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The Implications of Brexit for UK and EU Regional Competitiveness

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abstract

Any form of Brexit will impact heterogeneously in terms of sectors and regions on the competitive position of firms in both the UK and Europe. The ongoing uncertainty about the conditions under which the UK will be leaving the EU creates difficulties in structurally estimating these impacts. Using uniquely detailed interregional trade data on goods and services for the EU, we apply a novel methodology that disentangles region-sector sensitivities (elasticities) of firms' competitive positions to (non)tariff barriers from the implications of different post-Brexit UK–EU trade scenarios. This enables us to derive the economic geography of competitive opportunities and vulnerabilities of Brexit of firms, along with the degree of uncertainty that surrounds these effects, independently from scenarios. Our analysis demonstrates that the adverse international competitive vulnerabilities of UK regions are much larger than those of the rest of the EU due to the dependency of the UK on the EU via global value chains. The impact on the competitive positions of firms means that within the UK, Brexit is likely to increase interregional inequalities. In contrast, interregional inequalities across Europe may actually fall, depending on the nature of the post-Brexit UK–EU trading arrangements. Moreover, the key political focus on the nature of the post-Brexit arrangements appears to be misplaced in that most UK regions are rather insensitive to the specific nature of the deal. As such, the economic geography implications of Brexit appear to be largely unrelated to UK domestic political narratives.

Key words:

European regional development
Brexit
impact analysis
competitiveness
regional inequality

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Supplemental data for this article can be accessed here.

The exact nature of the post-Brexit UK–EU trade relationship is not known and may be uncertain for a long period of time. However, the very short time period for negotiating a new agreement, along with the position set out by the UK government in early 2020, strongly suggests that the final UK–EU trading arrangement will be akin to something like a more limited version of the EU–Canada trade agreement or even the more distant EU–Australia agreement, if not a default to a so-called hard Brexit, which involves the UK reverting to World Trade Organization (WTO) trade rules (UK Trade Policy Observatory 2016; Stojanovic 2018; O'Carroll 2020; Peston 2020; *The Economist* 2020), a scenario that will bring many challenges with it. Importantly, both the Canadian or Australian types of agreements imply a profound change in the nature of UK–EU trading relationships because both set-ups are very much closer in terms of their regulatory architecture to a hard Brexit based on WTO trading rules than they are to remaining in the single market via EU membership, membership in the European Economic Area, or membership in the European Free Trade Association. Indeed, the likely end point of the UK–EU negotiations will position the UK further away in trade-governance terms from the EU than either Turkey or the Ukraine.[1] The large majority of evidence implies that the potential implications of a *no-deal* Brexit suggest that there will be strong adverse implications for all UK regions as well as some other EU regions. More specifically, the exposure of regional economies to cross-border trade is likely to be more serious for many of the largely *Leave*-voting, geographically noncore and economically weaker regions of the UK than they are for the geographically core, economically stronger and largely *Remain*-voting regions of the UK (Los et al. 2017; Chen et al. 2018; Billing, McCann, and Ortega-Argilés 2019). In particular, the UK regions, which are generally close to continental Europe, typically face lower levels of Brexit trade-risk exposure than UK regions geographically further away from mainland Europe, except for Scotland. These conclusions were first established by Los et al. (2017) and Chen et al. (2018) and have subsequently been confirmed by a dozen or so different papers and reports using different research techniques and data sets (Billing, McCann, and Ortega-Argilés 2019). At the same time,

[1] https://ec.europa.eu/commission/sites/beta-political/files/slide_presented_by_barnier_at_euco_15-12-2017.pdf.

it was also established by Chen et al. (2018) that for many EU member states and regions, and especially those geographically noncore and economically weaker regions situated in the far south, the far east, and the far north of Europe, the economic exposure to Brexit was very minimal (Chen et al. 2018) in comparison to the exposure faced by regions in the UK, Ireland, or the core regions in northwestern Europe. In particular, EU regions in continental Europe close to the UK were far more exposed to Brexit trade-related risks than those that are geographically further away from the UK. The value-chain positions of regionally specialized industries play an important role here in determining these differing regional exposure levels.

The aim of this article is to dig deeper into the regional implications of Brexit and more specifically to consider how Brexit will impact the *competitive vulnerability or opportunity* of industries in different regions at the level of NUTS2 regions in Europe and how robust these implications are with respect to different types of Brexit agreements. The relationship between competitiveness and changes in locational and trade network characteristics is complex (Krugman 1996; Baldwin and Wyplosz 2009). In this article, we do not focus on the competitiveness of firms, per se, but rather on their competitive position within industry-region–specific networks, including those that cross UK–EU international borders. We examine how the competitive positioning of sectors in each region will change due to the increasing tariff- and nontariff-related costs associated with Brexit. This allows us to identify the extent to which each sector in each region needs to restructure in order to offset these cost increases, relative to other competitor sectors and regions. Obviously, both UK and EU industries will undergo behavioral changes in response to Brexit involving the spatial restructuring of input–output relationships, a reconfiguration of cross-border supply chains, and changes in their relative market presence in different regional markets. However, for this analysis, we explicitly make no assumptions regarding the nature of these behavioral (monetary and trade) policy and strategic structural changes. Rather, our methodology simply allows us to calculate the different relative orders of magnitude of restructuring, which are eventually required for different industries in different regions in order to adjust to the tariff and nontariff cost increases associated with Brexit.

Our analysis is undertaken by building a novel Leontief price model that not only includes regional sectoral structure and value-chain effects but also incorporates the *revealed spatial competition* relationships underpinned by these value-chain structures across all UK and EU regions. We then analyze the change in the ability of firms in region/sector contexts to compete due to changes in the production costs or tariffs that have to be paid on sales markets due to Brexit. Understanding the orders of magnitude involved in these changes then allows us to identify the competitive vulnerability or opportunity of different regions and regional sectors in a post-Brexit context.

Our general finding is that within the UK, not only do the economically weaker regions display the highest levels of competitive vulnerability to Brexit but that the exact details of the post-Brexit UK–EU trading arrangement make little difference to the high levels of vulnerability exhibited by these weaker regions. In contrast, the UK's economically stronger regions are relatively less vulnerable to Brexit, and also their relative vulnerability is reduced by a relatively freer UK–EU trading relationship. As such, Brexit is likely to make the UK's regional inequalities worse. This has not been demonstrated before in such detail. In contrast, many EU regions display very limited competitive vulnerability to Brexit, but they are in general relatively more responsive to the nature of the post-Brexit UK–EU trade arrangements. In particular, we find that the variation in the effects of the different potential forms of Brexit (uncertainty) on the competitiveness of industries in regions is relatively small in the UK, whereas EU

regions typically have more to gain from a freer post-Brexit trading arrangement, although their overall levels of vulnerability are lower than for UK regions. In other words, the importance of the UK–EU negotiations on the type of Brexit is therefore mainly important for the rest of the EU and to a lesser extent for the economically stronger UK regions. In contrast, the economically weaker UK regions are likely to suffer the most, independent of the results of the negotiations on the future economic relation between the UK and the EU.

The rest of the article is structured as follows. The next section discusses the disconnection between local community perspectives, political narratives, and the likely post-Brexit prospects for UK regions, which we then extend to the notion of competitive vulnerability or opportunity. This is followed by a section that introduces the concept of revealed competition, which integrates both value-chain interactions with spatial competition principles, as reflected in a revealed competition indicator. This is essential in order to allow us in the following section to map out the competitive vulnerability and opportunity of different industry-region combinations, and in the section after that to map out the sensitivity of regions to alternative post-Brexit UK–EU trade arrangements. The penultimate section examines some specific region-industry examples, and the final section provides conclusions.

The Context: Political Narratives, and the Geography of Discontent

In the 2016 EU Referendum, the main pro-Leave narrative was that of the UK regaining sovereignty and exercising its ability to *take back control* of the nation's economic, social, and environmental policies. At the national level, one of the key pro-Brexit *economic* arguments was that breaking away from EU rules will allow the UK to become more competitive by being able to set its own competition, technical and regulatory standards, as well as its own independent trade agreements. According to these arguments, the purported improved competitiveness of the UK will in the long run offset any short-term adjustment difficulties associated with leaving the EU. These arguments have therefore also given rise to the claim that the specific nature of the post-Brexit UK–EU *deal* is critical for the UK's long-run competitiveness, and almost all of the UK parliamentary discussions during 2016–20 have been related to the particularities of the potential post-Brexit UK–EU agreements.

These take back control economic narratives were also intertwined with *social* narratives based on the claim that the real beneficiaries of EU membership were the out-of-touch *metropolitan elites*, rather than the rest of the country, and the evidence suggests that these social arguments had real traction at the local level because it was the economically weaker regions that voted most strongly to Leave while the more prosperous regions tended to vote Remain. Today, the UK displays among the highest interregional inequalities in the industrialized world (McCann 2020), inequalities that give rise to a profound *geography of discontent*, and the specific geography of the EU Referendum voting patterns suggests that a profound geography of discontent was indeed at work (Los et al. 2017; McCann 2018, 2020) in which local economic conditions played a key role in how people responded to the 2016 UK–EU Referendum (Fetzer 2019). Indeed, evidence from many countries (Hendrickson, Muro, and Galston 2018; OECD 2018, 2019; Dijkstra, Poelman, and Rodríguez-Pose 2019) suggests that these geography of discontent patterns are nowadays more widely observed. In economically weaker regions where people perceive that they are being increasingly marginalized or left behind by modern globalization, the voting behavior

(Rodríguez-Pose 2018) can result in something akin to a mutiny (Collier 2018) in which constituencies vote against the status quo without necessarily any clear sense of what the future might hold beyond a vague belief that things can only improve, a belief bolstered by the spurious claims of particular politicians. Indeed, this has been the experience in the UK, whereby the regions that voted most strongly in favor of Brexit are precisely those same regions with the greatest to lose in terms of trade-mediated demand (Los et al. 2017; Chen et al. 2018) and policy support (Fidrmuc, Hulényi, and BörkeTunalı 2019).

