

## **Diversity of supply for oil and oil products in OECD countries in 2015**

### **Introduction and summary**

Countries meet their oil needs through a combination of indigenous production and trade. Each year, BEIS updates a comparative assessment of how OECD countries manage their crude oil and transport fuel demand, using data from the IEA database<sup>1</sup>. The aim is to determine how the UK compares with other OECD countries in terms of how it secures oil supplies. Whilst the assessment tends to be stable over time, the analysis provides an overview of the most recent data available.

Within the OECD, only four countries were net exporters of crude oil in 2015: Norway (producing over 5 times its indigenous demand), Canada, Mexico and Denmark. All other OECD countries had to meet their demand through imports with some 10 countries producing no crude oil indigenously – the same figure as in 2014.

The majority of OECD countries met their motor gasoline (petrol) demand through indigenous production, with much of Western Europe being net exporters. Despite motor gasoline having the second lowest average diversity index, it achieved the highest average score in the supply index out of the four products due to high levels of indigenous production in the OECD.

For jet fuel, the position is markedly different with only a third of OECD countries self-sufficient. Norway and the United Kingdom were the top two scorers for diversity of imports within the OECD.

Most OECD countries were not able to support their diesel consumption by indigenous production alone. Greece, Korea and the Netherlands scored highest for self-sufficiency within the OECD, with Greece producing over three times the amount it consumed.

The UK could have met over three quarters of its demand for crude oil through indigenous production, in comparison to two thirds in 2014, and ranked fifth in the supply index with regards to crude oil. The UK was able to meet its demand for motor gasoline through indigenous production and was second only to the United States for diversity of imports. For jet and diesel, the UK was in the lower third of the OECD in terms of its indigenous production scores, but was second for diversity of imports for jet and third for diesel. The overall position is broadly similar to that seen last year.

### **Charting oil self-sufficiency and diversity of supply**

#### Bubble Charts

The bubble charts demonstrate the relationship between a country's demand, its indigenous production, diversity of its gross imports and the political stability of the countries of import. The profiles show:

- **Self-sufficiency:** the proportion of a country's demand that could be met through indigenous production is shown on the vertical axis. A score of 1 indicates a country produces as much oil as it uses.
- **A diversity score:** the diversity and political stability – defined via the World Bank's governance indicators - of a country's gross imports is shown on the horizontal axis (see appendix 2 for a methodological note).
- **Consumption:** is represented by the circle or bubble, the area of which indicates the level of consumption for 2015 for each OECD country.

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<sup>1</sup> <http://data.iea.org/>

## Special feature – Supply of oil and oil products

### Bar Charts

The bars charts provide a means of comparing OECD countries by self-sufficiency and diversity of imports, creating a 'supply index'. These profiles combine the proportion of demand that could be met through indigenous production (shown in the coloured part of the chart) with the diversity and political stability of import origins (shown in white). Appendix 1 shows the underlying data.

### Choropleth Map

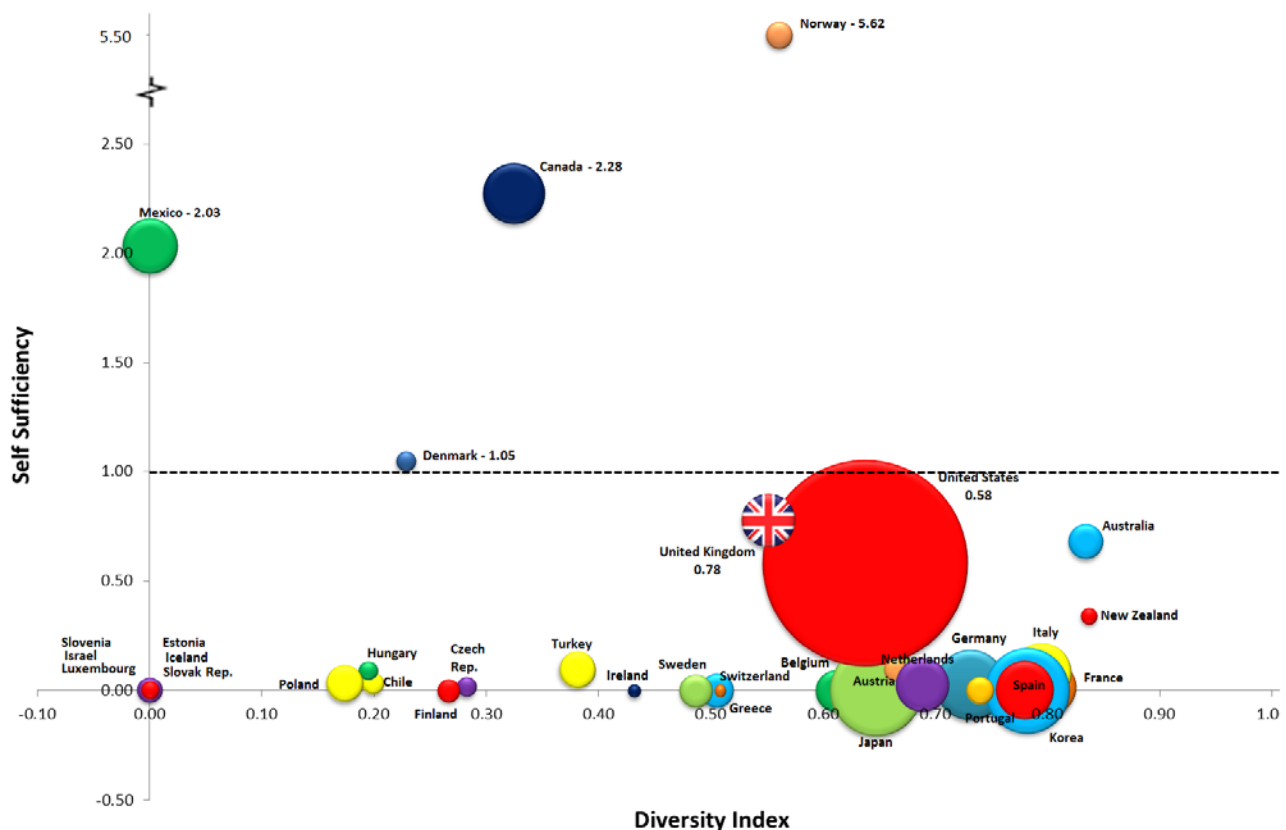
These maps indicate a visual representation of the source countries and quantities of each product's exports. A darker shade represents that a high proportion of the world's exports originated from that particular country, whereas lighter shades indicate that fewer exports originated in that country. Appendix 1 shows the underlying data.

