathbf{f}^{ur}$	$\mathbf{F}^{uu}$	$\mathbf{F}^{ue}$	$\mathbf{F}^{uo}$	$\mathbf{x}^{u}$
Regions in other EU countries	$\mathbf{Z}^{er}$	$\mathbf{Z}^{eu}$	$\mathbf{Z}^{ee}$	$\mathbf{Z}^{eo}$	$\mathbf{f}^{er}$	$\mathbf{F}^{eu}$	$\mathbf{F}^{ee}$	$\mathbf{F}^{eo}$	$\mathbf{x}^{e}$
Countries outside the EU	$\mathbf{Z}^{or}$	$\mathbf{Z}^{ou}$	$\mathbf{Z}^{oe}$	$\mathbf{Z}^{oo}$	$\mathbf{f}^{or}$	$\mathbf{F}^{ou}$	$\mathbf{F}^{oe}$	$\mathbf{F}^{oo}$	$\mathbf{x}^{o}$
Value added	$\mathbf{w}^{r}{}'$	$\mathbf{w}^{u}{}'$	$\mathbf{w}^{e}{}'$	$\mathbf{w}^{o}{}'$					
Gross output	$\mathbf{x}^{r}{}'$	$\mathbf{x}^{u}{}'$	$\mathbf{x}^{e}{}'$	$\mathbf{x}^{o}{}'$					

Source: Adapted from Chen et al. (2018)

The off-diagonal blocks within **Z** refer to trade in intermediate inputs between industries in different types of geographical entities. The elements in $\mathbf{Z}^{ru}$, for example, indicate the values of intermediate input sales by industries in the focal region *r* to industries in other regions in the UK. Similarly, $\mathbf{Z}^{re}$ presents values of intermediate input sales by industries in the focal region to regions in other EU countries, such as Stuttgart or Stockholm. $\mathbf{Z}^{er}$ contains flows in the opposite direction: intermediate inputs imported from regions elsewhere in the EU by the focal UK region.

The matrices and vectors in the block labelled **F** have a similar interpretation in terms of the regions and countries involved, but refer to deliveries of final products. We represent final demand as exerted in region *r* by column vectors $\mathbf{f}^{\cdot r}$, rather than by matrices with multiple columns. We do so because our research questions do not require distinctions between final uses (like consumption demand or gross fixed capital formation).

Row-wise summation of deliveries for intermediate use and for final use gives gross output of industries in all regions. Gross output levels are given by the last column, **x**. Double-entry bookkeeping ensures that the values in the bottom row are equal to the values in this rightmost column: payments by an industry for the intermediate inputs and for production factors (value added, including profits) in the corresponding column equal the value of sales by that industry. Value added by industries in each of the regions and countries is contained in the row vectors $\mathbf{w}^{\cdot\prime}$.

Details about the construction of the EUREGIO input-output tables can be found in Thissen et al. (2018). Information contained in the World Input-Output Database (release 2013, see Dietzenbacher et al., 2013) was merged with data from regional economic accounts, data from Cambridge Econometrics, input-output tables or supply and use tables for regions in some countries and transportation data.

2.2. Tracing GVCs using input-output tables

Input-output tables as described above provide quantitative information about the world production structure. A column shows the monetary values of all intermediate inputs and production factors that the corresponding region-industry requires to produce its output. If all elements in such a column are divided by the value of gross output, a "production recipe" for this industry results. What does the electrical and transportation products industry in the West Midlands use to produce a euro of its output?[3] The square matrix **A** contains the input coefficients a_{ij}^{rs}, which are obtained as $a_{ij}^{rs} = z_{ij}^{rs}/x_j^s$ (r and s stand for regions, i and j for industries). The values of a_{ij}^{rs} is not only determined by technological input requirements, but also by interregional and international trade patterns. The value added coefficients are computed in a similar vein, $v_j^s = w_j^s/x_j^s$. Information on the use of labour in quantity terms (e.g. in numbers of jobs) is not contained in input-output tables, but is in the present context available at the same level of industry aggregation, from other sources. If the number of jobs in industry j in region or country s is denoted by d_j^s, the employment coefficients are computed as $e_j^s = d_j^s/x_j^s$. The elements v_j^s and e_j^s together constitute the (column) vectors **v** and **e**, respectively.

Assume now that the West Midlands transport equipment industry produces 1 mln € of output. This is done by productively combining production factors (labour, physical capital) with various intermediate inputs, such as metal products from the West Midlands itself, business services from London and electronic products from China. The production of these intermediate inputs from "first tier suppliers" requires inputs of production factors and intermediate inputs in turn. The metal products from the West Midlands might for example

[3] In EUREGIO, all monetary values have been converted into euros, using IMF's official market exchange rates (averaged over a year).

require steel from West Wales and the Valleys, while the Chinese electronics firm cannot produce without paying royalties for intellectual property of Japanese firms. These "second tier suppliers" require inputs in turn. If production processes are sliced up due to low coordination and transportation costs, demand for a car from the West Midlands generates value added creation in many other regions, countries and industries. As Los et al. (2015) show, the value added and employment generation in any of the region-industries due to final demand for the output of industry m (e.g. cars) in region k (e.g. the West Midlands) are given by the elements of the vectors

$$\mathbf{w}^{mk} = \mathbf{v}'(\mathbf{I} - \mathbf{A})^{-1}\mathbf{F}^{mk}\mathbf{i} \qquad (1)$$

and

$$\mathbf{d}^{mk} = \mathbf{e}'(\mathbf{I} - \mathbf{A})^{-1}\mathbf{F}^{mk}\mathbf{i} \qquad (2)$$

In (1) and (2), $\mathbf{i}$ stands for a summation vector consisting of ones, which adds the elements in a final demand block $\mathbf{F}$ in row-wise fashion. $\mathbf{F}^{mk}$ consists of zeros, except for the elements in the row corresponding to industry m in region k. The square matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is known as the (global) Leontief inverse.

Equations (1) and (2) yield information on the extent to which industries in regions contribute to the value of final output of an industry in a region, or, in other words how important the role is that they play in this specific GVC. By setting fewer elements in the final demand block $\mathbf{F}$ equal to zero, contributions to multiple GVCs can be computed at once. The main assumption of this approach is that the production recipes as contained in the $\mathbf{A}$ matrix and the $\mathbf{v}$ and $\mathbf{e}$ vectors apply to all products sold by the industries, irrespective of the destination of these. It is well-known that exporting firms tend to employ different technologies.[4] Some experimental national input-output tables have recently been constructed that could be used to take firm heterogeneity into account, but global tables with this feature are not available yet.

In what follows, we will develop several indicators based on elements of $\mathbf{w}^{mk}$, $\mathbf{d}^{mk}$ and $\mathbf{F}^{mk}$, focusing on the role of UK regions in GVCs. Each of these addresses a different question.