In order to reexamine the pro-Brexit economic claims based on notions of competitiveness, but specifically at the local and regional levels, we need to develop a framework that sets competitiveness in both a structural and spatial dimension. We examine the competitive vulnerability or opportunity that Brexit offers different industries in UK and EU regions under a no deal hard Brexit whereby UK–EU trade reverts to WTO terms. As already mentioned above, the explicit regulatory divergence priorities and negotiation timelines of the UK government mean that any post-Brexit arrangement agreed to by the end of 2020 is likely to come relatively close to this default position. We also examine how sensitive are the competitive vulnerability or opportunity implications for UK and EU regions and sectors to alternative outcomes of any UK–EU post-Brexit trade negotiations, beyond a no deal hard Brexit. All of the analysis in this article use the PBL 2013 EUREGIO world regional input–output data set for 256 European NUTS2 regions and blocks of countries in the rest of the world that distinguishes between 61 industries (2 digit NACE revision 2) as a baseline (see Thissen et al. 2018, 2019 for a technical description), and which is the data set that underpins the EU's own interregional economic analyses (Mercenier et al. 2016). This data set is constructed from national and regional data sets in combination with microsurvey data on the transportation of goods and business trips, and is especially designed for a pan-EU, industry-specific and regional cross-sectional analysis. It is currently the only data set available that enables a detailed sectoral analysis of competitive vulnerabilities and opportunities in European regions.[2]

Vulnerability and Opportunities in Revealed Regional Competition[3]

Revealed Competition as Regional Vulnerability to Brexit Trade Arrangements

Enhancing UK competitiveness by breaking away from EU regulations was a key narrative of the pro-Leave lobby fitting to the competitiveness-related policy goals of many regional, national, and supranational governments (McCann and Ortega-Argiles 2017). However, the lack of consensus on a definition of regional competitiveness complicates both economic analysis and policy debates on competitiveness (Krugman 1996) and its relation to Brexit. We therefore use the empirical measurement of revealed regional competition introduced in Thissen et al. (2013) and extensively

[2] It should be noted that while the data on regional trade are derived from survey-based microdata on the transport of goods, its subdivision in intermediate and final demand is an estimate. This may affect the cost effects in the Leontief price model. However, since no better (or alternative) data are available we cannot improve on these estimates. The revealed competition model is based on sales (trade destinations) and is therefore derived from the high-quality, product-specific total regional trade flows. The construction of the used data set is explained in Thissen et al. (2018) and Thissen et al. (2019).

[3] Appendix A: Methodology, in the online material, provides technical details on the revealed competitiveness indicator in combination with value chain calculations using the Leontief price model.

discussed in van Oort and Thissen (2017) as a measure for competitiveness. Combining this concept of revealed regional competition with region and sector-specific changes in production costs of industries using a multiregional Leontief price model enables us to analyze the region-industry specific competitive vulnerability and opportunities due to Brexit.

As a basic understanding, the principle of revealed competition between regions concerns the market overlap of regions when selling goods and services. Firms from Eindhoven, Cardiff UK, and Madrid (production locations), for instance, compete in Barcelona (sales market) where they all sell medical equipment. As such they have an overlap in their Barcelona sales market.[4] When the firms from Eindhoven and Cardiff also sell medical equipment to the sales market in New York, while Madrid is not active on that market, firms from Eindhoven and Cardiff have a larger market overlap and a higher revealed competition than firms from either Eindhoven or Cardiff with Madrid.[5] The size of a production location also plays a role in the degree of revealed competition. The firms from Cardiff face larger revealed competition from firms from Eindhoven than vice versa, since the production of medical equipment in Cardiff is smaller than in Eindhoven. Cardiff therefore has a smaller part of the different sales markets. By investigating market overlaps in sales markets with large regional detail, while covering the complete world as the overall sales market, we obtain insights into the most important sales markets and the largest market overlap of firms in these markets from different regions. By adding up the market overlap in all sales markets weighted with their region-specific importance, we get insights in the degree of revealed competition between firms from different regions. As in our small example of medical equipment sales, in our analysis of the consequences of Brexit on the competitive vulnerability and opportunities of firms in different regions, we then compare cost increases for specific sectors in specific regions with those of their competitors weighted with the degree of revealed competition between them. When cost increases of an industry in a specific region are less than the average of their competitors, this will give them a competitive opportunity. On the other hand, when cost increases are larger, this gives them a competitive vulnerability. The degree of revealed competition, and thereby the degree of competitive opportunities and vulnerabilities, can also be decomposed into a domestic and an international effect by looking at the degree of revealed competition between firms producing in the same country or between firms producing in different countries.

We then also perform a wide-scale sensitivity analysis of the consequences of Brexit on regional competitive opportunities and vulnerabilities with respect to different forms of Brexit. We do this by calculating all possible effects on the competitive vulnerabilities and opportunities of 61 industries in 256 European regions when 61 different 1-percentage point tariffs between the UK and the remaining member states of the EU are introduced. These are elasticities of the competitive opportunities and vulnerabilities of 61 different industries in 256 European regions with respect to 61 different tariffs. The degree of variation in these elasticities over different tariffs gives an indication of the vulnerability of a specific industry in a specific region to the specific details of the post-Brexit UK–EU trade agreements.

[4] Example based on van Oort and Thissen (2017).

[5] In the case of Brexit, the selling Cardiff firms will be impacted more directly when tariff changes are introduced than the Eindhoven or Madrid firms (provided that behavioral and policy circumstances do not change.

Dealing with Supply Chain Effects: An Illustrative Example

Examining the implications of Brexit on regional, industry-specific competitive opportunities and vulnerabilities requires us to also consider more closely the issues of supply chains. Many firms and industries in Europe operate within complex cross-border supply chain systems, which means that the installation of new trade barriers has complex indirect as well as direct cost effects. Observation of tariffs schedules alone cannot tell us how costs for a specific industry in a particular region will increase, because we need to consider how these cost increases percolate throughout the whole of the supply-chain system across all other sectors and regions with which the firms are connected. Both must be explicitly taken into account.

In order to understand the nature and importance of the issue, we begin by using an illustrative example of the possible Brexit-related effect on the competitiveness of beer producers in different countries.

Suppose that steel produced in the UK and the Netherlands is used in the UK production of beer cans, which are then used by British, Dutch, and German beer producers located in the UK and also in the Netherlands and Germany. Thus, a Brexit-related tariff on steel being traded from the Netherlands to UK firms may not only result in higher direct UK steel prices but also may result in an increase in the production costs of many beer cans in the UK, and consequently in the final price of a can of beer. The cost effects of Brexit on the UK, Dutch, and German companies producing beer will depend in part on their ability to shift steel sourcing into or away from the UK, and also on the extent to which they directly compete with each other in the British, Dutch, and German consumer markets. Moreover, beer producers do not only use beer cans but also other inputs such as grains, insurance, information and communication technology, and financial services, etc., and each of these sectors will also be affected differently by Brexit due to their position within global value chains; in turn, these sectors will affect beer producers' costs in different ways. As such, Brexit induces direct cost increases associated with the tariff- and nontariff-related costs and indirect costs that are transmitted via the input–output and global value-chain networks. The overall cost increase facing beer producers from the three different countries will depend on their own specific positioning within these complex configurations of cross-border input–output and global value-chain relationships also involving all other sectors and regions.

Although the costs of all beer producers will stay either equal or will increase, this does not, however, mean that the competitiveness of all beer producers falls. The reason is that it also depends on their spatial presence in different markets. The Dutch, British, and German beer-producing industries will have a different market presence in different regions. In regions where the three beer producers all have a major market presence, the differential tariff and nontariff cost effects of Brexit on each of the countries will imply that the competitiveness implications will be different for the three beer producers, with the producer whose costs increase the most facing the greatest loss of competitiveness in that particular market. In contrast, in regions where a particular beer producer has a very dominant position with little or no competition, the cost increases associated with Brexit will be mainly passed on to customers.

This particular beer production example demonstrates that the distributional competitiveness effects of Brexit are not clear-cut, with some individual firms or sectors in specific regions potentially gaining competitive positions and associated market shares, while others will, in all likelihood, be losing out on all competitiveness dimensions. This is a characteristic of the industry-specific and regional-specific heterogeneity of

revealed competition (Thissen et al. 2013).[6] As such, in order to understand the overall regional competitiveness implications of Brexit, we therefore need to examine the interactions between the input–output global value-chain cost implications and also the patterns of spatial competition across all UK and EU sectors and regions. In our analysis here we therefore extend these same principles to all UK and EU regions and sectors calculating all these interactions across the whole UK and EU economies, including all of the cross-region and cross-border value-chain and cost-chain structures.

Using this framework, we are also able to analyze to what extent the competitive position of beer producers is affected by the variance in the possible tariff-related effects due to different alternative post-Brexit tariff arrangements on all of their different inputs. In order to do this, we begin with the no deal base case scenario of Dhingra et al. (2017) and Dhingra, Machin, and Overman (2017) in which UK–EU trade operates under WTO rules and then one by one, we selectively remove the WTO-related tariff and nontariff costs associated with each individual sector from the overall system-wide cost calculations, in order to see how much the removal of any one particular sector from the WTO rules—due to their incorporation in any future UK–EU trade deal—changes the overall system-wide cost increases. So, in the above example of the beer producers, we solely remove the tariff and nontariff costs associated with the production of grains, and we then recalculate the overall cost increases for beer producers. We then reinstate the cost increases for grains back into the system and then remove the tariff and nontariff costs associated with steel and recalculate the overall cost changes, and then we repeat the exercise for financial services, etc. After doing this iteratively for all sectors, we can then examine the variance of the overall cost changes to the exclusion of any particular sector from WTO-schedules due to their inclusion in a UK–EU trade deal. In cases where this variance is low, it means that the trade-related changes associated with different alternative post-Brexit agreements will hardly alter the overall competitiveness implications for the beer producers, whereas in cases where this variance is high, the competitiveness implications for beer-producing firms, industries, and regions are indeed very sensitive to the specific details of the post-Brexit trade agreements. The same principle holds for all other sectors.

In order to understand how sensitive the competitive positions of industries, in particular UK and EU regions, to Brexit are, we therefore need to aggregate all of these sectoral effects for each region according to the presence of each of these sectors in each region and their particular spatial competition patterns and compare them over all possible Brexit scenarios. The overall construction of our revealed competition *C* indicator, which is specific to regions and sectors and combinations of individual product markets in which firms have a presence, is based on the framework of Thissen et al. (2013) and van Oort and Thissen (2017). The detailed analytical methodology is explained in Appendix A: Methodology in the online material.