## Results

### Crude

Only four OECD countries were self-sufficient for crude oil in 2015 (Chart 1). Norway had by far the highest self-sufficiency score, producing over 5 times its own consumption of crude oil. With a self-sufficiency score of 0.78, the UK was above the OECD average of 0.41. Similarly, the UK's diversity score of 0.55 was above the average score of 0.43.

**Chart 1: Diversity and self-sufficiency of crude oil for OECD countries, 2015**



The majority of OECD countries showed diversity and political stability scores that reflect a strong trading element, with a relatively small contribution from indigenous production (Chart 2). Chart 2 shows that the UK placed highly in the ranking of OECD countries being one of only a few countries with significant oil production.

Chart 2: Supply index of crude oil for OECD countries, 2015

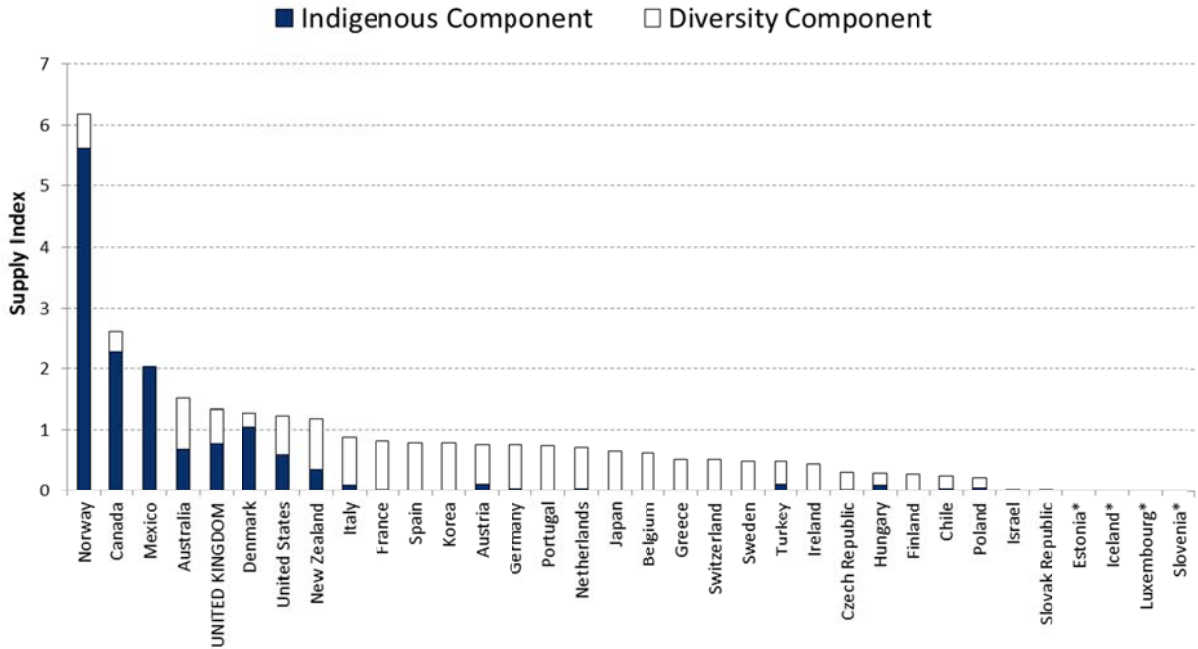
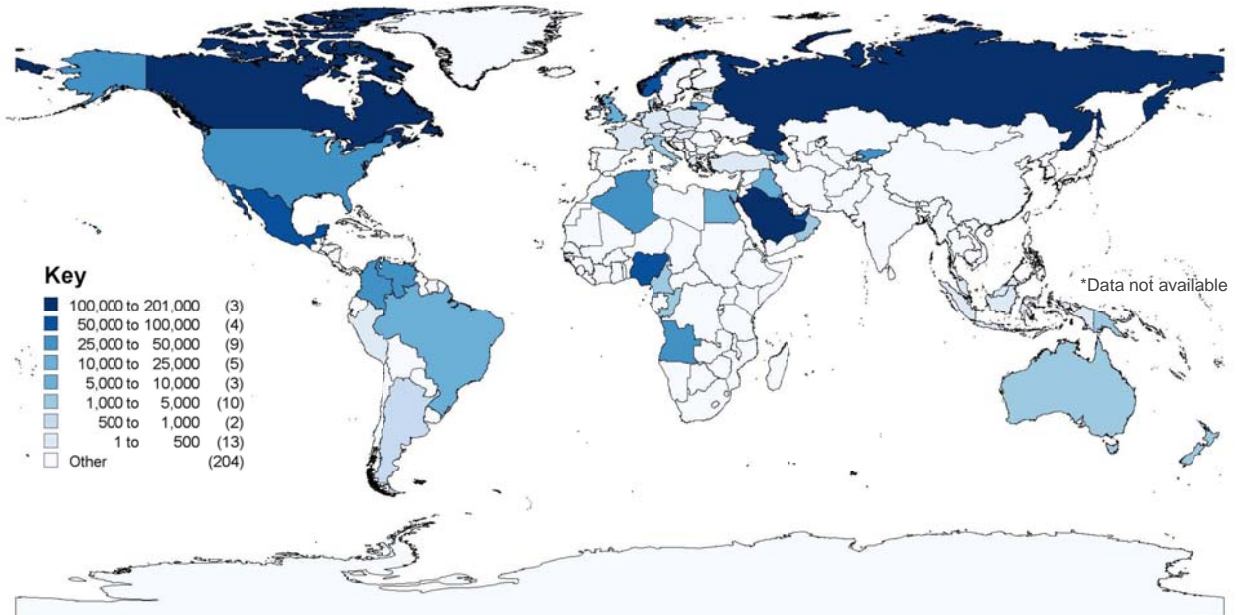


Chart 3 is an illustration of where crude oil exports originated in 2015. Currently, Saudi Arabia, Russia and Canada are by far the biggest exporters of crude in the world. Norway exported the most crude of all European nations; the UK was the 3<sup>rd</sup> biggest exporter in Europe and placed 18<sup>th</sup> overall. Although the United States produced over three times as much as any other OECD country, they exported relatively little due to a nationwide ban on almost all crude exports. The 40-year ban was lifted in December 2015, with May 2016 seeing the highest quantity of crude exported from the US on EIA records<sup>2</sup>. The United States has still been exporting comparatively small quantities up to June 2016 despite the lift of the ban, but we may expect to see an increase of crude exports from the US in the future.

