Technical appendix

Methods used in the study by John Springford, Philip McCann, Bart Los and Mark Thissen on economic dependence of UK regions on demand for final products in the rest of the European Union, and some additional results.

Disclaimer

The results reported for the UK in this appendix represent the first provisional estimates from the interregional trade extensions to the World Input-Output Database. The results reported here along with the estimates for all other EU regions will be further checked and calibrated for accuracy in the coming weeks, after which the final results will be published online for all 245 EU NUTS2 regions later on in the summer of 2016.

As a consequence of the increasing international fragmentation of production processes (see, e.g., Los et al., 2015) the dependence of a region on foreign demand for final products cannot be accurately estimated by relying on gross exports statistics alone anymore. If intermediate inputs are sourced outside the region in any stage of production, the value added generated in the region will be lower than suggested by gross exports (Timmer et al., 2013). The value added in a country due to final demand elsewhere can also be underestimated, however. This happens if the region considered sells components, materials or business services to other regions, which then manufacture the final products that embody these intermediates and deliver these to other countries.

In order to arrive at reasonable estimates of regional dependence on (specific parts of) foreign demand for final products, a global input-output table with regional detail is required. The stylized set-up of such a table is presented in Figure 1.

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

			Country A				Country B				ROW		Country A		Country B			Gross Output
			Reg A1		Reg A2		Reg B1		Reg B2				Reg A1	Reg A2	Reg A1	Reg A2		
			I1	I2	I1	I2	I1	I2	I1	I2	I1	I2	FD	FD	FD	FD	FD	
Country A	Reg A1	I1																
		I2																
	Reg A2	I1																
		I2																
Country B	Reg B1	I1																
		I2																
	Reg B2	I1																
		I2																
ROW		I1																
		I2																
Value Added																		
Gross Output																		

Z F x w' x'

This stylized global input-output table contains two countries (A and B) and a group of countries merged into the Rest of the World, ROW. A and B have been disaggregated geographically into two regions each (A1, A2, B1 and B2). For each of these regions, industry-level detail is available for two industries (I1 and I2). The rows refer to industries

that sell, the columns to industries that purchase. The matrix **Z** contains the values of intermediate deliveries by all industries in all regions and countries, to all industries in all regions and countries. In a similar vein, the matrix **F** contains the values of deliveries to final users in each of the regions and countries. This final demand consists of household consumption, government consumption, gross fixed capital formation and changes in inventories. The sum of all sales by industries in regions and countries are represented by the (column) vector **x**. As **w**' is a row vector indicating value added by each of the industries in each of the regions and countries, double-entry bookkeeping implies that the sums of the values of purchase of intermediate inputs and value added as contained in **x**' equal the gross output levels in **x**.

The results documented in this report have been obtained on the basis of global input-output tables in which 40 countries (accounting for about 85% of world GDP) plus a composite "country" labeled Rest of the World are represented. The countries are those included in the World Input-Output Database (WIOD; see, Timmer et al., 2015). All current EU members are included, apart from Croatia. Merging data in WIOD with data in Eurostat's regional economic accounts, a number of survey-based regional supply and use tables or input-output tables, and estimates of interregional trade based on transport statistics (see Thissen et al., 2013, 2016), allows us to construct the regional trade details at the NUTS2-level for all of the major EU-countries. In total, 245 NUTS2 European regions are represented, and for all regions and countries present in the data, 14 industries can be identified. An annual time series of global input-output tables with regional details have been constructed for the period 2000-2010.[1] Since all cells in global input-output tables must be expressed in a common value unit, all transactions were converted to current euros (which implies that changes in regional dependencies on final demand from other EU countries could partly be due to changes in relative prices and exchange rate movements).

The analysis for this report is inspired by the trade in value added approach pioneered in Johnson and Noguera (2012). It uses matrix-algebraic expressions that represent the essential characteristics of input-output analysis (see Miller and Blair, 2009). A basic insight from this field of analysis is that all gross output is ultimately caused by final demand. Hence, The point of departure are those columns in the matrix **F** that correspond to EU countries other than the UK itself. By summing over these columns (implicitly setting all final demand exerted by UK regions and non-EU countries to zero), a new final demand vector is found. We denote this by **f***. If some UK regions export final products to regions elsewhere in the EU, **f*** will contain positive elements for these regions. The production of the final products requires the production of intermediate inputs. These are equal to the elements in the vector **Af***, in which **A** represents the square matrix with intermediate inputs required per euro of gross output. **A** is obtained by multiplying **Z** by the inverse of the diagonalized vector **x**. If British regions sell intermediate inputs to industries in other EU regions that produce final