The Innovative Contributions of This Approach

There are two key, novel elements of our approach that have not been undertaken or demonstrated before. First, we can examine the overall post-Brexit trade-related competitive vulnerability and opportunity implications for cities and regions across the UK

[6] In a simple Hotelling-type of spatial competition model, a small reduction in costs, for example, due to a fall in the exchange rate, allows firms to dominate a market. However, this is not the case here because of the complexity of all the cross-border input–output and value-chain interactions whereby exchange rate movements have asymmetric and offsetting implications for different elements in the input–output global value. Indeed, the fall in the £/€ exchange rate since the 2016 EU Referendum has made no real difference to the UK's global trade deficit or the UK's trade deficit with the EU.

and EU. Moreover, within this we are also able to isolate those effects on revealed competition, which are related purely to the changes in regional and sectoral positioning in international markets from those that are related to changes in positioning only in domestic markets. These results are all reported in the next section. Second, we are able to split the Brexit-related implications into an economic analysis part that examines the overall effects (in terms of cost elasticities) of regional sectors to changes in tariff and nontariff barriers, and a political economy part that allows for the uncertainty associated with Brexit due to the variety in possible tariff and nontariff barrier combinations that may arise as a result of the political negotiations.[7] Our methodology thereby separates the regional distribution of the estimated size and patterns of regional competitiveness implications across UK and EU regions from the eventual choice of (the as yet unknown) post-Brexit trade scenario. These results are reported in "Uncertainty of Brexit Implications." In "Regional and Sectoral Specificity," we then look at particular region-industry examples to highlight the types of competitive vulnerability and opportunity implications associated with different cases.

Mapping Production Cost Increases and Competitiveness Impacts

Using this methodology, we find that the likely effects of a hard Brexit on regional production costs and competitiveness will differ substantially over regions and sectors in the UK and in Europe. Figure 1 presents the estimated total production cost increase in all NUTS2 EU-regions. We see from the figure that there are large differences between the UK and the continent in the increase in costs when a hard Brexit is imposed. The cost increase faced by UK regions is far higher than for any other country, with other northwestern European countries and regions being the next most-severely hit areas. This general pattern broadly reflects the trade-exposure risk patterns described by Chen et al. (2018). Within the UK, especially those UK regions outside London (main core) and medium-sized city-regions like Manchester, Liverpool, and Leeds (secondary cores) are affected more. In mainland Europe, relatively larger cost increases can be seen in agricultural Zeeland and Flevoland in the Netherlands, Ireland, and south Hungary, and in production-intensive German regions— but never to the degree as in UK regions.[8] The main reason for these differences in the cost effects are the sectoral compositions of production in different regions and the regional trade patterns of these regions. The cost effect is comprised of the two effects distinguished in our earlier methodology section. First, there is the tariff increase that induces a direct cost effect between producers who are trading between the UK and the member states of the EU. Introducing tariffs for goods and services entering or leaving the UK raises export and import prices for UK and EU firms trading with each other in final goods, and the degree of trade between UK regions and EU regions determines the size of this sales price-increasing effect. Second, there is the indirect or value-chain production cost effect due to intermediate products being used in production that also cross these UK–EU borders at some point in the value chain. The international value chains of industries in UK regions are generally highly impacted by tariffs, in contrast to similar industries in the EU where all interregional common market linkages are not affected.

[7] We follow standard procedures in translating nontariff barriers into tariff barriers (Dhingra et al. 2017; Dhingra, Machin, and Overman 2017).

[8] The Belgian region of Luxemburg has a particular high score due to an extremely dominant food specialization.

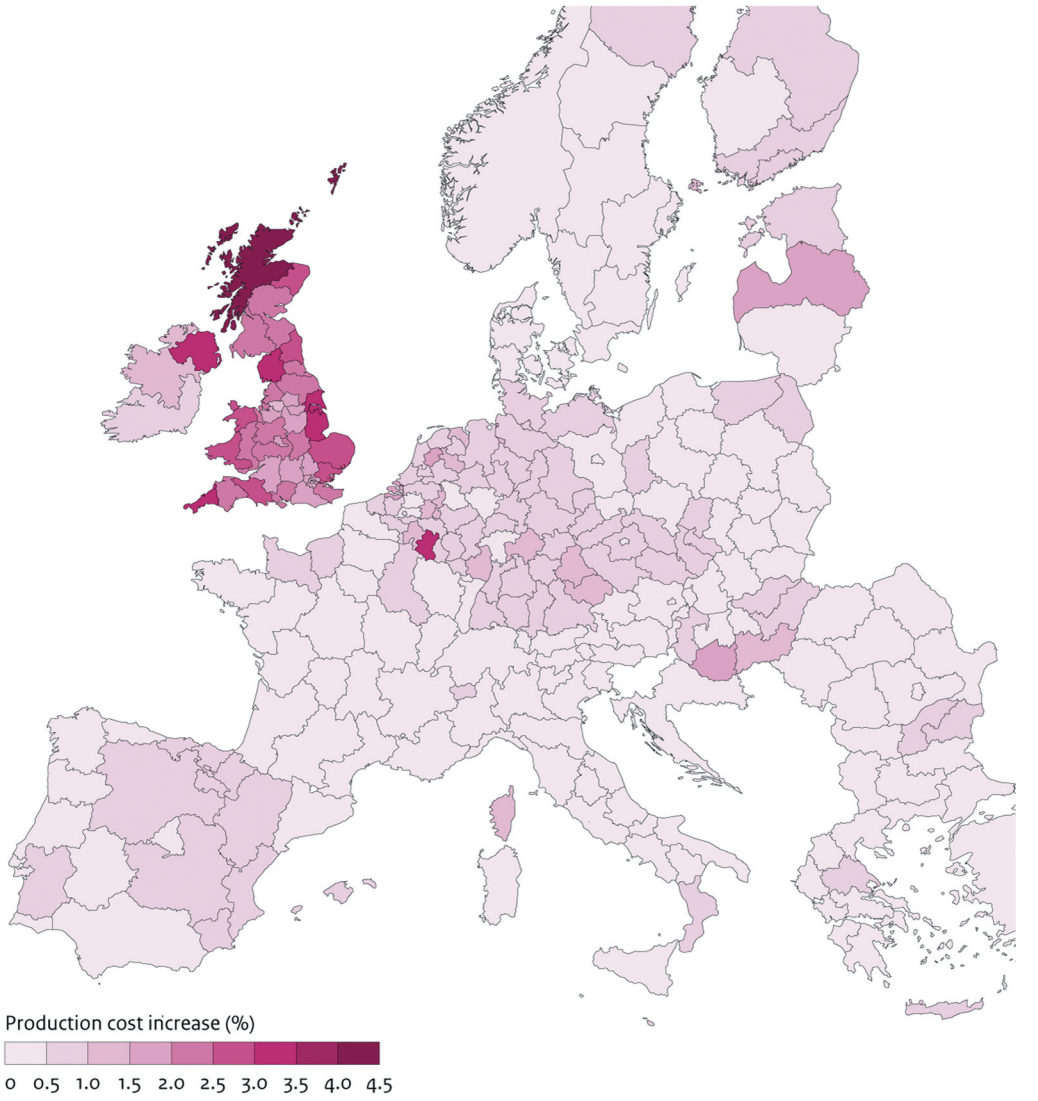

Figure 1. Total production cost increase in hard Brexit scenario in EU regions.

In the hard Brexit scenario, most services have lower combined tariff and nontariff barriers than industry or agriculture. This causes a smaller sales price effect of Brexit for regions that have more services specializations. Moreover, since services use relatively fewer industrial and agricultural products in their production processes, they also have lower production cost increases. The larger cities tend also to have larger internal trade within the region, which also makes them less susceptible to Brexit. And finally, there is an international effect where regions that are competing more internationally in Europe will be hit more severely. Figure 1 though, does not reflect impacts from competitiveness structures (introduced in "The Context: Political Narratives and the Geography of Discontent") yet, and we will return to this issue in a moment.

As we see from Figure 1, the regional economies in the UK are likely to be hit substantially more in terms of rising costs than regions in other European countries. The total cost effect (tariff and value chain effect) is +1.7 percent for the UK as a whole, +0.8 percent for the Netherlands, and +0.4 percent for the EU as a whole (see Table 1). The cost increase effect of the UK is thus approximately two times higher than for the Netherlands and some four times greater than for the EU excluding the UK. In general, the magnitude of the relative differences in Brexit-induced cost increases between the UK and EU are very similar to the differences in Brexit trade-risk economic exposure reported by Chen et al. (2018). While tariffs are important for car manufacturing in the UK, it is tariffs on the food-producing sector that may be more important in the (agriculturally specialized) Netherlands. For specific sectors, cost increases may be much larger than the national averages. Calculated cost increases are particularly high for the car manufacturing industry in the UK (Bailey and de Propris 2017), but they are also substantial for other manufacturing and service sectors. Due to Brexit, the UK always faces substantially larger cost increases than other European countries in all sectors (Table 1). For example, in the manufacturing of motor vehicles (UK +12.8 percent, mainland Europe +2.2 percent), pharmaceutical products manufacturing (UK +1.2 percent, mainland Europe +0.3 percent), food products manufacturing (UK +3.9 percent, mainland Europe +1.3 percent), and in financial services (UK +0.8 percent, mainland Europe +0.1 percent) and other business services such as publishing (UK +1.6 percent, mainland Europe +0.3 percent). Such cost increases are sufficient to wipe out the profit margins of many sectors in the UK (McCann 2016).

Yet, a cost increase for a specific sector in a specific region may be offset in terms of competitiveness when competing regions face similar or even higher cost increases. Regional changes in these *competitive* opportunities and vulnerabilities are calculated as cost increases for regions vis-à-vis all their sector and sales market specific competitors.

Products traded within the UK or within mainland EU will not be affected by Brexit tariffs and hence may become relatively cheaper compared to products that cross the UK–EU boundary. Applying the framework of revealed regional competition to our analyses of production costs, whereby regions are only compared to other regions with which they share both a spatial-specific and sector-specific market overlap, we can determine and demonstrate developments in their competitive positions in two different ways: including own-country competitors, and excluding these, hence focusing on international competitors of regions only (compare Thissen et al. 2013).[9] Generally, a considerable amount of regional trade competition is between regions within the same country due to proximity, institutional and transport effects, and especially for services that are locally consumed (Burger et al. 2014). On the other hand, it is especially international competition that represents a more level playing field for firms' competitiveness in present day globalized economies (Iammarino and McCann 2013). For example, in the national-inclusive definition within the UK, the economy of Merseyside competes in niche markets with Manchester, Birmingham, Cheshire, Dortmund, and Munich, while in the national-exclusive, international-only definition, the economy of Merseyside competes with that of Dortmund and Munich only (Thissen et al. 2013). We present regional competitive opportunities and vulnerabilities due to Brexit using both these definitions, since they provide additional and complementary insights.