Chart 3: Worldwide Crude Oil exports (kt), 2015



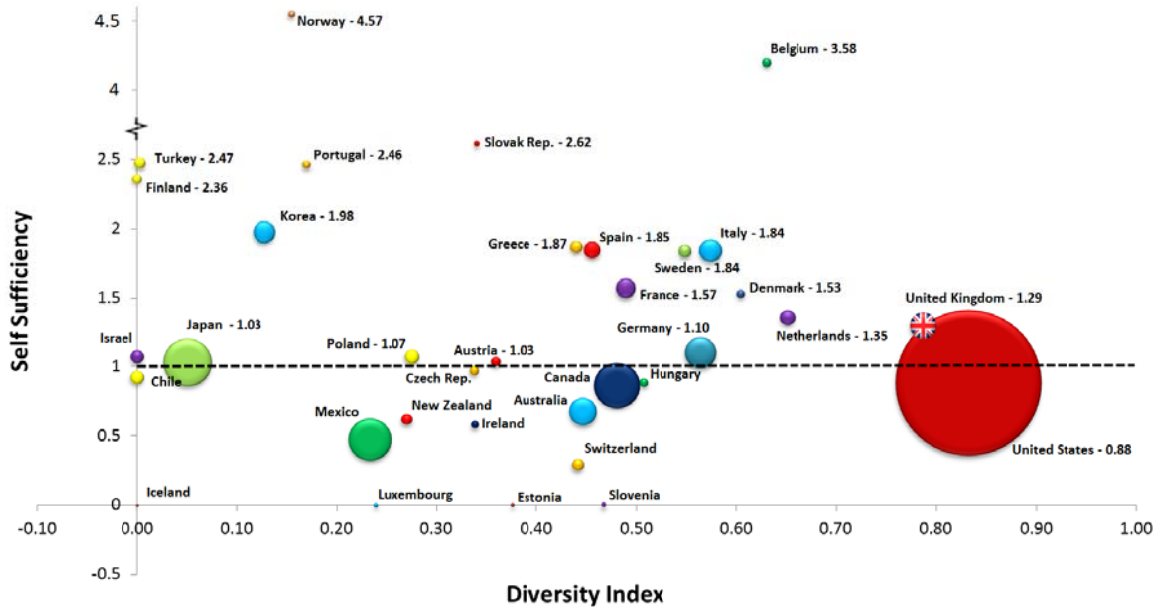
<sup>2</sup> [www.eia.gov/dnav/pet/pet\\_move\\_exp\\_dc\\_NUS-Z00\\_mdbl\\_m.htm](http://www.eia.gov/dnav/pet/pet_move_exp_dc_NUS-Z00_mdbl_m.htm)

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Motor Gasoline

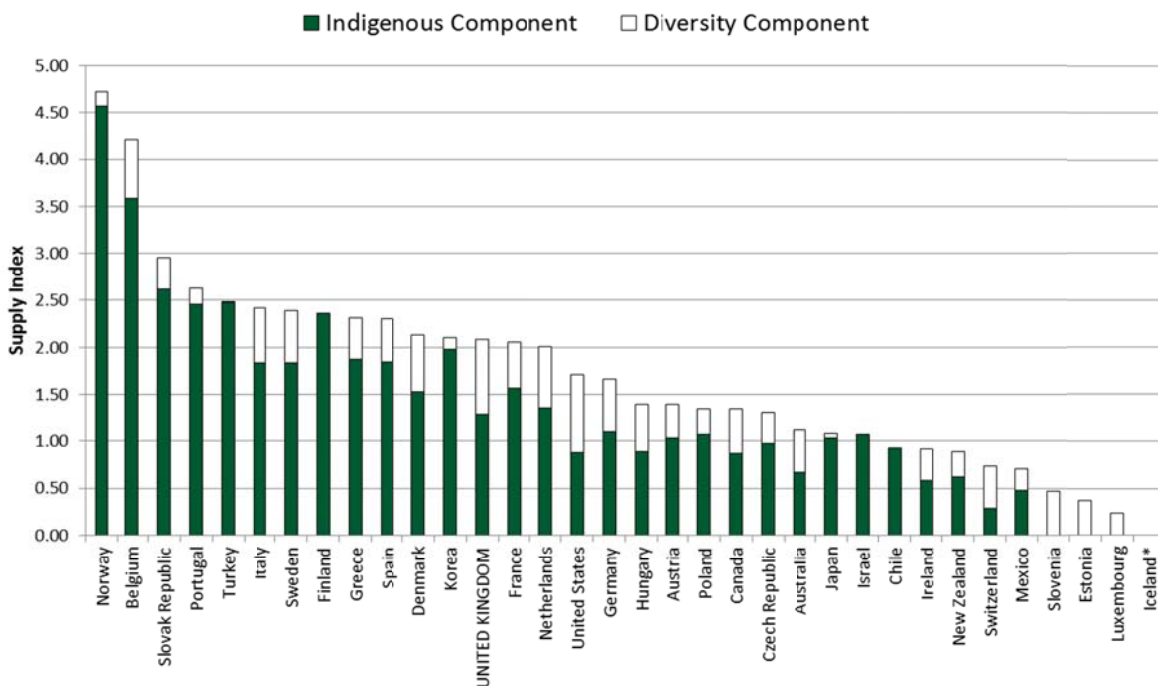
The profiles for motor gasoline are considerably different to that of crude. Over 50 per cent of the 34 OECD countries were self-sufficient in 2015 (Chart 4). Consumption in the US dwarfs that of other OECD countries; equal to 65% of the world total. The UK had a self-sufficiency score of 1.29, which was slightly below than the average across all OECD countries of 1.34. The UK's diversity score of 0.79, however, was higher than the OECD average of 0.36.