3. The importance of GVC activities for UK regions

Our first question asks how important GVCs actually are, for value added generation and employment in UK regions. We also ask whether this importance has changed in the first decade of the century, i.e. in the period in which growth of international production

[4] See De Gortari (2019) for an analysis for Mexico.

fragmentation was most rapid. To find an answer to these questions, we rely on the measures of "GVC income" and "GVC jobs" introduced by Timmer et al. (2013), which are in line with our definition of a GVC provided in the beginning of Section 2. Our definition of GVC income is "all value added generated in production processes of final manufactured products" and we define GVC jobs as "all jobs directly and indirectly required for the production of final manufactured products".

These definitions imply that we use equations (1) and (2) by setting all rows in the final demand block equal to zero for industries m that do not belong to the manufacturing sector. All final demand rows for manufacturing industries retain their values, for all UK regions and for all countries in the EUREGIO tables. If we retain the value added and employment coefficients (in $\mathbf{v}$ and $\mathbf{e}$) for the particular region in which we are interested and set all other elements of these vectors to zero, the sums of the elements in $\mathbf{w}^{mk}$ and $\mathbf{d}^{mk}$ equal GVC income and GVC jobs in the focal region.

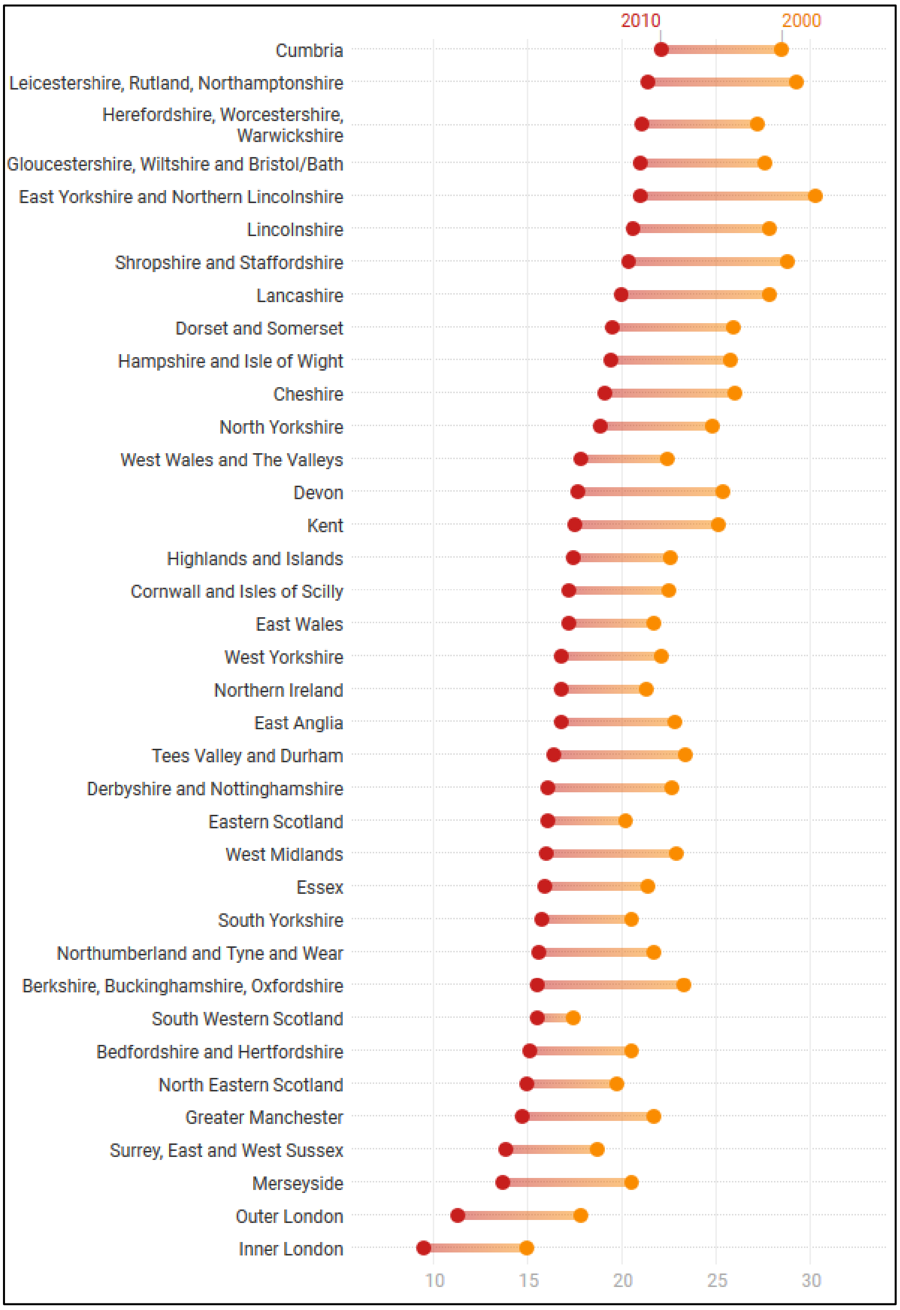
Regional GDP consists of two parts: GVC income as defined above and value added generated in activities that do not contribute to GVCs. Examples of the latter are the provision of personal and community services, the activities of retailers and for example the production of business services that are ultimately used by services industries. A similar split can be defined for employment. We use the ratios between GVC income and GDP and between GVC jobs and total employment as our measures of regional importance of GVCs.

Figure 2 shows that the regional variation in the importance of GVCs is substantial.[5] In 2010, GVC activities were most important for regions like Cumbria, Leicestershire, Herefordshire and Gloucestershire, in which more than 20% of GDP was contributed by GVC activities. At the other end of the spectrum, we find Inner London and Outer London, with shares of only 9.5% and 11.3% respectively. These differences are mainly due to differences in sectoral compositions of regional economies. More striking, in our view, is the fact that GVC activities became less important for all regions, over the 2000-2010 period. The reduction in importance of GVCs was limited for some regions (SW Scotland in particular, -1.9 %-points), but in other regions the change was much more dramatic. We find the most marked differences for East Yorkshire and Shropshire, with changes of -9.3 and -8.4 %-points, respectively.[6] The reductions are also sizable for both London regions. Using a different indicator and different input-output tables, IJtsma et al. (2018) found strong evidence that the UK as a country became less integrated in GVCs (between 2000 and 2014), as opposed to other large European countries like Germany and France. The results depicted in Figure 2 clearly suggest that this tendency has not been specific to a few regions in the UK, but has been substantial all over the country.

[5] See Table A.1 in the appendix for detailed results.

[6] Table A.1 shows that the most sizable reductions in the share of employment in GVC-activities has declined most prominently in Leicestershire and the West Midlands, by more than 10 %-points. In 2010, the share of GVC jobs in total employment was lowest (between 8 and 9%) in Outer London, followed by Highland & Islands. These shares were highest for Cumbria and Leicestershire (shares exceeding 16%).

Figure 2: Share of GDP generated by GVC activities (in %)



Source: Authors' computations based on EUREGIO (Thissen et al., 2018).