Figure 2 shows the overall competitive opportunities and vulnerabilities of UK and EU regions that are associated with Brexit in the left-hand side panel, while the competition effects of the international-only (national-exclusive) opportunities and vulnerabilities are in the right-hand side panel. As we see in Figure 2, again the overall national and regional losses for the UK regions are much higher than for other EU regions. Some regions in the

[9] Note that when own-country competitors are excluded, all own-country sales markets are still included.

Table 1

Total Competitiveness, Cost Changes and Sensitivity to Brexit Scenario in UK Regions for Selected Industries.

	EU Average	NL Average	UK Average	Greater Manchester	Cheshire	Merseyside	East Riding and North Lincolnshire	West Yorkshire	Lincolnshire	West Midlands	Berkshire, Buckinghamshire, and Oxfordshire
All sectors	0.11 (0.4)	0.48 (0.8)	0.54 (1.7)	−0.15 (1.4)	−0.20 (1.6)	0.33 (2.2)	0.47 (3.1)	−0.09 (1.5)	0.50 (3.3)	0.10 (1.8)	−0.06 (1.6)
Crop and animal production, hunting, and related service activities	0.0 (0.5)	0.8 (1.6)	1.3 (6.6)	−0.2 (6.1)	−1.7 (4.8)	0.6 (6.9)	2.6 (7.0)	0.0 (6.1)	1.5 (7.0)	2.4 (7.6)	1.2 (7.2)
Fishing and aquaculture	−0.7 (0.2)	−0.9 (1.9)	6.4 (8.2)	5.2 (6.9)	4.8 (6.5)	4.4 (6.1)	6.8 (9.3)	4.8 (6.5)	10.0 (11.9)	4.4 (6.2)	5.2 (6.9)
Mining and quarrying	0.1 (0.1)	0.0 (0.0)	0.1 (0.5)	−0.1 (0.4)	−0.2 (0.3)	−0.2 (0.3)	0.2 (0.7)	−0.1 (0.4)	0.5 (1.1)	0.2 (0.7)	0.0 (0.5)
Manufacture of food products; beverages and tobacco products	1.1 (1.3)	4.7 (5.5)	−5.3 (3.9)	−5.2 (3.1)	−3.6 (2.5)	−4.9 (3.1)	−5.7 (6.4)	−4.6 (4.8)	−3.1 (7.5)	−4.0 (5.6)	−6.9 (4.2)
Manufacture of textiles, wearing apparel, leather, and related products	0.2 (0.3)	4.8 (6.0)	3.2 (3.1)	3.4 (6.0)	0.6 (2.2)	2.3 (4.3)	4.2 (6.9)	2.0 (4.1)	2.4 (4.5)	2.2 (4.4)	2.4 (4.4)
Manufacture of coke and refined petroleum products	0.4 (0.4)	0.6 (0.4)	1.4 (2.9)	2.0 (4.7)	0.6 (3.6)	−1.0 (2.0)	6.1 (8.7)	0.1 (3.4)	2.1 (5.2)	2.5 (5.3)	0.3 (3.3)
Manufacture of chemicals and chemical products	0.6 (1.3)	0.8 (1.4)	0.5 (6.1)	−2.7 (5.1)	−0.5 (5.8)	−0.2 (6.2)	0.7 (8.4)	−3.6 (4.2)	4.2 (11.2)	−1.3 (6.5)	−3.9 (5.2)
Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.0 (0.3)	0.0 (0.3)	3.8 (1.2)	2.8 (3.9)	−0.5 (0.7)	0.0 (0.5)	5.4 (6.4)	3.8 (4.8)	2.5 (3.6)	4.6 (5.7)	0.1 (1.3)
Manufacture of rubber and plastic products	0.2 (1.0)	−0.1 (1.0)	6.9 (7.7)	5.5 (11.1)	0.1 (6.1)	2.3 (7.7)	4.6 (11.6)	7.2 (12.5)	5.9 (12.3)	3.7 (10.1)	7.1 (12.4)
Manufacture of basic metals	0.2 (0.4)	0.0 (0.4)	6.7 (3.9)	6.0 (8.5)	−0.9 (2.6)	1.9 (4.3)	6.6 (9.2)	5.6 (8.2)	8.5 (10.7)	4.7 (7.4)	6.3 (8.7)
Manufacture of fabricated metal products, except machinery and equipment	0.1 (0.2)	0.2 (0.4)	0.8 (1.8)	0.1 (2.1)	−0.6 (1.5)	−0.5 (1.4)	0.6 (3.0)	−0.1 (2.0)	3.1 (5.0)	−0.4 (1.7)	−0.2 (2.0)
Manufacture of computer, electronic, and optical products	0.3 (0.7)	0.3 (0.6)	2.6 (1.5)	1.7 (3.3)	−0.5 (0.8)	−0.3 (1.1)	3.8 (5.3)	2.2 (3.8)	3.6 (5.2)	2.4 (4.0)	1.5 (3.3)
Manufacture of machinery and equipment n.e.c.	0.2 (0.6)	0.0 (0.8)	4.7 (5.0)	3.4 (9.1)	−0.5 (2.9)	1.2 (3.9)	6.3 (11.9)	4.0 (9.6)	5.6 (11.5)	2.8 (8.9)	2.7 (9.5)
Manufacture of motor vehicles, trailers, and semitrailers	−0.1 (2.2)	0.0 (1.1)	11.0 (12.8)	5.4 (14.5)	−0.7 (8.1)	8.9 (15.8)	18.0 (26.0)	6.1 (15.6)	10.3 (19.1)	4.1 (13.6)	4.8 (15.2)
Manufacture of other transport equipment	0.7 (1.4)	0.6 (1.3)	6.9 (6.2)	6.7 (10.7)	1.1 (4.4)	3.2 (6.3)	11.2 (16.1)	8.5 (12.6)	8.9 (13.4)	4.6 (9.0)	5.3 (10.0)
Manufacture of furniture; other manufacturing	0.4 (0.8)	0.5 (0.9)	3.0 (1.7)	1.6 (4.5)	−2.5 (1.1)	−1.6 (1.7)	5.3 (8.6)	1.5 (4.7)	4.7 (8.0)	1.4 (5.0)	0.8 (4.7)
Sewerage, waste management, remediation activities	0.1 (0.6)	0.1 (1.2)	−0.1 (2.8)	0.6 (2.4)	0.1 (2.5)	0.9 (3.1)	−0.1 (2.2)	0.1 (1.9)	0.3 (2.6)	−0.1 (2.5)	−1.4 (3.3)
Wholesale trade, except of motor vehicles and motorcycles	0.1 (0.2)	0.8 (1.3)	−2.7 (4.1)	−0.4 (4.0)	−0.1 (4.3)	−0.8 (3.8)	−5.9 (3.0)	−1.6 (3.5)	−4.8 (3.0)	−1.7 (3.8)	0.3 (4.5)
Retail trade, except of motor vehicles and motorcycles	0.2 (0.2)	0.8 (1.0)	0.8 (1.0)	0.7 (1.3)	−0.1 (0.6)	0.3 (1.0)	0.5 (1.6)	0.5 (1.2)	1.1 (1.9)	0.7 (1.4)	0.6 (1.3)
Land transport and transport via pipelines	0.1 (0.2)	0.2 (0.2)	−0.7 (1.4)	−0.9 (0.8)	0.4 (1.7)	0.3 (1.6)	−0.2 (1.9)	−0.9 (0.9)	−0.4 (1.6)	−1.0 (0.9)	−1.1 (0.9)
Water transport	0.5 (0.9)	0.3 (0.4)	0.0 (0.6)	0.1 (2.3)	−2.3 (0.3)	−2.0 (0.6)	0.3 (2.1)	−1.9 (0.9)	8.2 (10.0)	1.7 (4.0)	−0.6 (2.6)
Warehousing and support activities for transportation	−0.1 (0.1)	0.0 (0.1)	1.4 (1.8)	1.5 (2.0)	1.1 (1.5)	1.1 (1.6)	0.8 (1.8)	1.1 (1.7)	1.3 (2.1)	1.4 (2.0)	1.6 (2.2)
Accommodation and food service activities	0.1 (0.3)	0.0 (0.2)	1.9 (2.5)	0.8 (2.6)	−0.8 (1.5)	−0.2 (2.1)	2.6 (4.7)	0.8 (2.7)	3.1 (5.2)	1.7 (3.7)	1.2 (3.6)
Publishing activities	−0.1 (0.3)	−0.7 (0.5)	0.8 (1.6)	1.2 (1.9)	0.1 (1.1)	0.9 (1.9)	0.9 (1.5)	0.8 (1.5)	1.3 (1.9)	0.9 (1.8)	0.3 (1.9)
Motion picture, video, television program production; programming and broadcasting activities	−0.2 (0.3)	−0.9 (0.2)	1.0 (1.6)	1.1 (1.7)	0.3 (1.1)	1.2 (2.1)	0.9 (1.5)	0.8 (1.4)	1.3 (1.9)	0.9 (1.7)	0.6 (1.9)
Telecommunications	−0.1 (0.2)	−0.3 (0.3)	1.1 (2.0)	1.2 (2.3)	0.5 (1.5)	1.0 (2.0)	1.1 (2.1)	0.8 (1.9)	1.6 (2.6)	1.0 (2.2)	0.7 (2.1)
Financial service activities, except insurance and pension funding	−0.1 (0.1)	−0.3 (0.1)	0.8 (0.8)	0.9 (1.2)	0.8 (1.1)	0.9 (1.2)	0.7 (0.9)	0.9 (1.2)	0.9 (1.1)	0.8 (1.0)	0.6 (0.9)
Insurance, reinsurance, and pension funding, except compulsory social security	0.1 (0.2)	0.1 (0.1)	0.0 (0.5)	−0.2 (0.3)	−0.3 (0.4)	0.0 (0.7)	0.2 (0.9)	−0.2 (0.3)	0.5 (1.2)	−0.2 (0.3)	−0.3 (0.4)

(*continued*)

Table 1
(*Continued*)