**Chart 4: Diversity and self-sufficiency of motor gasoline for OECD countries, 2015**



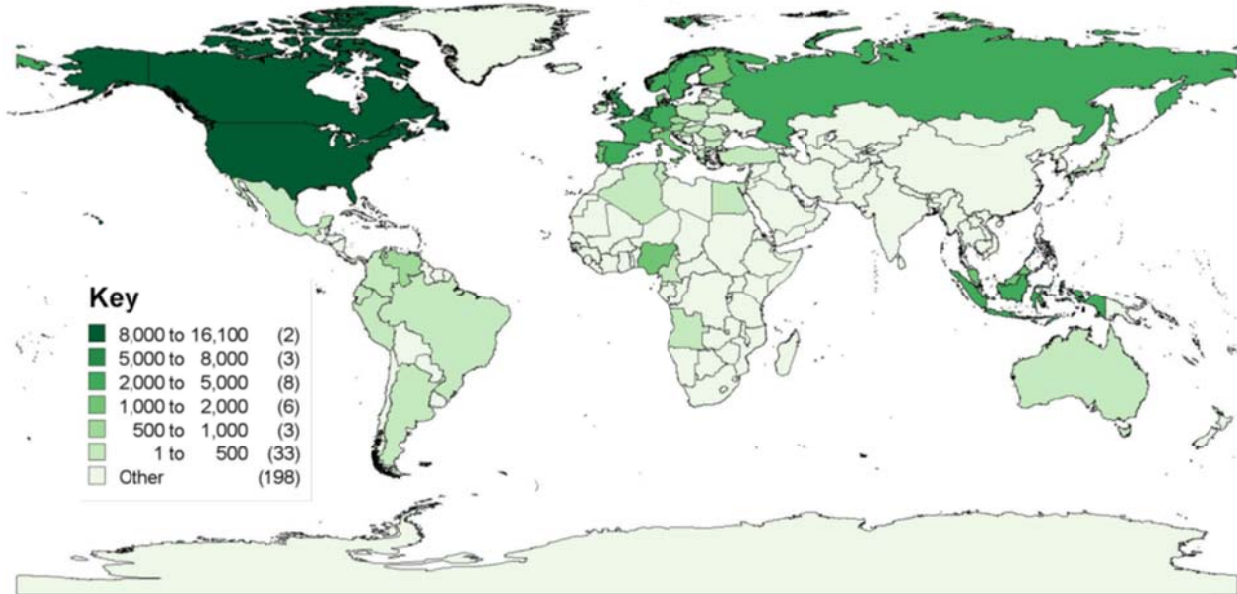
Our supply index (Chart 5) shows how the vast majority of countries produce enough motor gasoline to meet their needs. The UK ranks 14<sup>th</sup> out of the 34 OECD countries in the supply index of motor gasoline.

**Chart 5: Supply index of motor gasoline for OECD countries, 2015**



The main area of exports for motor gasoline around the world is North America, with the United States the largest exporter in the world, exporting twice the amount of the next biggest exporter, Canada. Europe is also shown on the map to be a very significant exporter of motor gasoline to the rest of the world with the United Kingdom, the Netherlands and Belgium of particular note. However, many large economies such as Australia, Japan and China export very little quantities of motor gasoline.

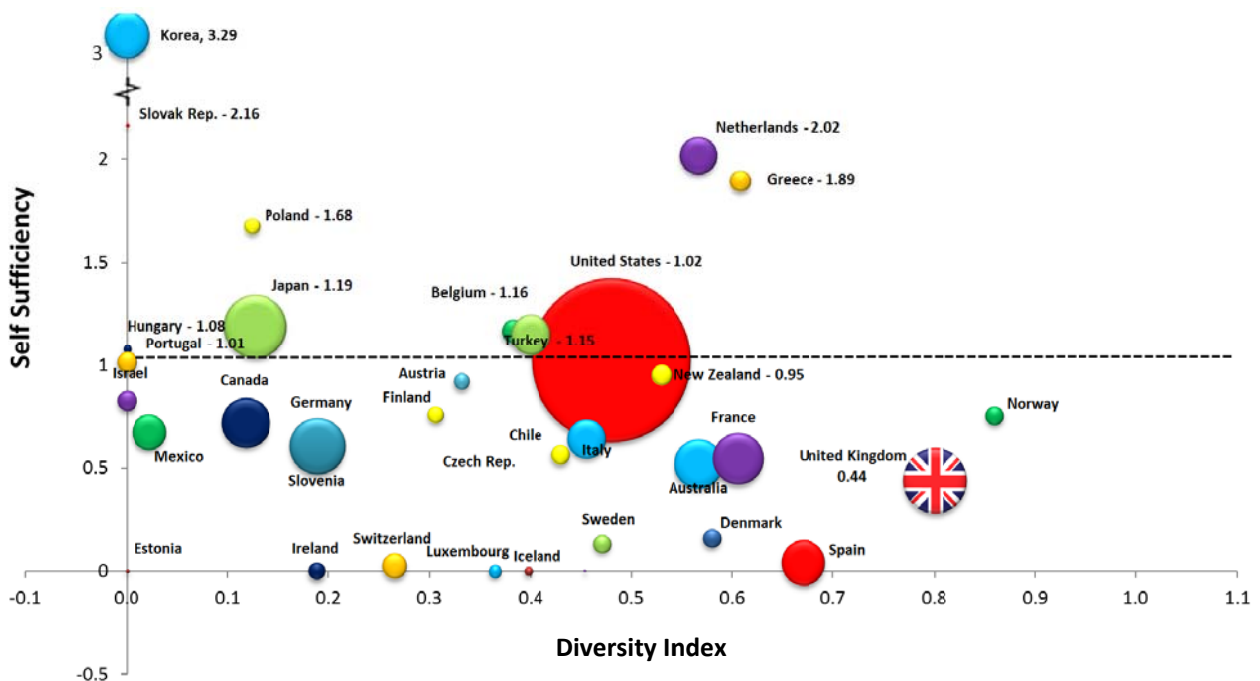
**Chart 6: Worldwide Motor Gasoline exports (kt), 2015**



Jet Fuel

Chart 7 shows that, with a self-sufficiency score of 0.44, the UK was below both the self-sufficient threshold of 1 and the OECD average 0.80 for jet fuel. However, the UK's import diversity score of 0.80 was more than double the average for all OECD countries (0.34) and was the second highest of all OECD countries after Norway.