The most important cause of the declining importance of GVC activity is most probably the decline of the UK's manufacturing sector. McKinsey (2012) already reported that the UK had the fifth largest manufacturing sector (measured by value added) of the world in 1990, but had slid to ninth position twenty years later. The limited importance of GVC activities for the London regions is not surprising in light of the observations by McCann (2016, p.227), who found that the London economy is much more closed than many of the capital city regions elsewhere in Europe. Its financial services industry has given it its reputation of a "global city", but this label is much less accurate if the entire regional economy is considered.

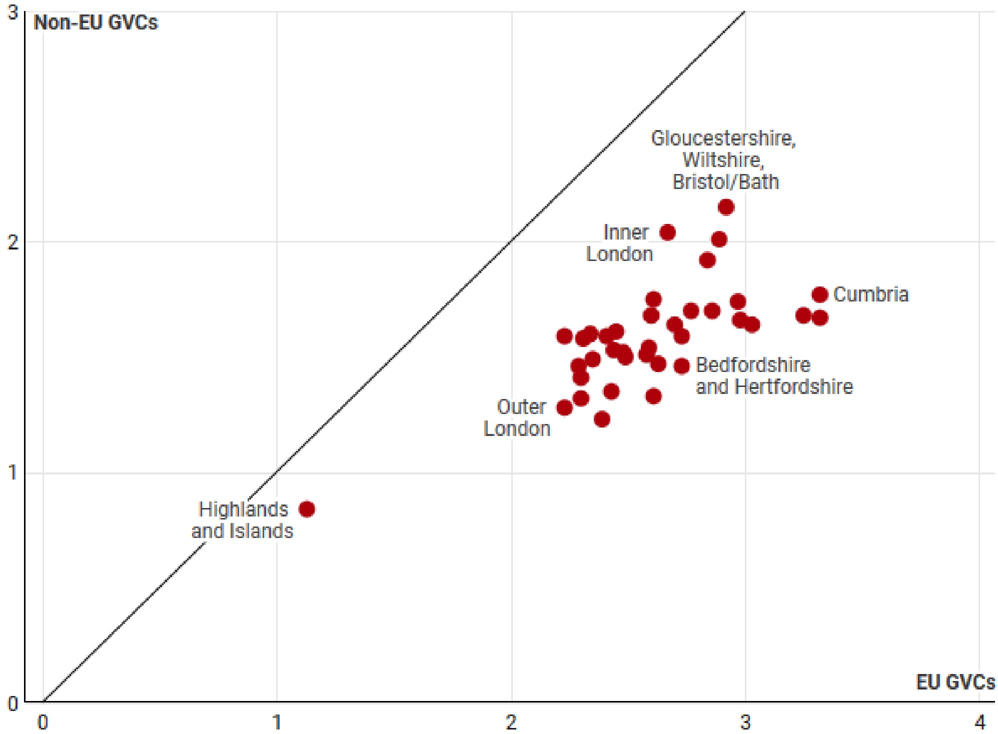
Despite the fact that the tendencies and differences reported in Figure 2 are in line with observations by other experts (using different types of data), it is essential to understand that the attribution of services exports to use categories in the construction could play a non-negligible role. Exports of services to final users (e.g. households) do by definition not contribute to GVC income, whereas exports of services as intermediate inputs could well do this, if they are ultimately embodied in manufactured final products. The procedures to "trade-link" national supply and use tables as adopted in the construction of WIOD (on which the EUREGIO database is based) are described in Dietzenbacher et al. (2013). This account clearly indicates that bilateral services trade figures tended to cause more inconsistencies with national accounts data, and that it was impossible to devise a sophisticated way to attribute services trade to use categories. For countries and regions with a diversified composition of exports, such problems might not affect GVC income indicators to a substantial extent. For the services-based economies like UK and for London in particular, the outcomes might be more sensitive to these data problems.

The results presented so far are based on income and jobs in all GVCs taken together. To construct Figure 3, we attributed each GVC to one of three types, based on geography. First, part of the activities in British regions contribute to value chains for final products finalized in the UK itself, whereas others relate to final manufactured products of which the last stage of production takes place in other EU countries. Third, activities in UK regions can contribute to the production process of manufactured final products from non-EU countries (including EUREGIO's Rest of the World). Figure 3 focuses on the shares of jobs of the second and third type of GVC in total regional employment.[7]

A first observation is that EU GVCs are more important than non-EU GVCs. All regions are located below the 45-degrees line, which indicates situations in which the non-EU GVCs would be exactly as important as EU GVCs for regional employment creation. Apart from Highlands & Islands (Northern Scotland), which is clearly the least dependent on GVCs for products finalized anywhere outside the UK, between 2% and 3.5% of employment in all regions contribute to EU GVCs and between 1% and 2.5% to non-EU GVCs. Cumbria is the region in which employment is most strongly related to EU GVCs, while Gloucestershire (including Bristol and Bath) scores highest in terms of the labour share contributing to GVCs with countries of completion outside the EU. The City (Inner London) does not rely very much on EU GVCs, but ranks second in terms of the importance of non-EU GVCs for its employment. This finding corroborates the arguments by McCann (2016) about London being a "global" city.

[7] The computations are comparable to what Los and Timmer (2018) label VAX-P (they focused on value added rather than employment).

Figure 3: Shares of labour contributed to EU GVCs and non-EU GVCs in regional employment (in %), 2010



Source: Authors' computations based on EUREGIO (Thissen et al., 2018).

The analysis above already allows for a bit of speculation. Regions for which relatively large shares of employment contribute to EU GVCs might well face higher risks than regions for which these shares are relatively small. Still, as was emphasized by IJtsma et al. (2018), even economies that contribute mainly to non-EU GVCs might suffer substantially. They show that the UK exports sizable shares of its products (both goods and services) to the EU, from where products that "embody" the UK's products are transported to the Far East or other regions outside the EU. In Section 5, we will pay more specific attention to the potential consequences of Brexit for employment in UK regions.

4. Regional GVC competitiveness

The rapidly increased fragmentation of production processes has had implications for the measurement of competitiveness. It is important in this respect that we focus here on what could be called "revealed" competitiveness. That is, we do not focus on *determinants* of competitiveness (like a highly educated workforce, good infrastructure, a stable macroeconomic conditions, etc.), but on the extent to which the combination of these determinants leads to a situation in which the *outcomes* show whether a country or region does well in generating value added in a context of global competition.