	EU Average	NL Average	UK Average	Greater Manchester	Cheshire	Merseyside	East Riding and North Lincolnshire	West Yorkshire	Lincolnshire	West Midlands	Berkshire, Buckinghamshire, and Oxfordshire
Activities auxiliary to financial services and insurance activities	−0.3 (0.2)	0.0 (0.1)	0.6 (1.7)	0.7 (1.1)	0.5 (0.9)	0.5 (0.9)	0.4 (0.7)	0.6 (1.0)	0.4 (0.8)	0.6 (0.9)	0.7 (1.0)
Imputed rents of owner-occupied dwellings	−0.2 (0.0)	−0.1 (0.0)	0.6 (0.0)	0.5 (0.0)	0.5 (0.0)	0.7 (0.0)	0.4 (0.0)	0.4 (0.0)	0.6 (0.0)	0.5 (0.0)	0.5 (0.0)
Scientific research and development	0.0 (0.1)	−0.1 (0.1)	0.9 (2.2)	0.9 (1.8)	0.6 (2.4)	1.2 (2.1)	0.8 (1.6)	0.6 (1.4)	1.0 (1.9)	0.8 (1.7)	0.9 (1.8)
Advertising and market research	−0.2 (0.1)	−1.0 (0.2)	1.5 (1.3)	1.5 (1.2)	1.5 (0.9)	1.9 (1.6)	1.2 (1.1)	1.1 (1.0)	1.5 (1.3)	1.4 (1.2)	1.4 (1.2)
Other professional, scientific, and technical activities; veterinary activities	0.1 (0.1)	0.1 (0.1)	0.3 (2.2)	0.3 (1.9)	−0.5 (2.0)	−0.2 (2.4)	0.7 (1.5)	0.2 (1.4)	0.8 (1.9)	0.2 (1.7)	−0.6 (1.9)
Travel agency, tour operator reservation service, and related activities	0.0 (0.2)	−0.2 (0.2)	0.7 (0.3)	0.6 (0.9)	0.2 (0.2)	0.5 (0.3)	0.6 (1.0)	0.4 (0.8)	0.8 (1.2)	0.5 (1.0)	0.6 (1.1)
Residential care activities and social work activities without accommodation	0.1 (0.1)	0.1 (0.1)	−0.3 (0.7)	0.0 (0.4)	−0.1 (0.4)	0.9 (0.5)	−0.4 (0.9)	−0.4 (0.5)	0.4 (0.9)	−0.7 (0.6)	−0.7 (0.7)

Notes : The results for the EU, the Netherlands, and the UK are the weighted averages over the effects on sectors and regions. These average effects are not completely comparable to the total effects on the regional economies since not all feedback loops have been taken into account (see also equations 8 and 10 in the supplementary material).
Grey in table: above average size sector (specialization) with divergent average certainty effect in the region. Dark grey: above average certainty of impact of Brexit (insensitive to the exact Brexit [non]tariff scenario). Light grey: below average certainty of impact of Brexit (sensitive to the exact Brexit [non]tariff scenario). Numbers: effect on competitiveness—a negative number is an improvement in competitiveness. The cost increase numbers are between brackets. Selection of sectors: at least one element/cell in the row should be grey.

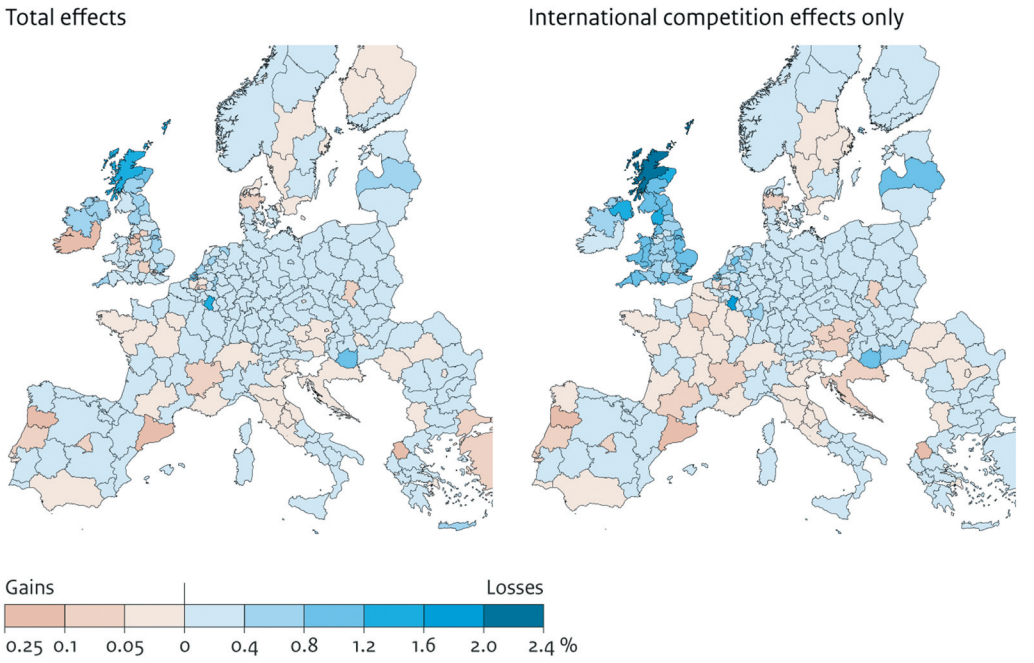

Figure 2. Competitive opportunities and vulnerabilities of a hard Brexit scenario in European regions.

Low Countries, Ireland, plus a small number of Central European regions also experience competitive vulnerabilities. The severe competitive vulnerabilities across much of the UK are a major concern for UK long-run national productivity, especially at a time when the UK is facing severe productivity challenges (McCann 2016). At the same time, many other regions of Europe face competitive opportunities at the UK's expense.

The difference between the left-hand (overall competition effects) and right-hand (international competition effects) panels in Figure 2 represents domestic competition effects.[10] We see in Figure 2 that several regions in the UK actually are relatively strong in domestic competition effects, compensating for the losses in international competition. In the UK-only analysis, for example, as we see in the left-hand panel of Figure 2, there are a small number of northern (Greater Manchester, Leeds, and Cheshire), midlands (Shropshire and Staffordshire), and southern (Berkshire, Buckinghamshire, and Oxfordshire) UK regions whose competitiveness improves with Brexit, largely because the UK regions around them face even greater cost increases while being shielded from international competition. Yet, while their competitive opportunities increase, increasing costs are more likely to be transferred to consumers. Similarly, some French, Italian, Austrian, Spanish, Flemish, and Nordic regions face both international and domestic competitive opportunities, due to reduced competition from UK regions, whereas all German, Irish, and almost all Polish regions face competitive vulnerabilities.

The relative improvements in the positions of some regions, for example Cheshire, Greater Manchester, and West Yorkshire, is thus at the expense of the worsening of the positions of other nearby regions in the UK. The same holds for regions in Ireland. This is because the competitive positions of firms in regions relate to the relative direct and indirect cost effects of

[10] See Appendix A: Methodology, in the online material, for the precise definition.

their competitors who often reside in nearby regions and are active on domestic markets. In a hard Brexit scenario, many UK-based firms will benefit from the direct increase in sales prices of EU competitors due to the imposed tariffs, but at the same time they will disproportionally lose out on the indirect value-chain cost increases. These losses are distributed unevenly over regions and sectors. As a result, some UK firms will have competitive opportunities in the UK-internal market, mainly at the expense of other UK firms that are competitively more vulnerable. In terms of purely international competition, as we see in Figure 2, right-hand side, all UK regions lose out vis-à-vis non-UK EU regions, whereas the combined domestic plus international effect means that a small number of UK regions have competitive opportunities while the rest face competitive vulnerabilities.

Uncertainty of Brexit Implications

Variations in the exact design of any post-Brexit UK–EU treaty lead to uncertainty in assessing the post-Brexit competitiveness implications for different regions and different industries, such that there are different degrees of sensitivity to the variations of agreement design faced by different regions. However, the method we introduced (in "Vulnerabilities and Opportunities in Revealed Regional Competition") and applied (in "Mapping Production Cost Increases and Competitiveness Impacts") allows us to map the regional degree of sensitivity or uncertainty of Brexit impacts on competitive vulnerabilities and opportunities. Figure 3 shows the sensitivity to Brexit scenarios for Europe as a whole, including the UK, and Figure 4 focuses on the UK only.[11] In terms of regional and sectoral implications, it is clear that the largest impacted regions in the UK (and on the mainland in Germany) display only limited sensitivity to the post-Brexit trade agreement design. In other words, no matter what exactly eventually emerges as the design of the post-Brexit agreement, the adverse economic effects will be relatively large in the UK. In the UK, Figure 4 shows that the economies of London and of the larger northern cities (Manchester, Liverpool, Edinburgh, Glasgow) however are relatively sensitive (more uncertain) to the implications of Brexit on their economies, while more peripheral regions are more certain of their (typically much more negative) implications. Thus, the larger cities still have a lot to gain (or rather potentially greater reductions in losses of competitiveness) from a *good* Brexit deal. Meanwhile, regional economies in France, Scandinavia, Spain, the Netherlands, and Eastern Europe, which are specialized in agricultural production and/or (traditional) manufacturing activities, are also rather sensitive to the Brexit design scenario, whereas Belgian, Danish, and German regions display little sensitivity to the design (Figure 3). Figures 2, 3, and 4 should be viewed simultaneously in order to compare the competitiveness implications with the certainty of these implications so as to get a full picture of the regional competitiveness implications of Brexit.

Regional and Sectoral Specificity

Given the detail in our constructed data, the regional impacts can also be decomposed into industry-region specific implications, which are interesting for two reasons.

[11] The sensitivity to the Brexit deal is calculated in terms of the variance calculated as described in Appendix A Methodology in the online material. Figures 3 and 4 are based on relative variance of each region in comparison to the whole of Europe (Figure 3) and just the UK (Figure 4), respectively. The variance baselines in these two cases are different, given that the overall UK variance is much lower (the UK is less sensitive to the actual nature of the final deal) than that of the rest of Europe. As such, the scales are somewhat different in the two cases. Therefore, for example, in Figure 4, we see that Greater Manchester, West Yorkshire (Leeds), and West Midlands are all relatively sensitive or responsive to the nature of the final deal by UK standards, although by EU standards, as we see in Figure 3, they are relatively insensitive.