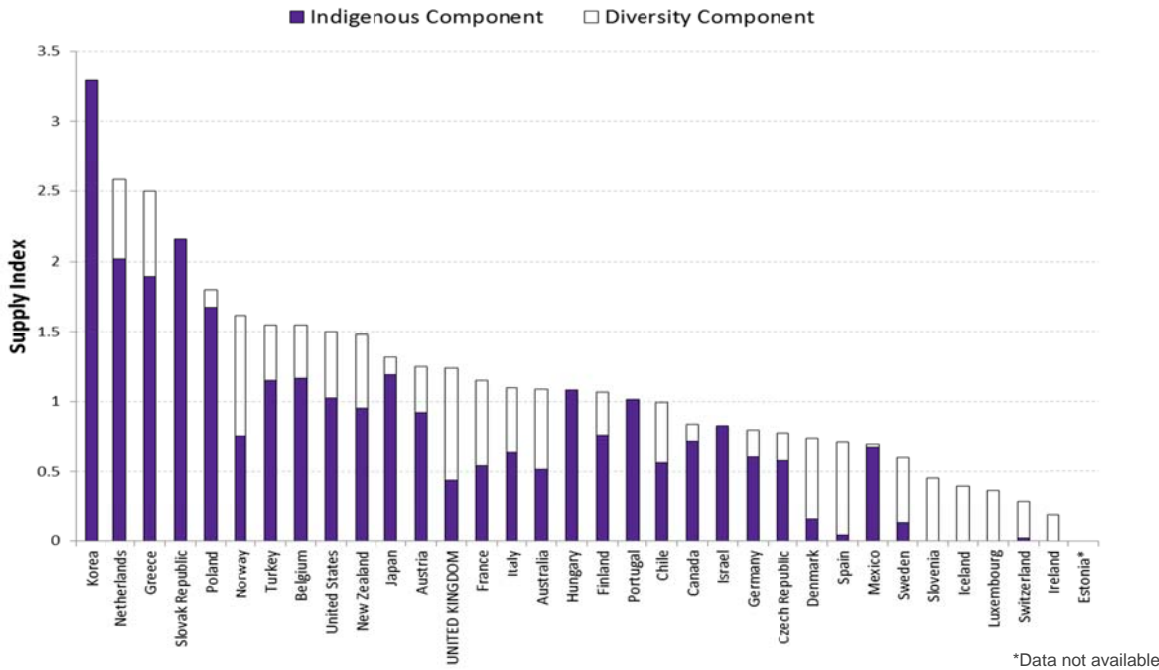
**Chart 7: Diversity (and self-sufficiency) of jet fuel for OECD countries, 2015**



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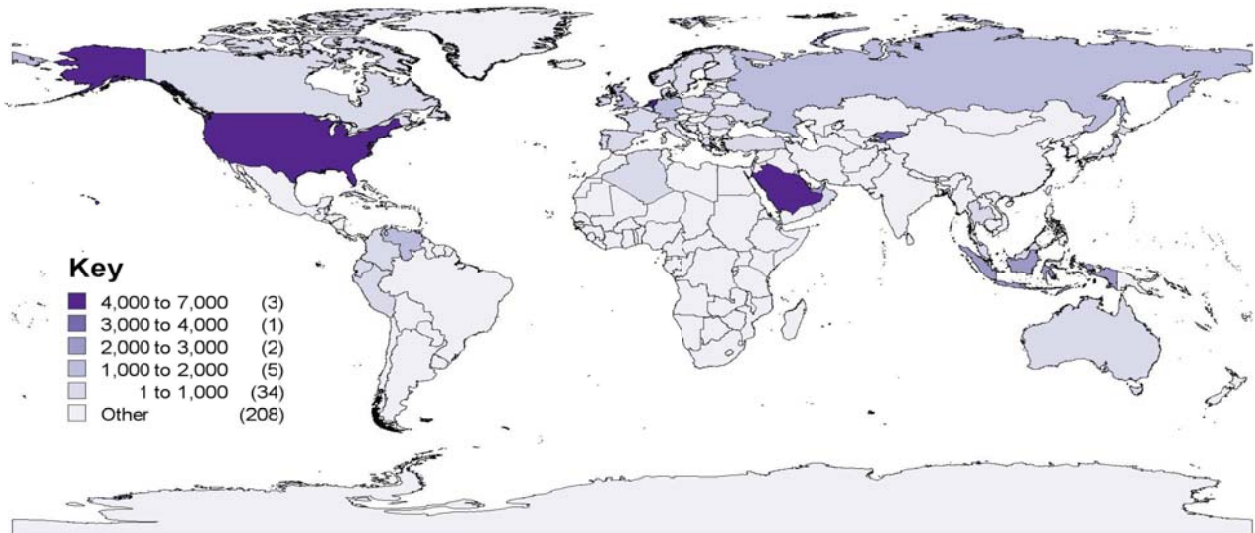
Many OECD countries have significant production capacity of jet fuel. For instance, Korea produces some three times its demand and doesn't require any imports. Despite significant production of jet fuel, the UK met less than half of its demand, one of the largest deficits in the OECD. Demand from Heathrow (the busiest airport in Europe) is a significant factor in this deficit with the UK second only to the United States in demand for jet fuel. The UK is however well placed for diversity of supply and has one of the most diverse and stable import sources within the OECD.

**Chart 8: Supply index of jet fuel for OECD countries, 2015**



Jet fuel is only exported in significant quantities from a few countries around the world, with Korea, the Netherlands, the United States and Saudi Arabia exporting the most. The Netherlands is a trading hub for many oil products, with large amounts of imports then 're-exported' and not used for the country's own consumption. Europe exports relatively small amounts of jet fuel (excluding the Netherlands) as does Japan, Canada and North Africa.