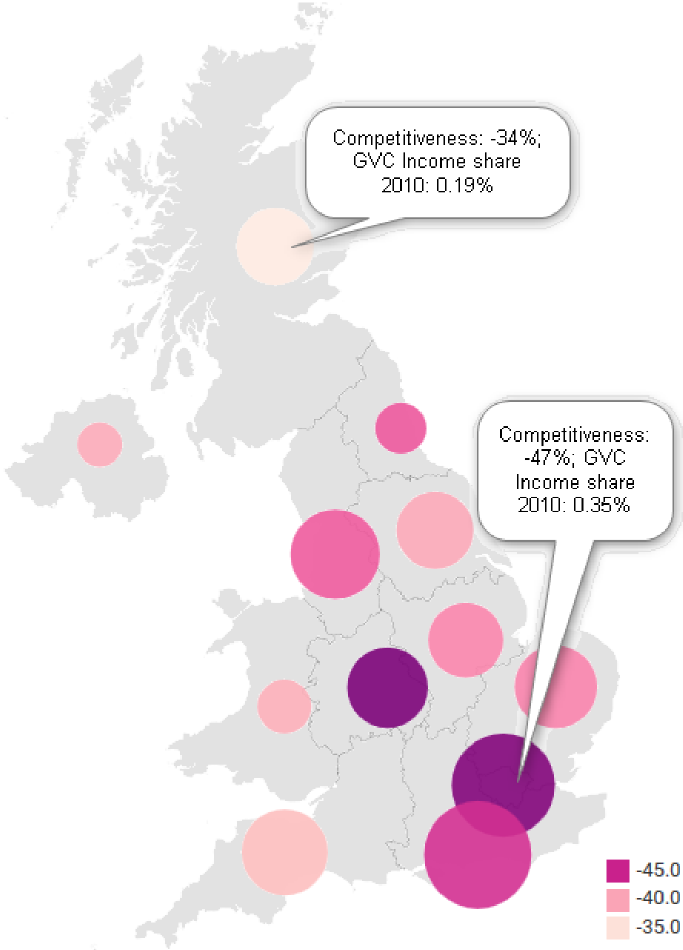
In a world in which regions hosts all stages of production (from scratch till final product), conventional gross exports statistics can provide good indications of the revealed competitiveness of these regions. As Timmer et al. (2013) argue, this is no longer true after GVCs started to become pervasive in the first decade of the century. Gross exports do no longer almost exclusively contain value added generated in the region itself, but are now composed of value added contributed by activities elsewhere (this value is incorporated in imports of intermediate inputs) and by the region itself. Only the latter category should be considered as an indicator of regional competitiveness. A region that adds virtually no value to its imports can hardly be seen as very competitive. Another downside of gross exports-based indicators as emphasized by Timmer et al. (2013) is that the country's or region's performance on domestic markets does not play a role in the assessment of its competitiveness. Still, most casual observers would view the UK's car manufacturing industry as less competitive if it would not sell any cars to British customers anymore.

Timmer et al. (2013) suggested to consider changes in the ratio between national/regional GVC income and worldwide GVC income as an indicator of changes in the competitiveness of countries and regions.[8] This implies that we can use equation (1) again in the numerator of this indicator. In contrast to the indicator adopted in the previous section (in which regional GDP is the denominator), however, we now have worldwide GVC income as the denominator. This denominator equals the value of all final manufactured products, irrespective of where the last stage in the production process took place. The share of this value as captured by the region under consideration will grow if it becomes a more attractive place to locate (in particular high value adding) activities and can therefore be seen as a proper indicator of regional competitiveness. It is important to note that this indicator considers all GVCs, i.e. including those for which the focal region is the location of the final production stage. Since we do not make a distinction between final manufactured products sold in the region itself and those sold elsewhere, the second point of criticism on gross exports-based competitiveness measure as expressed by Timmer et al. (2013) is avoided as well.

Figure 4 shows how regional competitiveness changed in NUTS1 regions. It reveals a rather bleak picture. All UK regions have lost competitiveness, and the losses are sizable. Scotland has lost little relative to the other regions, but its share in worldwide GVC income still declined by 34% (its share amounted to 0.19% in 2010). We find that the Midlands and London incurred the largest losses in competitiveness, losing close to half of their 2000 shares in worldwide GVC income. The Southeast also lost considerably.

[8] The approach could also be adopted to assess industry competitiveness, but this is an avenue of research that we do not pursue in this paper.

Figure 4: Changes in competitiveness of UK regions (all GVCs, NUTS1, 2000-2010).



Note: NUTS1 regions. Surfaces of circles proportional to GVC income share in 2010.
Source: Authors' computations based on EUREGIO data (Thissen et al., 2018).

We should note explicitly that the loss of competitiveness of London is not due to the fact that we have defined GVCs as all activities required for the production of final *manufactured* products. As discussed before, these include financial services and other business services sold to producers that eventually contribute to the production of manufactured products. Hence, London could have gained in competitiveness if (everything else equal) its financial services activities had become more attractive for manufacturers (and their services suppliers) in the UK and elsewhere in the world. London's reality for the period 2000-2010 has been different, however. We should reiterate the data-related caveat discussed in the previous section here, though. Data on exports of services tend to be less accurate than data on exports of merchandise. On top of that, our computations of GVC income (which is the numerator of the GVC competitiveness indicator) is dependent on whether services exports are sold to final users or to intermediate users. Inaccuracies in the attribution of services exports to either of these can lead to inaccuracies in the GVC competitiveness indictor. Still, we do not have reasons to believe that the reported changes in competitiveness are systematically over- or understated.

Table 1: Changes in regional GVC competitiveness (NUTS2, all GVCs, 2000-2010).

	2000	2010	Change		2000	2010	Change
United Kingdom - Aggregate	4.26%	2.44%	-42.7%				
1 Cornwall and Isles of Scilly	0.02%	0.02%	-29.4%	20 East Wales	0.07%	0.04%	-41.4%
2 North Eastern Scotland	0.04%	0.03%	-31.2%	21 Leicestershire, Rutland, Northamptonshire	0.14%	0.08%	-41.5%
3 South Western Scotland	0.11%	0.07%	-32.0%	22 Herefordshire, Worcestershire, Warwickshire	0.10%	0.06%	-41.6%
4 South Yorkshire	0.06%	0.04%	-34.3%	23 Inner London	0.39%	0.23%	-41.6%
5 Cumbria	0.04%	0.02%	-35.4%	24 Devon	0.07%	0.04%	-41.8%
6 Cheshire	0.08%	0.05%	-36.1%	25 East Yorkshire and Northern Lincolnshire	0.07%	0.04%	-42.8%
7 Highlands and Islands	0.02%	0.01%	-36.3%	26 Kent	0.11%	0.06%	-43.7%
8 Gloucestershire, Wiltshire, Bristol/Bath	0.21%	0.14%	-36.4%	27 Surrey, East and West Sussex	0.18%	0.10%	-43.7%
9 Eastern Scotland	0.12%	0.07%	-36.8%	28 Derbyshire and Nottinghamshire	0.12%	0.07%	-43.8%
10 West Wales and The Valleys	0.08%	0.05%	-37.3%	29 Greater Manchester	0.16%	0.09%	-45.3%
11 Lincolnshire	0.04%	0.03%	-37.8%	30 Bedfordshire and Hertfordshire	0.13%	0.07%	-46.1%
12 Hampshire and Isle of Wight	0.15%	0.09%	-38.3%	31 Tees Valley and Durham	0.06%	0.03%	-46.1%
13 North Yorkshire	0.05%	0.03%	-39.1%	32 Lancashire	0.10%	0.06%	-46.2%
14 East Anglia	0.15%	0.09%	-39.2%	33 Merseyside	0.08%	0.04%	-46.7%
15 Northern Ireland	0.10%	0.06%	-39.5%	34 Shropshire and Staffordshire	0.11%	0.06%	-47.0%
16 West Yorkshire	0.14%	0.08%	-40.7%	35 Berkshire, Buckinghamshire, Oxfordshire	0.24%	0.12%	-49.8%
17 Dorset and Somerset	0.09%	0.05%	-40.7%	36 West Midlands	0.19%	0.09%	-50.5%
18 Essex	0.10%	0.06%	-40.9%	37 Outer London	0.27%	0.12%	-55.2%
19 Northumberland and Tyne and Wear	0.07%	0.04%	-41.2%				

Note: Regions ordered by proportional change in GVC income shares.