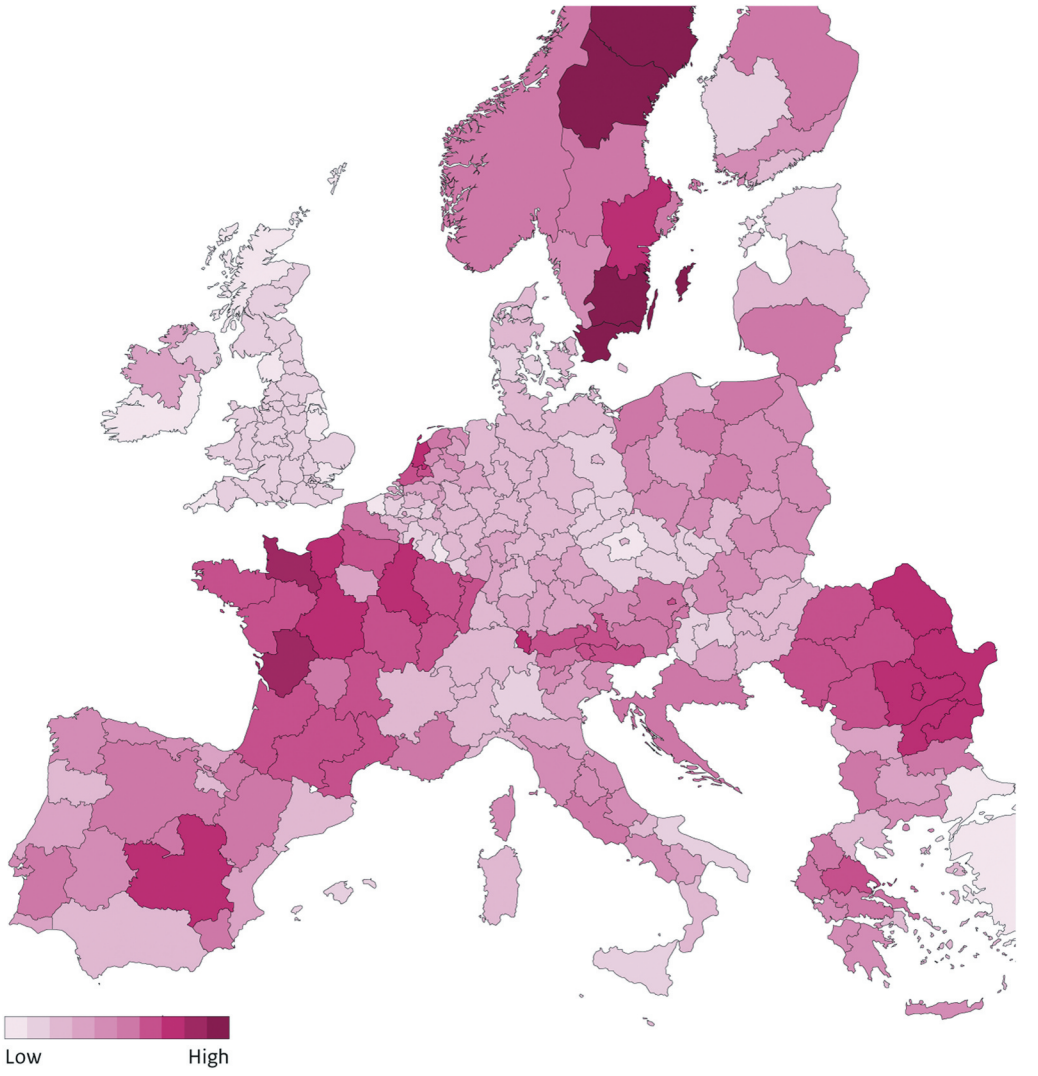

Figure 3. Sensitivity to Brexit scenario in European regions.

First it shows the sometimes-large variation in the impacts over industry-region combinations that are hidden below the regional averages. Second, this information may be applicable to local policies more than national ones (McCann 2016). Table 1 presents the combined (domestic plus international) competition effects (left-hand side of each cell) and the cost increase effects (in brackets in cells) for selected regions and industries in the UK, and in the Netherlands and the EU as a whole.[12]

The cost-increase effects can be substantial in region-industry combinations, but when other competing regions have larger cost-increasing effects, the relative competitiveness of regions can still improve due to Brexit. The grey scale of the cells in Tables 1 and 2 represents the sensitivity of the impacts to the nature of the Brexit deal of relatively large sectors only. It indicates whether changes in competitiveness depend on many different tariffs (darker grey)

[12] The full version for all UK and EU regions and industries is available on request.

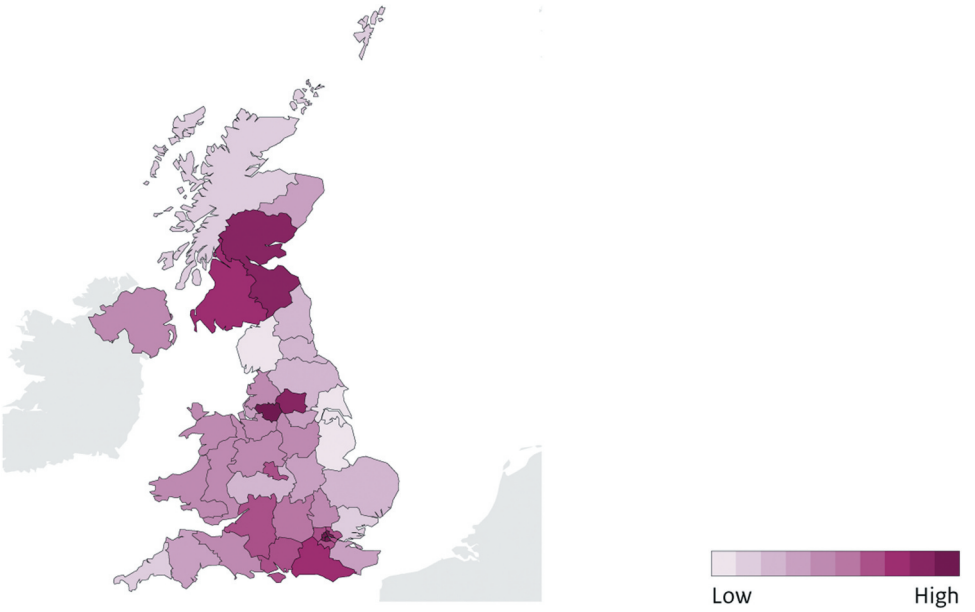

Figure 4. Sensitivity to Brexit scenario in UK regions only.

or depend on only a few tariffs (lighter grey). In the former case, the relative effect of Brexit on competitiveness will be relatively independent of the Brexit scenario (or the nature of the final deal), while in the latter case, the actual negotiated political Brexit deal may have a strong effect on the actual effects of Brexit on competitiveness. It is this regional and sectoral specificity of the size of the effects, in combination with the likeliness of this effect, that is important for understanding the complexity of Brexit and providing local policy makers with the intelligence that is applicable to their situation.

Although our constructed data requires some caution for such detailed analysis, some sector-regional trends are robustly visible. To take as an example, Table 1 shows that the largest impacted industry in the UK is the motor vehicle industry, with major competitive vulnerabilities in the regions of the West Midlands, Merseyside, and East Riding. Combined with a small sensitivity to different Brexit scenarios, this implies that the automotive industries in these regions will be severely impacted on, irrespective of the nature of the final Brexit deal. The region of Cheshire, however, which is also home to a substantial automotive industry, actually has competitive opportunities because its sales and supply chains are relatively UK-oriented.[13] However, these competitive opportunities are at the expense of the other UK car-producing regions, which tend to be more export-oriented and have more international supply chains. In particular, the Cheshire automotive industry faces only an 8.1 percent cost increase, compared to 15.8 percent,

[13] However, our analysis only considers trade and production cost effects and does not consider the intra-corporate global strategy implications. In this regard, Pitas (2019) discussed a warning about the dangers of Brexit for the Cheshire facility of Bentley (VW) in Crewe. There is also widespread concern about the long-term future of the Vauxhall Astra plant in Ellesmere Port owned by Group PSA, the parent company of Peugeot-Citroën (BBC News 2018, 2019). In both cases, these plants are part of much larger EU-based global automotive manufacturers with opportunities for plant relocation to regions with little or no adverse post-Brexit competitiveness implications.

and 26 percent increases in the West Midlands (Birmingham and Coventry), Merseyside (Liverpool) and East Riding of Yorkshire, and North Lincolnshire, respectively.

Other examples in Table 1 show that relatively certain (tariff-insensitive) impacts are in computer and optical manufacturing in Oxford, and the machinery and equipment manufacturing industries of West Midlands (Birmingham and Coventry), Merseyside (Liverpool), and West Yorkshire (Leeds-Bradford). Food production generally gains in competitiveness in the UK with little uncertainty.[14] UK services, which tend to be concentrated in larger cities, are sensitive to the post-Brexit scenario and can be impacted when a hard Brexit scenario is applied, although many services (except for the City of London financial markets) are barely discussed in the negotiations between the UK and the EU.[15]

What is immediately apparent from the top line of Table 1 is that the competitive vulnerability in the UK is about five times larger than the EU as a whole, and the increase in costs is four times higher. This is due to the higher importance of cross-border competition for UK regions and its dependence on cross-border value chains. At the same time, the competitive vulnerability in the UK compared to the Netherlands appears to be only 12 percent higher, while UK cost increases are more than twice those of the Netherlands. The reason for the difference is the larger domestic competition in the UK with competitors that face comparable cost increases due to Brexit. The higher cost for UK firms is caused by the higher dependency on UK–EU cross-border value chains, almost all of which will be affected by cost increases, whereas relatively more of the Netherlands' value chains remain unaffected by Brexit. Indeed, as we see in Figure 2 and Table 2, for many EU regions, the effects of Brexit on competitive vulnerabilities and opportunities are negligible. In other words, the relatively large competitive vulnerability of UK regions to Brexit is borne largely by the UK's firms and industries, which are heavily engaged in UK–EU trade, the same firms that are essential for driving the UK's overall productivity agenda. At the same time, it is likely for UK consumers to pay for a large share of the costs, since the relative cost effect on UK firms is much smaller than the absolute cost effect, giving UK firms the possibility to pass on a large part of the cost increase to UK consumers in the form of higher retail prices.