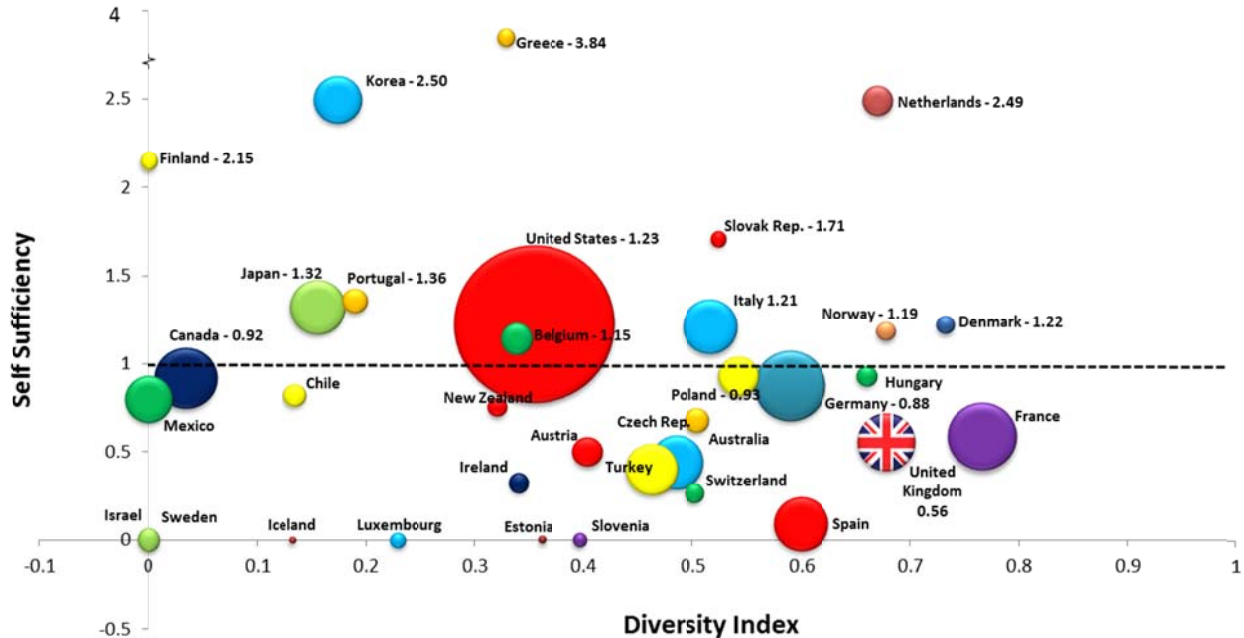
**Chart 9: Worldwide Jet Fuel exports (kt), 2015**



Diesel Road Fuel

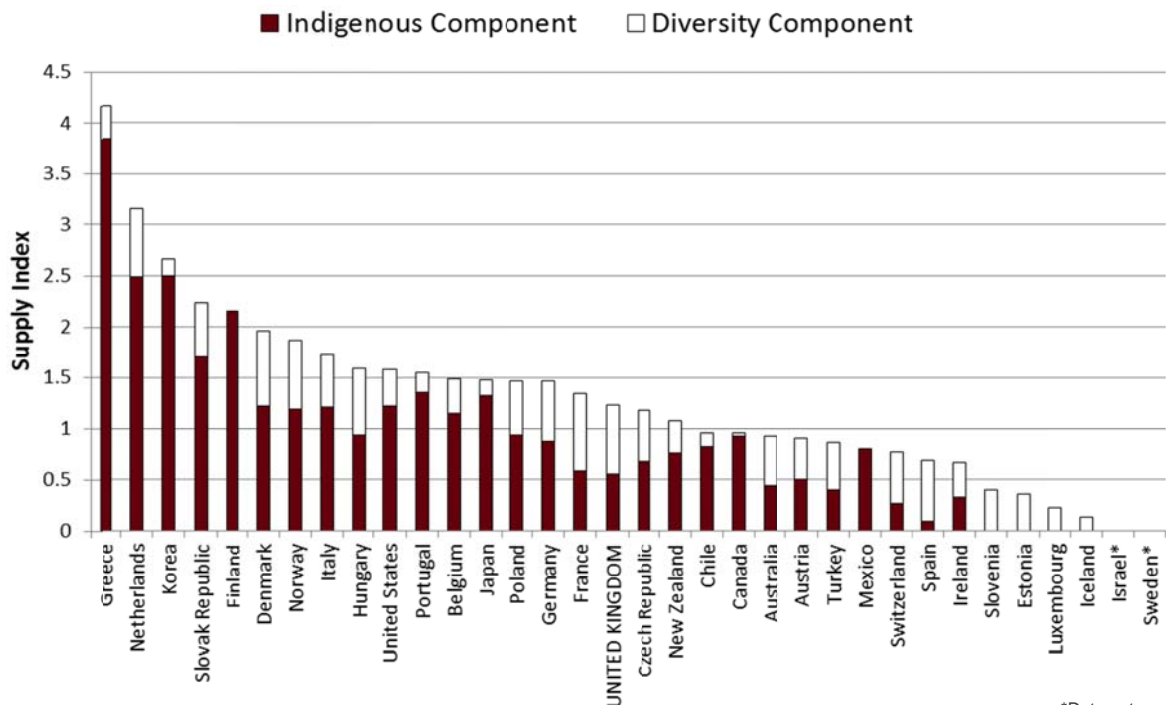
At 0.56 on the self-sufficiency axis, the UK was below the average OECD self-sufficiency score of 0.92 in 2015, producing just over half of the diesel it consumed. However, the UK is in a favourable position in terms of diversity and political stability of imports; the UK's diversity score of 0.68 was higher than the OECD average of 0.38 (Chart 10) and was the third highest out of all 34 countries.

**Chart 10: Diversity and self-sufficiency of diesel for OECD countries, 2015**



The majority of countries either met demand through indigenous production or by a combination of production and diverse imports. The profile depicts how the UK's supply index was the median value of all of the OECD countries' scores (Chart 11).