Source: Authors' calculations based on EUREGIO (Thissen et al., 2018).

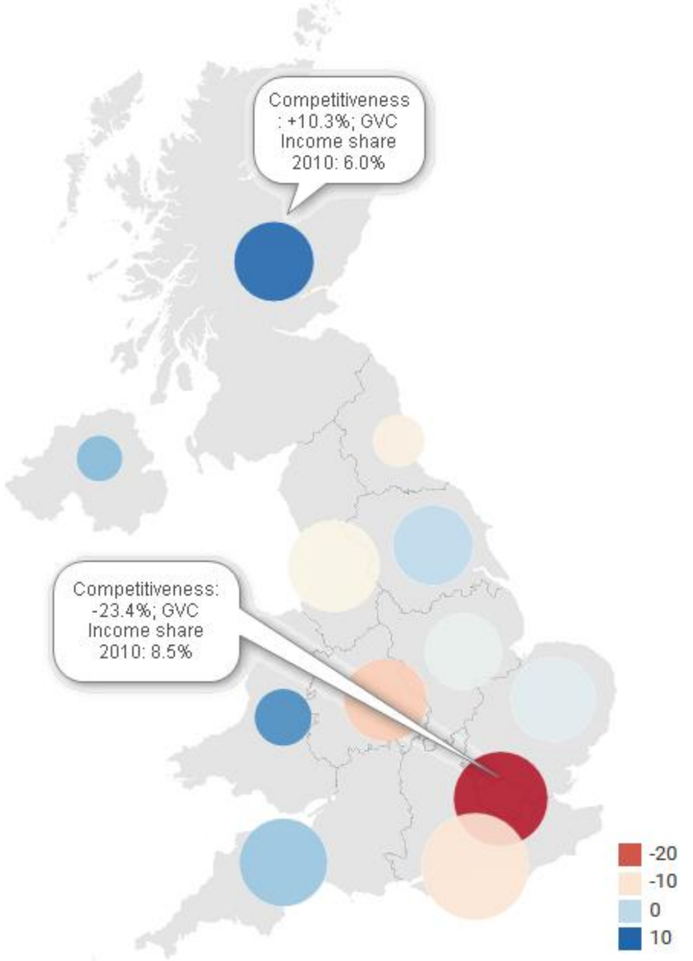
We document the results for NUTS2 regions in Table 1. At this level of regional aggregation, the heterogeneity across regions is larger, as could be expected. Still, the losses of competitiveness are substantial in all regions. At first sight, there are no clear geographical patterns visible, but more systematic analysis is needed to figure out why regions like Cornwall and South Yorkshire have not lost too much, while neighbouring regions like Devon and East Yorkshire have clearly been among the group of worse performing regions.

Figure 4 and Table 1 show that regional competitiveness has declined in the 2000-2010 period in each and every region. As mentioned before, the GVC income shares considered relate to all GVCs, irrespective of where the final stage of production takes place. A potentially interesting question that remains is whether competitiveness in UK GVCs (those for which the finalization of the consumer good or capital good happens somewhere in the UK) has also diminished. To obtain an answer, we first computed the value of final output of UK manufacturing industries in the EUREGIO tables. This value equals the value added anywhere in the world associated with these final products. We then computed the GVC income levels of UK regions by only retaining the elements of the final demand blocks associated with UK manufacturing industries in $\mathbf{F}^{mk}$ (see equation (1)) and setting all other elements to zero. The elements of $\mathbf{w}^{mk}$ corresponding to industries in UK regions then give the GVC income generated in UK GVCs only.

The results for NUTS1 regions as depicted in Figure 5 show that the changes in competitiveness in UK GVCs have been much more heterogeneous than for GVCs with countries of completion all over the world. Several regions increased their value added shares (Scotland by even more than 10%) in the total value of UK final manufactured products. The regions in the diagonal running from the West Midlands via London to South-East England, however, have lost GVC income shares between 2000 and 2010. Especially for London, the losses have been sizable, amounting to almost a quarter of its share. By 2010, about 8.5% of the value of final products manufactured in the UK was captured in London, down from slightly more than 11% in 2000.

As the top line in Table 2 shows, the GVC income share for the UK regions taken together in the value of UK final manufactured products declined from 78.5% in 2000 to 73.4% in 2010. The remaining share is captured by other countries. The decline in itself is not problematic. It actually reflects the very nature of the emergence of GVCs. Los et al. (2015) find results like these for almost all EU countries, and for most countries the competitiveness losses in "own" GVCs are much more sizable than reported for the UK. The worrying issue is that UK regions did not manage to contribute larger shares of the value of the output of GVCs with foreign countries-of-completion. If UK-based businesses would have been competitive, such increases in shares would have been realized. Our finding that even the regions that managed to receive a bigger slice of the UK GVCs have lost so much that their income shares in all GVCs (see Figure 4 and Table 5) have declined is a strong sign that UK regions have not been doing particularly well.

Figure 5: Changes in competitiveness of UK regions (UK GVCs, NUTS1, 2000-2010).



Note: NUTS1 regions. Surfaces of circles proportional to GVC income share in 2010.
Source: Authors' calculations based on EUREGIO (Thissen et al., 2018).

A comparison of Table 2 (for competitiveness in UK GVCs) with Table 1 (for competitiveness in all GVCs) reveals a relatively strong correlation between the two sets of results. Cornwall, a number of Scottish regions and South Yorkshire are among the regions that rank high on both lists, while the West Midlands and Outer London are the worst performing regions regarding both types of competitiveness. A notable exception to this rule is Inner London. It is clearly among the regions that lost the highest shares of GVC income in UK GVCs, while it ranks higher regarding competitiveness in all GVCs. This suggests that Inner London has been doing well in supplying financial and business services to globally organized production processes. A closer look at the proportional changes in GVC income shares for Inner London in Tables 1 and 2 shows, however, that the City has lost much more in all GVCs taken together than in UK GVCs only. Other UK regions have just fared even worse globally. Moreover, the strong decline of both London regions in UK GVCs provides further evidence of the increasing disconnect between London and the rest of the UK economy, as stressed by McCann (2016).

Table 2: Changes in regional competitiveness (NUTS2, UK GVCs, 2000-2010).