Comparable to Table 1, Table 2 presents the combined competition effects and cost increase effects (in brackets in cells) for selected regions and industries in mainland Europe. As can also be seen from Figure 2, the analyzed regions strongly contrast in terms of their competitiveness change in comparison to Table 1. The implications and cost increases in these mainland EU regions are on average much smaller than in their UK counterparts. Still, even relatively small changes in cost structures can lead to significant competitive vulnerabilities or opportunities in detailed region-sector combinations. Sectors that on average are vulnerable in UK regions (Table 1), tend on average to have an opportunity in the EU mainland regions (Table 2), but this is not necessarily the case in all region-sector combinations.

The regions of Zuid-Holland and Zeeland in the Netherlands, Oberbayern (Munich), and southern and eastern Ireland (Dublin) face on average competitive vulnerabilities, but for varying underlying reasons. In Zuid-Holland and Zeeland, large agricultural specializations have a negative impact, yet this is very sensitive to the details of the Brexit scenario. More certain for both regions is the competitive vulnerability of their

[14] It should be noted that potential UK behavioral and policy changes in sectors, such as changes in agricultural policy eventually replacing the EU policy in this sector, are not included in our analyses.

[15] Note that in Table 1 the degree of uncertainty is calculated from the perspective of the region. This implies mathematically that high or low uncertainty is determined relative to the average uncertainty over the sectors in the region.

Table 2

Total Competitiveness, Cost Changes and Sensitivity to Brexit Scenario in Mainland EU Regions for Selected Industries.

	Zuid-Holland	Zeeland	Vlaams Brabant	Île de France	Rhône-Alpes	Norte	Steiermark	Southern and Eastern Ireland	Cataluña	Oberbayern	Sydsverige
All sectors	0.40 (0.9)	0.88 (1.7)	−0.09 (0.5)	−0.04 (0.1)	−0.06 (0.1)	−0.14 (0.2)	−0.04 (0.1)	−0.18 (0.7)	−0.10 (0.1)	0.27 (0.9)	−0.01 (0.3)
Crop and animal production, hunting, and related service activities	1.2 (2.0)	1.3 (2.4)	0.2 (0.7)	0.0 (0.0)	0.0 (0.1)	0.0 (0.1)	0.3 (0.6)	0.0 (0.3)	−0.3 (0.2)	−0.4 (0.2)	−0.6 (0.1)
Fishing and aquaculture	1.6 (3.0)	0.3 (2.9)	−1.8 (0.5)	−0.7 (0.1)	−0.7 (0.1)	−0.2 (0.0)	−0.1 (0.1)	x	−0.9 (0.2)	0.0 (0.2)	−0.4 (0.1)
Mining and quarrying	−0.1 (0.0)	0.0 (0.0)	0.3 (0.3)	0.8 (0.9)	0.1 (0.1)	0.1 (0.1)	0.0 (0.0)	0.3 (0.5)	0.1 (0.1)	0.1 (0.1)	0.0 (0.0)
Manufacture of food products; beverages and tobacco products	9.1 (11.8)	8.2 (10.7)	−1.8 (1.5)	0.0 (0.1)	0.0 (0.1)	−0.1 (0.1)	0.1 (0.3)	0.1 (0.5)	0.0 (0.2)	3.9 (5.2)	0.2 (0.3)
Manufacture of textiles, wearing apparel, leather, and related products	1.1 (5.8)	11.0 (14.0)	−4.1 (1.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)	0.1 (0.2)	0.0 (0.1)	0.0 (0.1)	−0.1 (0.1)
Manufacture of coke and refined petroleum products	1.1 (1.5)	1.0 (1.5)	0.1 (0.3)	−0.1 (0.0)	0.1 (0.3)	0.0 (0.1)	−0.1 (0.1)	0.3 (0.8)	−0.1 (0.1)	−0.5 (0.2)	0.0 (0.2)
Manufacture of chemicals and chemical products	0.4 (0.9)	0.9 (1.9)	0.6 (1.5)	0.0 (0.1)	−0.3 (0.1)	0.0 (0.1)	−0.2 (0.1)	−0.7 (0.5)	0.0 (0.1)	1.2 (2.3)	0.0 (0.0)
Manufacture of basic pharmaceutical products and pharmaceutical preparations	0.0 (0.4)	0.2 (0.5)	0.0 (0.4)	−0.1 (0.1)	−0.1 (0.1)	0.0 (0.1)	−0.1 (0.1)	0.1 (0.4)	0.0 (0.1)	0.0 (0.2)	x
Manufacture of rubber and plastic products	0.0 (1.3)	0.6 (2.5)	−0.5 (1.3)	−0.4 (0.5)	−0.2 (0.7)	−0.2 (0.1)	−0.3 (0.4)	−2.2 (2.8)	−0.4 (0.1)	−0.5 (0.5)	−0.1 (1.3)
Manufacture of basic metals	−0.1 (0.3)	0.0 (0.6)	0.5 (1.2)	−0.1 (0.2)	−0.1 (0.3)	0.3 (0.7)	−0.2 (0.1)	−0.8 (0.6)	0.2 (0.5)	0.2 (0.7)	0.3 (1.0)
Manufacture of fabricated metal products, except machinery and equipment	0.1 (0.3)	0.4 (0.7)	0.2 (0.5)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	−1.2 (1.0)	0.0 (0.1)	0.0 (0.2)	0.0 (0.2)
Manufacture of computer, electronic, and optical products	0.3 (0.7)	0.4 (1.0)	0.1 (0.6)	−0.1 (0.1)	0.0 (0.4)	0.0 (0.5)	−0.1 (0.2)	1.7 (2.7)	−0.1 (0.2)	0.0 (0.2)	0.4 (1.2)
Manufacture of machinery and equipment n. e.c.	0.3 (1.0)	0.0 (1.1)	0.2 (1.2)	−0.1 (0.1)	−0.2 (0.1)	−0.3 (0.2)	0.0 (0.2)	−0.7 (1.8)	−0.1 (0.1)	0.2 (0.6)	0.2 (1.0)
Manufacture of motor vehicles, trailer,s and semitrailers	0.8 (5.0)	1.9 (12.1)	0.4 (5.0)	−0.8 (0.3)	−1.4 (0.2)	−1.0 (1.4)	−0.5 (0.1)	−2.6 (1.4)	−1.1 (0.5)	0.5 (2.5)	0.2 (5.8)
Manufacture of other transport equipment	0.1 (0.9)	2.6 (5.5)	−0.3 (0.8)	−0.2 (0.3)	−0.6 (0.4)	−1.5 (0.2)	0.2 (1.3)	−0.5 (1.4)	0.6 (2.8)	−0.3 (0.5)	2.7 (4.9)
Manufacture of furniture; other manufacturing	0.2 (0.8)	1.0 (1.9)	0.2 (0.7)	−0.5 (0.1)	−0.4 (0.1)	−0.7 (0.1)	0.2 (0.6)	x	−0.8 (0.1)	0.3 (0.7)	0.3 (1.0)
Sewerage, waste management, remediation activities	0.3 (1.2)	0.3 (1.0)	0.4 (2.0)	−0.4 (0.1)	−0.6 (0.5)	−0.8 (1.6)	0.0 (0.1)	−0.2 (0.3)	−0.6 (0.3)	−0.3 (0.4)	0.4 (0.8)
Wholesale trade, except of motor vehicles and motorcycles	0.6 (1.4)	1.3 (2.8)	0.2 (0.5)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)	0.0 (0.1)	−2.6 (0.6)	0.0 (0.1)	0.1 (0.3)	0.0 (0.1)

(*continued*)

Table 2
(*Continued*)

	Zuid-Holland	Zeeland	Vlaams Brabant	Île de France	Rhône-Alpes	Norte	Steiermark	Southern and Eastern Ireland	Cataluña	Oberbayern	Sydsverige
Retail trade, except of motor vehicles and motorcycles	0.7 (1.1)	2.3 (2.7)	0.0 (0.4)	x	x	−0.5 (0.1)	0.0 (0.1)	−4.4 (0.5)	−0.3 (0.1)	0.0 (0.2)	−0.2 (0.0)
Land transport and transport via pipelines	0.0 (0.0)	0.7 (1.0)	−0.3 (0.2)	−0.2 (0.0)	0.0 (0.0)	0.6 (0.8)	−0.1 (0.0)	−1.9 (0.7)	−0.1 (0.1)	−0.2 (0.1)	−0.2 (0.0)
Water transport	0.0 (0.1)	0.2 (0.4)	0.1 (0.2)	0.0 (0.1)	0.0 (0.1)	−0.1 (0.1)	2.0 (2.8)	1.1 (2.1)	1.5 (2.0)	0.0 (0.3)	0.0 (0.1)
Warehousing and support activities for transportation	−0.1 (0.1)	0.2 (0.4)	−0.1 (0.2)	−0.2 (0.1)	−0.2 (0.1)	−0.4 (0.1)	0.0 (0.0)	0.0 (0.4)	−0.2 (0.2)	−0.3 (0.2)	−0.2 (0.1)
Accommodation and food service activities	−0.2 (0.1)	0.2 (0.5)	0.3 (1.4)	0.0 (0.0)	0.0 (0.0)	−0.7 (0.1)	0.1 (0.2)	−1.9 (0.7)	−0.2 (0.1)	0.3 (0.6)	0.0 (0.0)
Publishing activities	0.1 (0.5)	−2.0 (0.4)	−0.3 (0.7)	−0.1 (0.1)	−0.1 (0.1)	−1.1 (0.2)	−0.1 (0.1)	0.0 -(100.0)	−0.2 (0.1)	0.0 (0.2)	0.0 (0.3)
Motion picture, video, television program production; programming and broadcasting activities	−0.2 (0.4)	−2.2 (1.1)	−0.2 (0.2)	−0.1 (0.1)	−0.4 (0.9)	−2.5 (0.7)	−0.2 (0.2)	0.2 (0.9)	−0.2 (0.1)	0.0 (0.2)	−0.1 (0.6)
Telecommunications	−0.1 (0.1)	−1.1 (0.9)	−0.6 (0.4)	−0.1 (0.1)	−0.1 (0.1)	−1.2 (0.3)	−0.1 (0.0)	−1.2 (0.7)	−0.4 (0.1)	0.0 (0.3)	−0.3 (0.3)
Financial service activities, except insurance and pension funding	−0.2 (0.1)	−0.6 (0.5)	−0.1 (0.1)	−0.1 (0.0)	−0.1 (0.1)	−0.2 (0.1)	0.0 (0.0)	−0.1 (0.3)	−0.1 (0.0)	−0.4 (0.1)	0.0 (0.0)
Insurance, reinsurance, and pension funding, except compulsory social security	−0.1 (0.1)	0.2 (0.3)	0.1 (0.2)	0.0 (0.0)	0.0 (0.0)	−0.3 (0.1)	−0.2 (0.1)	0.0 (0.2)	0.1 (0.4)	0.0 (0.1)	0.3 (0.4)
Activities auxiliary to financial services and insurance activities	−0.1 (0.0)	0.0 (0.2)	0.0 (0.2)	0.0 (0.0)	0.0 (0.1)	−0.2 (0.1)	0.0 (0.0)	0.1 (0.6)	−1.2 (0.3)	−0.3 (0.2)	−0.1 (0.0)
Imputed rents of owner-occupied dwellings	−0.1 (0.0)	−0.1 (0.0)	−0.1 (0.0)	0.0 (0.0)	−0.1 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	−0.1 (0.0)	−0.1 (0.0)
Scientific research and development	−0.3 (0.1)	0.4 (0.1)	−0.1 (0.2)	−0.1 (0.1)	−0.1 (0.1)	0.2 (0.1)	0.0 (0.0)	−0.7 (0.8)	−0.1 (0.0)	−0.1 (0.0)	0.0 (0.0)
Advertising and market research	−0.9 (0.1)	−2.5 (1.2)	−0.4 (0.3)	0.0 (0.0)	0.0 (0.1)	−0.3 (0.7)	−0.1 (0.1)	−0.7 (0.2)	0.0 (0.1)	−0.3 (0.0)	−0.1 (0.1)
Other professional, scientific, and technical activities; veterinary activities	0.0 (0.1)	0.2 (0.5)	0.0 (0.2)	0.1 (0.1)	0.1 (0.1)	0.0 (0.1)	0.0 (0.0)	0.6 (0.7)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Travel agency, tour operator reservation service, and related activities	−0.2 (0.2)	0.0 (0.4)	−0.3 (0.4)	0.0 (0.0)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (1.0)	−0.1 (0.6)	0.0 (0.0)	0.0 (0.1)
Residential care activities and social work activities without accommodation	0.0 (0.0)	0.2 (0.1)	0.0 (0.1)	0.1 (0.0)	0.2 (0.0)	−0.2 (0.1)	−0.1 (0.0)	x	−0.2 (0.1)	0.2 (0.0)	0.3 (0.0)