[1] The research was undertaken as part of the Multi-Institution and Multi-Country Research Project *Smartspec - Smart Specialisation for Regional Innovation* coordinated by Cardiff University. The project is funded through the EU's Seventh Framework Programme for research, technological development and demonstration under grant agreement number 320131. Information on WIOD is available at www.wiod.org/new_site/home.htm. The ways these WIOD figures play out for the EU-UK relationships is examined in detail in Springford et al. (2016) and McCann (2016).

products contained in **f***, this will be reflected in **Af***. Second-round effects are represented by **AAf***, third-round effects by **AAAf***, etc. Under empirically mild conditions, the sum of these direct and indirect effects converges to the output levels **x***:

$$\mathbf{x}^* = \mathbf{f}^* + \mathbf{A}\mathbf{f}^* + \mathbf{A}\mathbf{A}\mathbf{f}^* + \ldots = (\mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \ldots)\mathbf{f}^* = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}^*$$

The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is known as the Leontief inverse. The vector **x*** gives the gross output levels of all industries in all regions and countries that can be attributed to final demand exerted by EU countries other than the UK. If these are pre-multiplied by a diagonalized vector of value added coefficients **v** (obtained by post-multiplying **w'** by the inverse of the diagonalized vector **x**), the column vector **w*** is found. This vector gives the value added in each industry in each region and country that can be attributed to final demand exerted by EU countries other than the UK. By summing over the elements of **w*** that correspond to industries in a region of interest, the part of regional GDP due to demand by other EU countries can be estimated. Dividing this value by actual regional GDP as implied by the values in **w'** yields the reported shares of regional GDP caused by consumption and investment demand in the rest of the EU.

Table A1 presents results at the level of broad sectors. The columns labeled "EU dependence" document the percentage of sectoral value added in a UK region that can be attributed to consumption and investment demand in the rest of the EU. Primary industries include agriculture, mining and energy supply. The columns labeled "GDP share" show the percentages of regional GDP generated in the sector concerned. The final column of Table A1 provides the detailed provisional estimates for the total economic dependence of each UK region on EU demand. The higher is the % share the more highly integrated is the local regional economy with the rest of the EU economy. The level of EU economic integration for the whole UK economy is 9.5%, so regions with higher values than 9.5% are relatively more integrated with the rest of the EU than the UK is as a whole. Conversely, regions with a value lower than 9.5% are relatively less integrated with the rest of the EU than is the case for the UK as a whole.

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Table A1: Shares of regional GDP exported to EU and regional sectoral GDP shares, 2010