	2000	2010	Change		2000	2010	Change
United Kingdom - Aggregate	78.5%	73.4%	-6.5%				
1 Cornwall and Isles of Scilly	0.40%	0.47%	17.4%	20 Herefordshire, Worcestershire, Warwickshire	1.92%	1.88%	-2.2%
2 North Eastern Scotland	0.74%	0.85%	15.6%	21 Leicestershire, Rutland, Northamptonshire	2.77%	2.66%	-4.0%
3 South Western Scotland	1.98%	2.23%	12.8%	22 Northumberland and Tyne and Wear	1.38%	1.31%	-4.7%
4 West Wales and The Valleys	1.55%	1.71%	10.3%	23 Devon	1.31%	1.24%	-5.3%
5 Cumbria	0.70%	0.77%	9.5%	24 East Yorkshire, Northern Lincolnshire	1.34%	1.24%	-7.6%
6 South Yorkshire	1.11%	1.21%	8.7%	25 Surrey, East and West Sussex	3.17%	2.91%	-8.2%
7 Highlands and Islands	0.47%	0.50%	8.0%	26 Kent	2.05%	1.88%	-8.2%
8 Eastern Scotland	2.26%	2.41%	6.9%	27 Derbyshire and Nottinghamshire	2.32%	2.12%	-8.4%
9 Lincolnshire	0.81%	0.85%	5.1%	28 Bedfordshire and Hertfordshire	2.33%	2.10%	-9.9%
10 Cheshire	1.54%	1.59%	3.7%	29 Greater Manchester	3.02%	2.70%	-10.6%
11 Gloucestershire, Wiltshire, Bristol/Bath	3.94%	4.08%	3.5%	30 Tees Valley and Durham	1.20%	1.07%	-10.9%
12 Northern Ireland	1.83%	1.88%	2.8%	31 Lancashire	2.00%	1.78%	-11.2%
13 East Wales	1.30%	1.33%	2.7%	32 Shropshire and Staffordshire	2.18%	1.92%	-11.8%
14 North Yorkshire	1.02%	1.04%	1.7%	33 Merseyside	1.42%	1.23%	-13.4%
15 East Anglia	2.88%	2.89%	0.5%	34 Berkshire, Buckinghamshire, Oxfordshire	4.24%	3.48%	-18.1%
16 Hampshire and Isle of Wight	2.78%	2.79%	0.4%	35 Inner London	6.37%	5.18%	-18.6%
17 Essex	1.77%	1.77%	0.1%	36 West Midlands	3.47%	2.80%	-19.3%
18 Dorset and Somerset	1.61%	1.60%	-0.6%	37 Outer London	4.74%	3.32%	-29.9%
19 West Yorkshire	2.65%	2.62%	-1.0%				

Note: Regions ordered by proportional change in competitiveness in UK GVCs.

Source: Authors' calculations based on EUREGIO (Thissen et al., 2018).

5. The export-related risks of Brexit for regional employment

GVCs and the dependence of UK-based manufacturing plants on these have played an important role in discussions about the potential impacts of Brexit on the economies of the UK and its regions. The consequences for the car manufacturing industry in particular are often considered to be devastating. Foreign firms like Honda, Toyota and Nissan have decided to relocate some activities that have been performed in the UK, or decided not to pursue plans for new activities in the UK. In the announcements of these relocations, firms generally mention various reasons for strategic decisions like these, but there is strong evidence that investment decisions have changed considerably after the Brexit referendum (see Serwicka and Tamberi, 2018, and Breinlich et al., 2019). Regions like the Northeast of England and the West Midlands might be hurt disproportionally.[9] Still, the organisation of the production of other final manufactured products in internationally dispersed processes might have important impacts on the regional economic consequences of Brexit as well. In this section, we assess these.

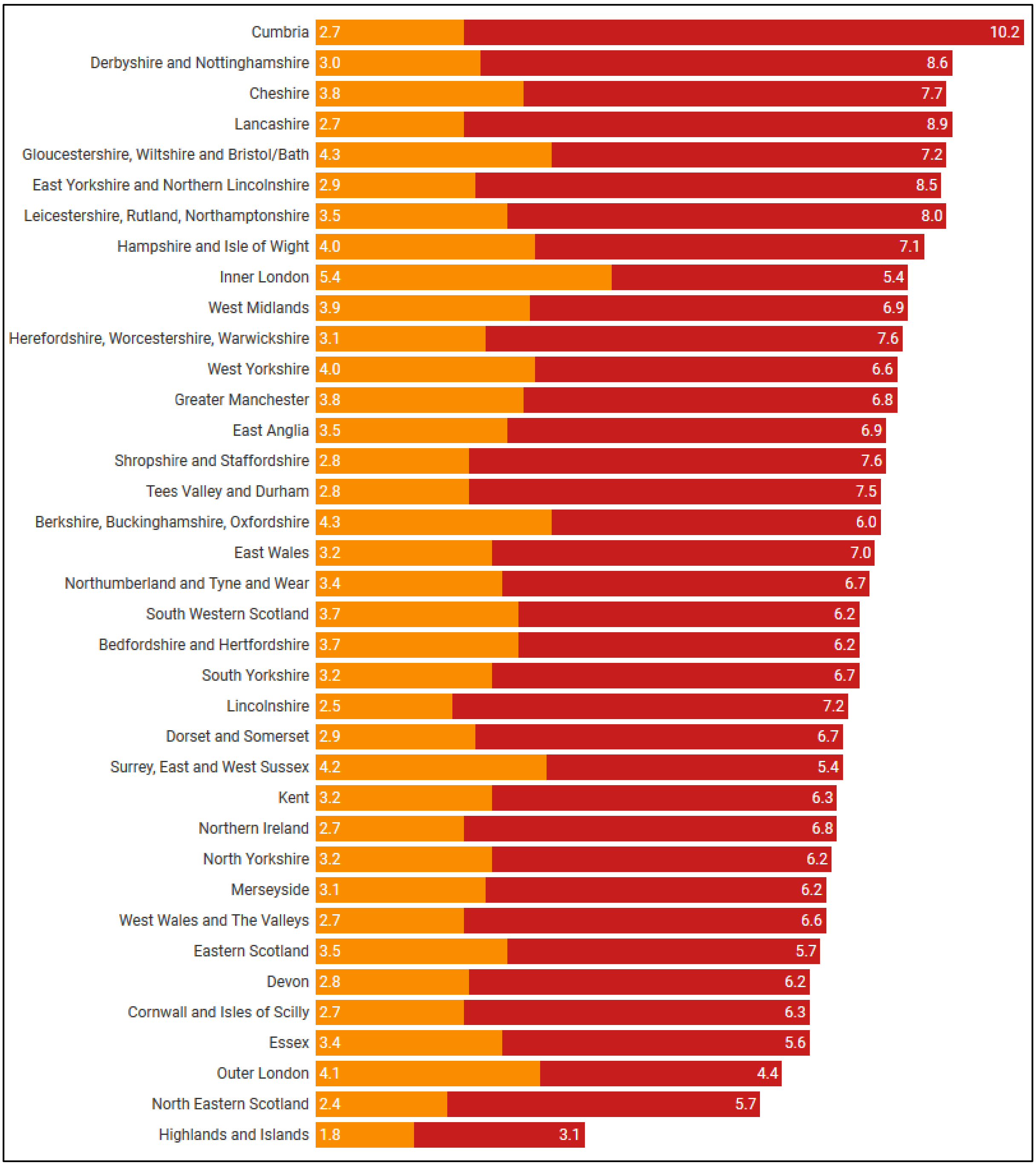
In their attempt to unify various types of measurement of bilateral exports of value added in a context of a GVC-networked world, Los and Timmer (2018) argue that their VAX-D measure is the appropriate indicator to assess the potential export-related risks of barriers to bilateral trade.[10] Given that this is the relevant context in the case of Brexit (exports crossing borders between the UK and EU-countries will be hampered, while exports that cross borders with third countries will not be affected), we opt for an analogous approach related to jobs.