Grey in table: above average size sector (specialization) with divergent average certainty effect in the region. Dark grey: above average certainty of impact of Brexit (insensitive to the exact Brexit [non]tariff scenario). scenario. Light grey: below average certainty of impact of Brexit (sensitive to the exact Brexit [non]tariff scenario). Numbers: effect on competitiveness - a negative number is an improvement in competitiveness. The cost increase numbers are between brackets. Selection of sectors: at least one element/cell in the row should be grey.

chemical specializations (in Zeeland with the Terneuzen Dow Chemical plant, and in Zuid-Holland with the petrochemical port complex of Rotterdam). Both regions are also certainly impacted on retail trade. Zuid-Holland further is more impacted by machinery and equipment industries and food production industries. Note that despite the average competitive vulnerability of these regions, certain industries may improve their competitive positions (like warehousing, telecommunication, and financial services). Oberbayern (Munich) then is negatively (and certainly) impacted in terms of its automotive industry, machinery manufacturing, and food production industries, while gaining in rubber and plastics production and petroleum products. The gains in business services in Munich are relatively uncertain and dependent on the post-Brexit scenario. As another example, the region around Dublin faces competitive vulnerability in its food production industries, while simultaneously having competitive opportunities in its chemical industries and in land transport activities.

Table 2 shows that regions have competitive opportunities because of different compositional effects as well. Ile the France (Paris) wins in its automotive and machinery production industries, and in transport and telecommunications. Yet, the competitive opportunities in business services in Paris and surroundings are strongly dependent on the exact post-Brexit scenario. The positive impact in Vlaams-Brabant (Leuven) in Belgium is driven by its food manufacturing industries and telecommunications. Competitive opportunities in the Portuguese Norte (Porto), Steiermark (Graz), and Catalunya (Barcelona) regions are related to machinery and automotive industry, rubber and plastics manufacturing, and telecommunications, respectively.

As such, winning and losing regions and sectors are scattered across Europe, and although less than their UK counterparts, they are still impacted to an extent and degrees of uncertainty that warrants close attention from national and local policy makers.

Conclusions and Discussion

We apply a novel methodology that disentangles region-sector sensitivity to (non)tariff barriers (elasticities) from scalable impacts of scenarios, and include spatial competition effects in which regional-specific and industry-specific implications on firms' competitive opportunities and vulnerabilities depend on their market shares in their domestic and export-serving regions and the cost increases that competitors that are active on these same markets face. Examining the initial impact of Brexit before the substitution of intermediate inputs takes place and without behavioral adjustments by public and private sectors, we find that the effects of a hard Brexit scenario on regional production costs and the competitive position of firms are much higher for sectors and regions in the UK than in the EU as a whole. This is because the UK value chains are far more integrated in the EU economy than vice versa, whereas for the EU they are on average a smaller mirror image of the UK effects. A loss in one's competitive position is another's gain, and since the major competition for the UK and its regions comes from the rest of Europe while the UK is much smaller than the EU, the EU must on average face mirrored smaller competitive vulnerabilities and opportunities than the UK. We also show that the region-specific and sector-specific outcomes for the UK result in some cases in large competitive vulnerabilities that threaten whole local industries. Meanwhile, the certainty of the negative implications on all UK regions, and to a much lesser extent on many northwestern EU regions, is in marked contrast with the uncertainty of the potentially positive implications for many southern European regions.

From our results presented here (especially Figures 2, 3, and 4, and Tables 1 and 2), we see that there is large variation in the post-Brexit implications for sector- and region-specific competitive opportunities and vulnerabilities that deviate from their respective national

effects. Indeed, some specialized regions may even have competitive opportunities at the expense of nearby competing regions. The UK's existing interregional inequalities, which are already very high by international standards, are likely to increase as a result of Brexit. In addition, within the UK, the competitiveness of the relatively weaker parts of each of the broad macroregions tend to be more severely hit (and with more certainty) than the more prosperous parts of each of the macroregions. For instance, within the broad macroregion of the south of England, the areas whose competitiveness is most adversely affected by Brexit are East Anglia, Devon and Cornwall, Essex, and Kent, while London, and the western arc around London through the Thames Valley, actually gain in competitiveness. As such, the competitive position of the economically stronger parts of the south of England is likely to increase relative to the economically weaker areas of the south of England. Similar developments can be observed in the Midlands and the north (including Scotland) where the economically stronger parts of these regions face less adverse competitiveness shocks than the economically weaker parts of the Midlands and north of England.

In marked contrast, across the rest of the EU, it is generally the weaker and more geographically peripheral regions in the southern and eastern fringes of the EU that benefit in terms of competitive opportunities due to the cost increases associated with Brexit. Other noticeable regions that have Brexit-related competitive opportunities are urban regions, such as Paris, Barcelona, Madrid, and Stockholm, although these effects are sensitive to the nature of the final deal.

A possible limitation of our analysis is that we arrive at fairly clear-cut conclusions using the best available EU-wide interregional data, while we have not discussed the possible behavioral responses to the post-Brexit context, including the restructuring of input–output and supply-chain relations, corporate internal restructuring, changes in subcontracting or marketing strategies, or monetary, trade, and sectoral policies, as these are too complex and myriad for this article. However, our conclusions provide details regarding the relative orders of magnitude of the scale of restructuring that regions and industries are likely to have to undergo in order to adapt to Brexit. The economically weaker areas of the UK would systematically need to display greater resilience and adaptability to trade-related shocks than the more prosperous regions, simply in order to leave the already very high UK interregional inequalities unchanged. Yet, many of the UK's weaker regions have low levels of structural embeddedness (Kitsos, Carrascal-Incera, and Ortega-Argilés 2019), and therefore their ability to withstand shocks is very limited. Indeed, the long-run regional productivity statistics for UK regions would suggest that the likelihood that the weaker regions will be more resilient to Brexit-related shocks than more prosperous regions is very small, to say the least (McCann 2016). Indeed, the emerging evidence supports our analysis (Fetzer and Wang 2020). In contrast to the UK, in the rest of the EU, it is the economically weaker regions in the south and east of Europe that will generally be required to undertake lower levels of post-Brexit restructuring than many of the more prosperous regions in the north and west of Europe, and the more prosperous regions are indeed likely to be better equipped to adapt than the less prosperous regions. However, whether or not interregional inequalities will actually rise or fall in mainland Europe also depends much more on the actual post-Brexit UK–EU arrangements, since the effects are very uncertain for mainly agricultural and traditional industrial regions.

The details of the final Brexit deal will affect the certainty of the impacts. The number of potential different tariffs increases with the *hardness* of the Brexit deal, increasing the uncertainty of the potential effects, especially in the EU. When considering the implications of the nature of a final Brexit deal in more detail for the competitive positions of regions and nations, it also becomes clear that details of the deal, which may be important for particular UK regions, are not necessarily important for the UK as a whole, and similarly what is

important for the UK is not necessarily important for the EU or other EU countries. As such, the fact that the trade negotiations are conducted at a UK-national and EU-wide level means that regional competitiveness implications of Brexit are likely to be largely asymmetric between the UK and EU, and the granularity of sector-region–specific impacts and sensitivities to the post-Brexit arrangements provides important intelligence for regional and local policy.

A final important conclusion is that our analyses do not imply that the UK and the EU should not try to negotiate a new trade deal that is as open as possible. Almost all of the available evidence concludes that a more comprehensive deal will be in the interests of both parties. However, as we have seen, the UK's losses of regional competitiveness are more certain and less sensitive to the exact design of a Brexit deal than the potential gains in regional competitiveness of other regions, and this is partly due to the fact that the larger losses are concentrated in the UK. In particular, our results imply that regional interests and the national interests are not closely aligned, and this is particularly the case for the UK. Brexit is likely to exacerbate UK interregional inequalities, and these changes will heavily counteract the *leveling-up* (Zymek and Jones 2020) agenda of the UK government.

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