**Chart 11: Supply index of diesel for OECD countries, 2015**

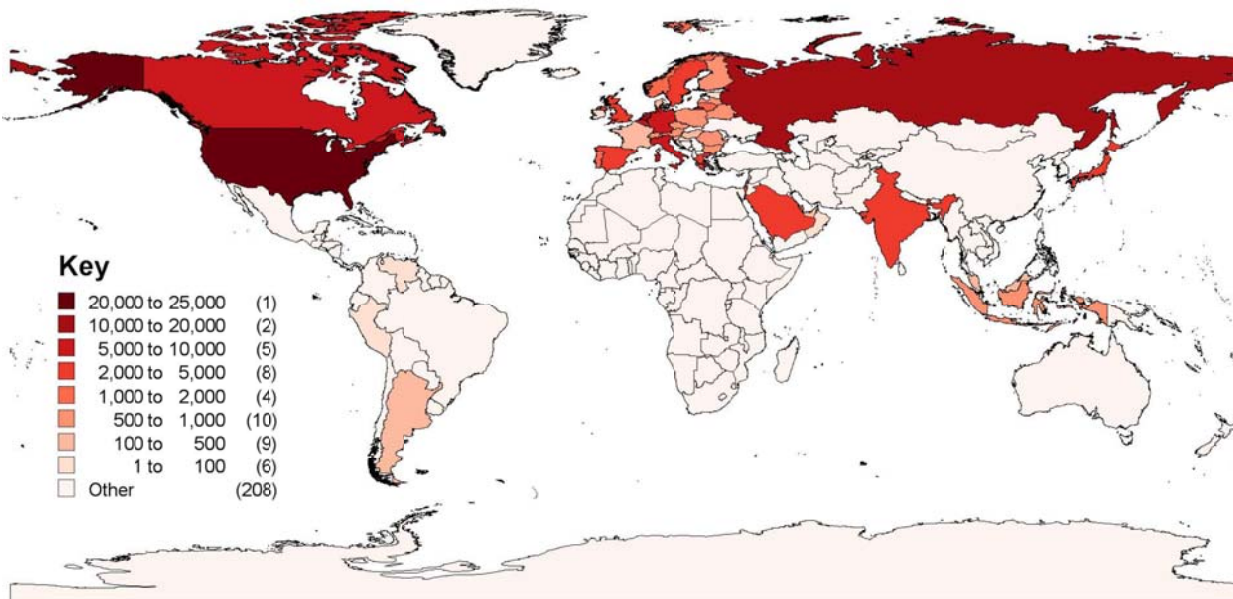


\*Data not available

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Chart 12 shows that the United States and Russia are the most significant exporters of diesel. There are limited quantities of exports from Asia and South America, with Europe and Canada exporting diesel in moderate quantities. The UK was the 10<sup>th</sup> largest exporter out of all 34 OECD countries.

**Chart 12: Worldwide Diesel exports (kt), 2015**



### Summary

#### Self-Sufficiency and Import Diversity of OECD Countries in 2015

The overall picture of diversity of supply for oil and oil products reflects a higher average supply index score for oil products than for crude oil, primarily driven by higher levels of indigenous production for oil products than for crude itself. With an average self-sufficiency score of 0.41, OECD countries are very much dependent on imports of crude oil to meet refinery demand, compared to average scores of 1.34, 0.80 and 0.92 for motor gasoline, jet fuel and diesel respectively. This is reflected by the fact that crude oil has the highest average diversity score (0.43) out of all products for imports into OECD countries, possibly due to the wide variety of crude products that are available on the market, creating a need to import from a diverse range of sources. Although average self-sufficiency scores for transport fuels were much higher, these scores are dependent on refining crude oil, and as such indigenous production of these products cannot be decoupled easily from crude oil supply.

Historically, motor gasoline production across the OECD has been higher than demand, because the refining profile has been biased towards petrol production. This was not the case in 2015, with the total amount produced in OECD countries 3% lower than total consumption quantities. However, 20 of these 34 countries were self-sufficient; particularly notable were Norway and Belgium, producing much higher quantities than the amounts they consumed. With an average self-sufficiency score of 1.34 and an import diversity score of 0.36, motor gasoline production in the OECD as a whole did not meet demand due to a small quantity of countries with little to no production. Despite this, motor gasoline was still the highest scoring oil product in the overall supply index.

Diesel production across the OECD is around 1% higher than demand, with an average self-sufficiency score of 0.92. Around a third of OECD countries were self-sufficient in 2015, with



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Greece producing over three times more than it consumed. This, along with an average diversity and political stability score of 0.38, ranks diesel the second highest oil product in the supply index.

Jet fuel imports had similar diversity scores to motor gasoline, averaging 0.34. This being the lowest diversity score out of the four products, combined with a below average self-sufficiency score of 0.80, put jet fuel as the lowest scoring oil product in the supply index. However the UK, along with a number of north-western European countries, scored much higher than average on the diversity index suggesting that a number of countries have taken steps to maximise the diversity and political stability of jet fuel imports.

#### Self-Sufficiency and Import Diversity of the UK in 2015

The UK compares well with other OECD countries for both self-sufficiency and diversity; scoring slightly better for diversity by ranking in the top three for jet fuel, motor gasoline and diesel, and in the top half for crude oil. The UK could meet around three quarters of its crude oil consumption via indigenous production and ranks fifth out of all OECD countries, according to its supply index. The UK meets its needs for motor gasoline from indigenous production, depending on its offshore fields for some of the crude oil and the production profiles of its refineries. Conversely, the UK relies on imports to meet its requirements for jet fuel and diesel road fuel as its refineries do not meet demand from increasing air movements and the shift towards diesel cars.

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Appendix 1 – Provisional data for 2015