For a formal discussion of a methods to compute our indicator, we refer to Los and Timmer (2018). Here, we limit ourselves to an intuitive explanation. First, the actual number of jobs is determined. Next, we compute a hypothetical number of jobs, associated with a situation in which exports of both intermediate products (including raw materials and business services) and final products to the EU are zero. The difference between these two levels is our indicator of the extent to which regional employment is exposed to the export-risks of Brexit. The hypothetical employment levels are computed using an equation very similar to equation (2). The difference is that the matrices **A** and $\mathbf{F}^{mk}$ are defined slightly differently. The alternative $\mathbf{F}^{mk}$ is obtained by taking the original block **F** from the input-output table depicted in Figure 1 and setting all elements in the submatrix $\mathbf{F}^{ue}$ to zero (all other elements retain their original values). The alternative matrix **A** is obtained by setting the elements of the intermediate inputs submatrix $\mathbf{Z}^{ue}$ to zero and recomputing the inputs coefficients matrix **A** based on this modified **Z**.

[9] In their EU-wide study about Brexit-risks for regions, Chen et al. (2018) find that setting aside UK and Irish regions, the South and Southwest of Germany are most exposed to the negative consequences of Brexit. They attribute this to the importance of the transportation equipment industry in those German regions.

[10] Aggregate VAX-D (i.e., aggregated over trade partners) was popularized by Koopman et al. (2014).

Figure 6: Exports-related regional employment risks of Brexit (in % of actual employment, 2010)



Note: Orange bar: employment risk of customs union/FTA Brexit arrangement. Red bar: Difference between risks of a no deal Brexit and a customs union/FTA Brexit arrangement.
Source: Authors' calculations based on EUREGIO (Thissen et al., 2018).

This method for employment risks analogous to the VAX-D indicator has the desirable feature that risks for non-exporting industries are not necessarily equal to zero. Services providers, for example, that do not export themselves, might still be exposed to Brexit risks if they sell their products to firms (in their own region or elsewhere in the UK) that do export. Without the availability of input-output tables with regional detail such as EUREGIO, effects like these could not be quantified.

The EUREGIO data for 2010 are the most recent data available. Hence, we cannot but assume that the regional and global production structure at the time were not too different from what they currently are, in the time in which Brexit might happen. Figure 6 (and Table A.2 in the appendix) provide information regarding the shares of jobs exposed to two kinds of Brexit. The orange and red bars together show the exposure of regional employment to a Np Deal Brexit (in which the UK and the EU would trade with each other on WTO terms, without any further agreement on tariff and non-tariff barriers to trade), in which all UK exports to the EU would be at risk. This is the type of analysis done for regional GDP and labour income in Chen et al. (2018). The orange parts of the bar refer to the employment risks of a Brexit scenario in which the UK would remain in some kind of free trade agreement (a customs union or a more 'bare bones' FTA). We assume that this implies that exports of goods will remain unchanged, and that loss of access to the EU's Single Market will only lead to the impossibility of exporting services.[11] This implies that the lengths of the red bars provide information on the extent to which a No Deal Brexit might be more detrimental to regional employment than a Brexit in which trade in goods would be unaffected.[12]

Not surprisingly, we find that regions that depend relatively much on GVC activities with respect to their employment (see Section 3) also tend to be the regions for which the trade-related employment risks of Brexit are highest. Cumbria is most at risk, with an exposure level of close to 13%, clearly above the UK's aggregate exposure level of slightly more than 10%. Other regions that are heavily exposed to Brexit are Derbyshire, Cheshire and Lancashire. At the other end of the spectrum, we find Scottish regions and Outer London, with risk levels of about 5% for Highland and Islands and about 8.5% for the other regions. Focusing on the differences between the two stylized types of Brexit considered here, we see that under a customs union/FTA arrangement employment in regions in the Southeast of England will most likely be hit hardest. These are the regions that have specialized most strongly n exporting services and would be impacted most by an end of Single Market membership. For Inner London, 5.4% of regional employment would be at risk. For other regions in this part of England, the risks would be close to 4%.

6. Concluding remarks

[11] In reality, exports of goods come with exports of services, for example via maintenance and repair contracts. Here, we do not consider such dependencies.

[12] It is important to stress that we quantify *risks* of two types of Brexit, or, in other words, *exposure levels*. Not all risks will materialize, due to behavioral changes of firms and households, both in the UK and elsewhere. Hence, the numbers as reported should not be seen as predictions of how regional economies will perform after Brexit. See IJtsma and Los (2019) for more details.

We have analyzed the role that UK regions play in global value chains (GVCs). We have found that UK regions are heterogeneous in terms of the extent to which their value added generation and employment rely on GVC activities. At the same time, we have found that they are very homogeneous in the sense that the importance of GVC activities have decreased markedly in all regions over 2000-2010, the period in which GVCs became a pervasive phenomenon. We also found that UK regions are similar in terms of their loss of international competitiveness. All UK regions lost GVC income shares. If, however, we only focus on GVCs for British final manufactured products, we find a lot of heterogeneity. London and the West Midlands have lost competitiveness, but regions in Scotland and in Southwest England in particular have gained competitiveness. Finally, we have considered the employment risks for regions in the wake of Brexit. We have considered two scenarios and concluded that these risks vary considerably across regions. If the UK would leave the Single Market and not be part of a customs union with the EU, employment in regions in the North and Northeast of England is at highest risk. If, however, the UK would only leave the Single Market but would strike a customs union deal with the EU, employment in Southeastern regions (including London) would be at highest risk.

To conclude this paper, we would like to emphasize that the results are based on data (global input-output tables with interregional detail for EU countries, at NUTS2 level) that are rich, but also less recent and fairly aggregated. Efforts to come up with similar data (which explicitly allow for the incorporation of indirect supply-chain effects) for more recent years with more industry detail would enable researchers to provide policymakers with more precise indicators related to current economic issues.

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Appendix

Table A.1: Shares of regional employment in GVC activities (2000, 2010).