	Primary Industries		Manufacturing		Construction		Services		Total Economy	
	EU-dependence	GDP-share	EU-dependence	GDP-share	EU-dependence	GDP-share	EU-dependence	GDP-share	EU-dependence	GDP-share
Tees Valley and Durham	17.0%	8.7%	26.7%	12.7%	1.8%	6.1%	5.3%	72.5%	8.8%	100.0%
Northumberland, Tyne and Wear	18.8%	5.1%	28.2%	11.6%	2.3%	5.4%	5.9%	77.9%	8.9%	100.0%
Cumbria	17.6%	4.5%	32.5%	27.3%	2.6%	6.7%	7.3%	61.4%	14.3%	100.0%
Cheshire	19.9%	7.5%	38.7%	11.9%	0.6%	4.2%	8.1%	76.4%	12.3%	100.0%
Greater Manchester	22.2%	0.8%	29.5%	10.2%	3.7%	5.7%	7.3%	83.3%	9.5%	100.0%
Lancashire	23.9%	2.7%	37.3%	19.2%	3.8%	6.2%	8.0%	71.9%	13.8%	100.0%
Merseyside	19.7%	1.9%	26.5%	10.6%	1.2%	5.0%	5.3%	82.6%	7.6%	100.0%
East Yorkshire and Northern Lincolnshire	20.6%	6.4%	35.5%	22.4%	2.8%	5.9%	8.1%	65.3%	14.7%	100.0%
North Yorkshire	17.7%	9.1%	33.5%	12.4%	2.6%	5.4%	7.0%	73.0%	11.0%	100.0%
South Yorkshire	21.1%	2.8%	29.0%	12.1%	1.9%	6.2%	6.5%	78.9%	9.4%	100.0%
West Yorkshire	18.7%	4.5%	27.2%	11.7%	2.1%	4.5%	7.3%	79.3%	9.9%	100.0%
Derbyshire and Nottinghamshire	17.3%	8.3%	25.6%	12.8%	2.1%	5.9%	6.5%	73.0%	9.5%	100.0%
Leicestershire, Rutland and Northamptonshire	21.1%	6.3%	37.5%	17.0%	3.0%	5.0%	8.9%	71.7%	14.3%	100.0%
Lincolnshire	11.0%	9.3%	27.3%	16.6%	1.5%	6.8%	6.0%	67.2%	9.7%	100.0%
Herefordshire, Worcestershire and Warwickshire	19.0%	6.8%	36.8%	15.8%	3.1%	5.4%	8.2%	72.0%	13.2%	100.0%
Shropshire and Staffordshire	20.7%	3.2%	35.8%	16.9%	3.3%	6.1%	7.6%	73.7%	12.5%	100.0%
West Midlands	21.1%	3.2%	27.4%	11.5%	2.7%	5.2%	6.9%	80.2%	9.5%	100.0%
East Anglia	14.8%	6.6%	27.2%	12.2%	2.5%	5.5%	6.7%	75.6%	9.5%	100.0%
Bedfordshire and Hertfordshire	18.0%	2.2%	31.8%	9.7%	1.4%	6.4%	6.6%	81.7%	8.9%	100.0%
Essex	19.0%	2.8%	33.9%	11.1%	2.5%	8.7%	7.3%	77.4%	10.1%	100.0%
Inner London	14.3%	3.6%	22.7%	2.9%	2.4%	4.3%	3.2%	89.2%	4.2%	100.0%
Outer London	15.1%	3.7%	25.8%	7.0%	0.8%	7.2%	4.6%	82.1%	6.2%	100.0%
Berkshire, Buckinghamshire and Oxfordshire	16.6%	7.0%	31.3%	9.1%	2.1%	4.4%	6.7%	79.6%	9.4%	100.0%
Surrey, East and West Sussex	15.6%	4.4%	31.5%	7.7%	2.3%	5.5%	5.9%	82.4%	8.1%	100.0%
Hampshire and Isle of Wight	22.7%	4.0%	42.3%	12.3%	4.0%	5.5%	8.7%	78.2%	13.1%	100.0%
Kent	19.6%	3.3%	44.6%	12.7%	4.3%	8.1%	8.5%	76.0%	13.1%	100.0%
Gloucestershire, Wiltshire and Bristol/Bath area	21.6%	5.3%	38.9%	14.0%	3.1%	4.6%	9.2%	76.0%	13.8%	100.0%
Dorset and Somerset	21.9%	5.4%	37.2%	14.6%	4.5%	6.0%	8.3%	74.1%	13.0%	100.0%
Cornwall and Isles of Scilly	14.9%	7.4%	28.5%	10.1%	1.4%	6.9%	5.4%	75.6%	8.2%	100.0%
Devon	19.3%	5.5%	37.1%	11.6%	3.5%	6.5%	6.9%	76.5%	10.9%	100.0%
West Wales and The Valleys	14.3%	2.1%	13.0%	15.9%	1.9%	9.0%	2.6%	72.9%	4.4%	100.0%
East Wales	13.3%	4.4%	10.9%	14.6%	1.5%	6.1%	3.0%	75.0%	4.5%	100.0%
North Eastern Scotland	14.4%	15.1%	6.3%	13.6%	2.1%	8.8%	1.5%	62.5%	4.2%	100.0%
Eastern Scotland	14.6%	12.2%	6.0%	15.1%	2.2%	9.1%	1.9%	63.5%	4.1%	100.0%
South Western Scotland	13.5%	52.8%	6.0%	3.9%	0.4%	4.2%	1.3%	39.1%	7.9%	100.0%
Highlands and Islands	15.6%	11.1%	9.5%	11.8%	0.2%	7.5%	0.7%	69.5%	3.3%	100.0%
Northern Ireland	16.3%	7.7%	26.7%	13.1%	0.6%	5.4%	5.7%	73.8%	9.0%	100.0%
United Kingdom	17.3%	5.5%	30.8%	11.3%	2.4%	5.8%	6.4%	77.5%	9.5%	100.0%

Source: Authors' computations on the basis of preliminary World Input-Output Database tables with interregional extensions (Thissen et al., 2016).