	Crude Oil			Motor Spirit			Jet Fuel			Diesel Road Fuel		
	Diversity plus Political Stability	Self sufficiency	Demand (KT)	Diversity plus Political Stability	Self sufficiency	Demand (KT)	Diversity plus Political Stability	Self sufficiency	Demand (KT)	Diversity plus Political Stability	Self sufficiency	Demand (KT)
Australia	0.83	0.68	22847	0.45	0.67	13680	0.57	0.52	6509	0.48	0.44	21577
Austria	0.66	0.10	8852	0.36	<b>1.03</b>	1665	0.33	0.92	704	0.40	0.50	6516
Belgium	0.61	0.00	32051	0.63	<b>3.58</b>	1366	0.38	<b>1.16</b>	1447	0.34	<b>1.15</b>	7010
Canada	0.32	<b>2.28</b>	67919	0.48	0.87	35080	0.12	0.72	6025	0.03	0.92	26259
Chile	0.20	0.03	8905	0.00	0.92	3251	0.43	0.57	1015	0.13	0.83	3674
Czech Republic	0.28	0.02	7223	0.34	0.97	1577	0.19	0.58	319	0.50	0.68	4460
Denmark	0.23	<b>1.05</b>	7336	0.60	<b>1.53</b>	1280	0.58	0.16	895	0.73	<b>1.22</b>	2325
Estonia	0.00	-	0	0.38	0.38	237	0.00	0.00	39	0.36	0.00	444
Finland	0.27	0.00	9808	0.00	<b>2.36</b>	1507	0.31	0.76	713	0.00	<b>2.15</b>	2406
France	0.80	0.01	57338	0.49	<b>1.57</b>	7083	0.61	0.55	6952	0.77	0.58	34519
Germany	0.73	0.03	93344	0.56	<b>1.10</b>	18226	0.19	0.61	8537	0.59	0.88	36756
Greece	0.51	0.00	21695	0.44	<b>1.87</b>	2463	0.61	<b>1.89</b>	1097	0.33	<b>3.84</b>	2179
Hungary	0.19	0.09	6454	0.51	0.89	1288	0.00	<b>1.08</b>	172	0.66	0.93	3071
Iceland	0.00	-	0	0.00	0.00	133	0.40	0.00	188	0.13	0.00	346
Ireland	0.43	0.00	3367	0.34	0.58	1034	0.19	0.00	802	0.34	0.33	2648
Israel	0.00	0.01	11737	0.00	<b>1.07</b>	3027	0.00	0.83	1092	0.00	-	0.00
Italy	0.79	0.08	66771	0.57	<b>1.84</b>	9173	0.46	0.64	3971	0.52	<b>1.21</b>	21620
Japan	0.65	0.00	153913	0.05	<b>1.03</b>	39105	0.13	<b>1.19</b>	10359	0.16	<b>1.32</b>	20079
Korea	0.78	0.00	137703	0.13	<b>1.98</b>	9009	0.00	<b>3.29</b>	5830	0.17	<b>2.50</b>	16096
Luxembourg	0.00	-	0	0.24	0.00	298	0.36	0.00	428	0.23	0.00	1653
Mexico	0.00	<b>2.03</b>	57545	0.23	0.48	33129	0.02	0.68	3229	0.00	0.80	16920
Netherlands	0.69	0.03	52777	0.65	<b>1.35</b>	4002	0.57	<b>2.02</b>	3692	0.67	<b>2.49</b>	6652
New Zealand	0.84	0.34	5428	0.27	0.62	2330	0.53	0.95	1127	0.32	0.76	2676
Norway	0.56	<b>5.62</b>	13720	0.15	<b>4.57</b>	874	0.86	0.75	908	0.68	<b>1.19</b>	2735
Poland	0.17	0.04	26140	0.28	<b>1.07</b>	3706	0.12	<b>1.68</b>	637	0.54	0.93	11908
Portugal	0.74	0.00	13973	0.17	<b>2.46</b>	1114	0.00	<b>1.01</b>	1164	0.19	<b>1.36</b>	4329
Slovak Republic	0.00	0.00	5931	0.34	<b>2.62</b>	599	0.00	<b>2.16</b>	43	0.52	<b>1.71</b>	1695
Slovenia	0.00	-	0	0.47	0.00	428	0.45	0.00	23	0.40	0.00	1366
Spain	0.78	0.00	64933	0.46	<b>1.85</b>	4929	0.67	0.04	5486	0.60	0.09	21780
Sweden	0.49	0.00	19982	0.55	<b>1.84</b>	2715	0.47	0.13	847	0.00	0.00	3980
Switzerland	0.51	0.00	2803	0.44	0.29	2516	0.27	0.02	1637	0.50	0.27	2683
Turkey	0.38	0.10	25513	0.00	<b>2.47</b>	2068	0.40	<b>1.15</b>	4372	0.46	0.40	19570
<u>United Kingdom</u>	<u>0.55</u>	<u>0.78</u>	<u>55147</u>	<u>0.79</u>	<u>1.29</u>	<u>12713</u>	<u>0.80</u>	<u>0.44</u>	<u>11353</u>	<u>0.68</u>	<u>0.56</u>	<u>24245</u>
United States	0.64	0.58	799397	0.83	0.88	398871	0.48	<b>1.02</b>	71567	0.35	<b>1.23</b>	185148
OECD Average	0.43	0.41	54722	0.36	<b>1.34</b>	17953	0.34	0.80	4800	0.38	0.92	15274

Source: IEA (<http://data.iea.org/>)

Items in **bold** highlight those countries where indigenous capacity exceeded domestic consumption.

## Appendix 2 – Methodology

### Data for crude oil and transport fuel self-sufficiency

Data for crude oil, motor gasoline and jet fuel were extracted from the IEA database. For diesel, data were provided on request from the IEA. Self-sufficiency was determined from data on indigenous production and consumption (production (kt) ÷ consumption (kt)).

### Crude oil and transport fuel diversity indices

The diversity index used here is a product of a standard diversity index and an index for political stability. As a basic index for measuring diversity, we used the Shannon-Wiener diversity index. The Shannon-Wiener index is of the form:

$$\sum_{i=1}^n -x_i \ln(x_i)$$

Where  $x$  is the proportion of total fuel supply represented by the  $i^{\text{th}}$  source country and  $n$  represents the final source country. A value below 1 signifies a country that is dependent on a small range of import sources, a value above 2 represents a country with a wide range of import sources. The minimum value of zero denotes a country that has one imported fuel source or relies entirely on indigenous production.

A previous comparative study on import diversities in Energy Trends March 2011 used the Herfindahl Index as the basic diversity index. Although both of these indices have their advantages, the Shannon-Wiener was chosen here as this represents the data with less skew, as well as placing more weight on the diversity of contributions from smaller countries and lessening the impact of larger nations.

Political stability was determined using data from the World Bank worldwide governance indicators. Specifically, the index reflects perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism. These data were standardised between 0 and 1.

**Source: World Bank** (<http://info.worldbank.org/governance/wgi/index.aspx#home>)

Once Shannon-Wiener and political stability indices were determined, these were multiplied and summed:

$$\sum_{i=1}^n -x_i \ln(x_i) b_i$$

Where  $b$  is an index of political stability of producing country. This is called the SWNI (Shannon-Weiner-Neumann index), in line with previous work.

Each SWNI index was normalised for each petroleum product between 0 and 1, in order to have a standardised index. This was done by working out a maximum diversity score, by assuming maximum diversity was equivalent to importing products in line with proportional contributions of exporting countries (e.g. if a single country were responsible for exporting 50 per cent of all product, and five other countries were responsible for 10 per cent each, we assumed maximum import diversity at a ratio of 5:1:1:1:1). This maximum diversity score then acted as our upper score of 1, with all other scores divided by this maximum to standardise the data.