	2000			2010		
	GVC employment share	EU GVC employment share	Non-EU GVC employment share	GVC employment share	EU GVC employment share	Non-EU GVC employment share
Tees Valley and Durham	21.7%	2.8%	2.1%	13.2%	2.6%	1.5%
Northumberland and Tyne and Wear	18.7%	2.6%	1.9%	11.8%	2.6%	1.5%
Cumbria	24.1%	2.9%	2.4%	17.4%	3.3%	1.8%
Cheshire	22.4%	2.8%	2.1%	14.2%	3.0%	1.7%
Greater Manchester	20.3%	2.6%	2.1%	12.4%	2.6%	1.8%
Lancashire	23.7%	2.7%	2.3%	15.9%	3.2%	1.7%
Merseyside	17.5%	2.4%	2.0%	10.8%	2.4%	1.5%
East Yorkshire and Northern Lincolnshire	23.8%	2.6%	2.1%	15.9%	3.0%	1.6%
North Yorkshire	19.4%	2.0%	1.8%	13.1%	2.3%	1.6%
South Yorkshire	20.3%	2.6%	2.0%	12.7%	2.6%	1.5%
West Yorkshire	22.1%	2.6%	2.1%	13.8%	2.6%	1.7%
Derbyshire and Nottinghamshire	23.2%	2.8%	2.1%	15.3%	3.3%	1.7%
Leicestershire, Rutland, Northamptonshire	27.0%	2.6%	2.3%	16.4%	2.8%	1.9%
Lincolnshire	23.9%	2.1%	1.9%	15.8%	2.4%	1.5%
Herefordshire, Worcestershire, Warwickshire	23.2%	2.6%	2.4%	15.7%	2.9%	1.7%
Shropshire and Staffordshire	24.7%	2.6%	2.3%	16.0%	2.8%	1.7%
West Midlands	23.8%	3.2%	2.6%	13.3%	3.0%	1.7%
East Anglia	20.2%	2.6%	2.0%	12.9%	2.7%	1.6%
Bedfordshire and Hertfordshire	18.6%	2.9%	2.2%	11.4%	2.7%	1.5%
Essex	17.5%	2.3%	2.1%	11.4%	2.3%	1.5%
Inner London	13.7%	2.2%	2.3%	9.3%	2.7%	2.0%
Outer London	14.5%	2.2%	2.0%	8.2%	2.2%	1.3%
Berkshire, Buckinghamshire, Oxfordshire	18.3%	2.5%	2.4%	11.9%	2.7%	1.6%
Surrey, East and West Sussex	14.2%	2.2%	2.0%	9.3%	2.5%	1.5%
Hampshire and Isle of Wight	19.0%	2.5%	2.4%	13.7%	2.9%	2.0%
Kent	17.5%	2.3%	2.1%	11.5%	2.4%	1.6%
Gloucestershire, Wiltshire, Bristol/Bath	20.9%	2.6%	2.5%	14.5%	2.9%	2.2%
Dorset and Somerset	20.2%	2.2%	2.1%	13.7%	2.4%	1.6%
Cornwall and Isles of Scilly	16.3%	2.0%	1.8%	12.0%	2.2%	1.6%
Devon	17.5%	2.1%	1.9%	11.8%	2.3%	1.6%
West Wales and The Valleys	19.1%	2.5%	2.0%	13.6%	2.4%	1.4%
East Wales	19.6%	2.7%	1.9%	13.2%	2.6%	1.3%
North Eastern Scotland	15.5%	2.0%	1.5%	12.5%	2.4%	1.2%
Eastern Scotland	17.4%	2.2%	1.7%	11.1%	2.3%	1.3%
South Western Scotland	18.8%	2.5%	2.1%	11.8%	2.5%	1.5%
Highlands and Islands	11.0%	1.0%	1.1%	8.6%	1.1%	0.8%
Northern Ireland	19.6%	2.2%	1.8%	13.0%	2.3%	1.4%

Source: Authors' calculations based on EUREGIO (Thissen et al., 2018).

Table A.2: Brexit risks, 2010 indicators

	Total trade risks		CU risks				Total trade risks		CU risks		
	Jobs at risk	Share	Jobs at risk	Share	Ratio		Jobs at risk	Share	Jobs at risk	Share	Ratio
United Kingdom - Aggregate	3,644,735	10.2%	1,316,109	3.7%	0.36						
1 Cumbria	33,271	12.9%	6,977	2.7%	0.21	20 South Western Scotland	135,805	9.9%	51,072	3.7%	0.38
2 Derbyshire and Nottinghamshire	125,450	11.6%	32,588	3.0%	0.26	21 Bedfordshire and Hertfordshire	99,120	9.9%	36,832	3.7%	0.37
3 Cheshire	66,249	11.6%	21,993	3.8%	0.33	22 South Yorkshire	68,462	9.9%	21,969	3.2%	0.32
4 Lancashire	85,912	11.6%	20,085	2.7%	0.23	23 Lincolnshire	32,008	9.6%	8,260	2.5%	0.26
5 Gloucestershire, Wiltshire and Bristol/Bath	167,139	11.5%	62,426	4.3%	0.37	24 Dorset and Somerset	59,822	9.6%	17,963	2.9%	0.30
6 East Yorkshire and Northern Lincolnshire	54,408	11.4%	13,767	2.9%	0.25	25 Surrey, East and West Sussex	144,443	9.5%	63,000	4.2%	0.44
7 Leicestershire, Rutland, Northamptonshire	108,508	11.4%	32,821	3.5%	0.30	26 Kent	79,837	9.5%	26,622	3.2%	0.33
8 Hampshire and Isle of Wight	118,642	11.1%	42,515	4.0%	0.36	27 Northern Ireland	99,292	9.4%	28,049	2.7%	0.28
9 Inner London	365,806	10.8%	183,613	5.4%	0.50	28 North Yorkshire	41,910	9.4%	14,261	3.2%	0.34
10 West Midlands	169,180	10.8%	60,622	3.9%	0.36	29 Merseyside	71,195	9.3%	23,843	3.1%	0.33
11 Herefordshire, Worcestershire, Warwickshire	75,482	10.7%	21,894	3.1%	0.29	30 West Wales and The Valleys	77,926	9.3%	22,932	2.7%	0.29
12 West Yorkshire	141,099	10.5%	53,196	4.0%	0.38	31 Eastern Scotland	108,406	9.2%	41,496	3.5%	0.38
13 Greater Manchester	161,101	10.5%	57,584	3.8%	0.36	32 Devon	52,453	9.0%	16,280	2.8%	0.31
14 East Anglia	130,796	10.4%	43,830	3.5%	0.34	33 Cornwall and Isles of Scilly	20,745	9.0%	6,317	2.7%	0.30
15 Shropshire and Staffordshire	81,286	10.4%	21,834	2.8%	0.27	34 Essex	76,270	8.9%	28,884	3.4%	0.38
16 Tees Valley and Durham	59,224	10.3%	15,947	2.8%	0.27	35 Outer London	189,063	8.5%	90,933	4.1%	0.48
17 Berkshire, Buckinghamshire, Oxfordshire	155,647	10.3%	64,335	4.3%	0.41	36 North Eastern Scotland	26,990	8.2%	8,023	2.4%	0.30
18 East Wales	65,715	10.2%	20,638	3.2%	0.31	37 Highlands and Islands	13,494	5.0%	4,971	1.8%	0.37
19 Northumberland and Tyne and Wear	82,581	10.1%	27,735	3.4%	0.34						

Note: Regions ordered by total share of jobs at risk in regional employment. Ratio: Share of customs union (CU) risk in total trade risk.

Source: Authors' calculations based on EUREGIO (Thissen et al., 2018).