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Tradability Index: A Comprehensive Measure for the Tradability of Output

Technical Paper on the wiiw Tradability Dataset

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The Vienna Institute for International Economic Studies
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Tradability Index: A Comprehensive Measure for the Tradability of Output

Technical Paper on the wiiw Tradability Dataset

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Abstract

This paper describes the main features of a measure for the specialisation in producing tradable output which is labelled tradability index. It is based on the assumption that all sectors produce goods and services that are tradable but to varying degrees. Therefore, while all sectors produce tradable output, the extent of the tradability varies across sectors depending on their export orientation at the global level. Combined with the economic structure of countries, the tradability of sectors can be used to calculate the tradability index. This technical paper explains the basic concepts of the tradability index and provides information on the underlying data.

Keywords: tradability of output, tradability index, export openness

JEL classification: F10, F40

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TABLES AND FIGURES

1. Introduction

There is a large body of literature emphasising the importance of structural features of the economy for various macroeconomic outcomes. For example, Baumol (1967) differentiates between progressive (high-productivity growth) and non-progressive (low-productivity growth) sectors. In this context manufacturing is typically considered to be a progressive sector. Therefore the sector composition matters for the aggregate growth performance. Rodrik (2010) stresses the importance of the non-traditional tradables sector for structural change and economic growth which again means mainly the manufacturing sector (or the industrial sector more broadly plus some business-related services). In the current account literature the distinction between tradable and non-tradable goods is common because of the implications for relative prices (Ostry and Reinhart, 1991; Obstfeld and Rogoff, 1996). As noted by Obstfeld and Rogoff (2001) the distinction between tradable and non-tradable goods becomes increasingly inappropriate as basically all goods and services have become tradable – though to a different degree which reflects the associated trade costs. In order to take this fact into account, a new index for the tradability of output is developed which is based on empirical information on sectors' global trade orientation. This measure is labelled tradability index, which will be explained in further detail in the next section. The resulting data are contained in the wiiw Tradability Dataset[1]. This dataset provides information on the tradability index for 46 European countries for the period 1995-2014.

[1] See: http://wiiw.ac.at/wiiw-tradability-dataset-ds-1.html.

2. Tradability index

A natural benchmark for the tradability of goods and services is how much they are actually traded (De Gregorio et al., 1994).[2] These authors consider a sector as tradable if more than 10 per cent of total output is exported. The concept of the tradability index (TI) departs from this approach by switching from a dichotomous classification of sectors into either tradable or non-tradable to a continuous measure of sectors' tradability. This gradual approach gives due credit to the fact that basically all goods and services are potentially tradable though to a different extent. More precisely, the dual distinction between tradable sectors and non-tradable sectors is replaced with a continuous 'tradability score' specific to each sector.

Two versions of this tradability index and the underlying tradability scores are suggested. In the first version, the tradability score is calculated using industry-level information on value added and value added exports (Johnson and Noguera, 2012). Intuitively, the value added export (VAX) of a particular industry and country is the value added created by that country and industry but absorbed in other countries.[3] In the second version, the tradability score is calculated using industry-level information on value added and gross exports. While both measures have their merits, methodologically the VAX-based concept appears to be preferable as it relates a value added based measure of exports to industry-level value added.

The tradability index has two components. The first component is the tradability score of sectors, the second component is the value added shares of the economic sectors in the economy.

For each sector *i* the VAX-based tradability score (TS^{vax}) is defined as the ratio between the industry-level value added exports and the industry-level value added for the world as a whole:

$$TS_i^{vax} = \frac{\sum_t \sum_j VAX_{i,j,t}}{\sum_t \sum_j VA_{i,j,t}}$$

where the subscript *t* indexes time and *j* indexes countries. The world in this context means the sum of the value added (*VA*) of the 40 countries plus the rest of the world that are covered in the 2013 release of the World Input-Output Database (WIOD)[4] which has been used for the calculations. In the wiiw Tradability Dataset information on the tradability score TS is found in the file labelled *'TS'*.

Note here that in the numerator and in the denominator the values are summed up not only over countries but also over time. Therefore the TS do not have a time dimension because they are time-

[2] An alternative approach to capture the tradability of goods (or sectors) is to look at tariffs or trade barriers more generally. The difficulty is that the magnitude of such trade barriers is hard to identify. While the trade costs for merchandise can be estimated with gravity models (see e.g. Anderson and Wincoop, 2004), this approach is harder to implement for services.

[3] See Appendix for the methodological details of calculating the value added exports.

[4] See: http://www.wiod.org/release13 and Timmer et al. (2015) for details.

invariant. The tradability score reflects the average export orientation of sector *i* over the period 1995-2011 which is the time span covered in the WIOD (2013 release). The implicit assumption here is that tradability is (if not exclusively, but still) primarily determined by intrinsic features of the goods and services produced by a sector. For this reason, it is appropriate to work with a time-invariant TS for each sector. Nevertheless, below an alternative version of the TI with a time-variant version of the TS will be presented. In the wiiw Tradability Dataset, this alternative version is referred to as *'TS_timevarying'*.

The tradability scores are calculated for 14 broader sectors which are listed in Appendix 1. The reason for this rather broad sector structure is data limitations.[5]

Likewise, the tradability scores for the TS based on gross exports (TS^x) are calculated as follows:

$$TS_i^x = \frac{\sum_t \sum_j X_{i,j,t}}{\sum_t \sum_j VA_{i,j,t}}$$

where $X_{i,j,t}^{j}$ denotes gross exports of sector *i* in country *j* at time *t*.

In the case of the VAX-based tradability scores the value added exports at the industry level need to be calculated. For this calculation the trade in value added concept in Johnson and Noguera (2012) is used following the expositions and steps in Stehrer (2012).

The calculation of the value added exports is done on the most detailed data available (35 industries). The (country-specific) industry-level VAX are then aggregated to the 14 broad sectors[6].

The resulting tradability scores for the 14 sectors are shown in Figure 1. The figure presents both the tradability score based on value added exports (dark blue bars) and the tradability score based on gross exports (light blue bars). Both rankings are very intuitive. In the TS based on value added exports (TS^{vax}), mining and manufacturing emerge as the sectors producing by far the most tradable output with a tradability score of 0.51 and 0.41 respectively. They are followed by the transport and communication sector and the agricultural sector. At the bottom of the ranking are the services sectors health and public administration, which are both characterised by a very low tradability score amounting to 0.006 and 0.014 respectively.

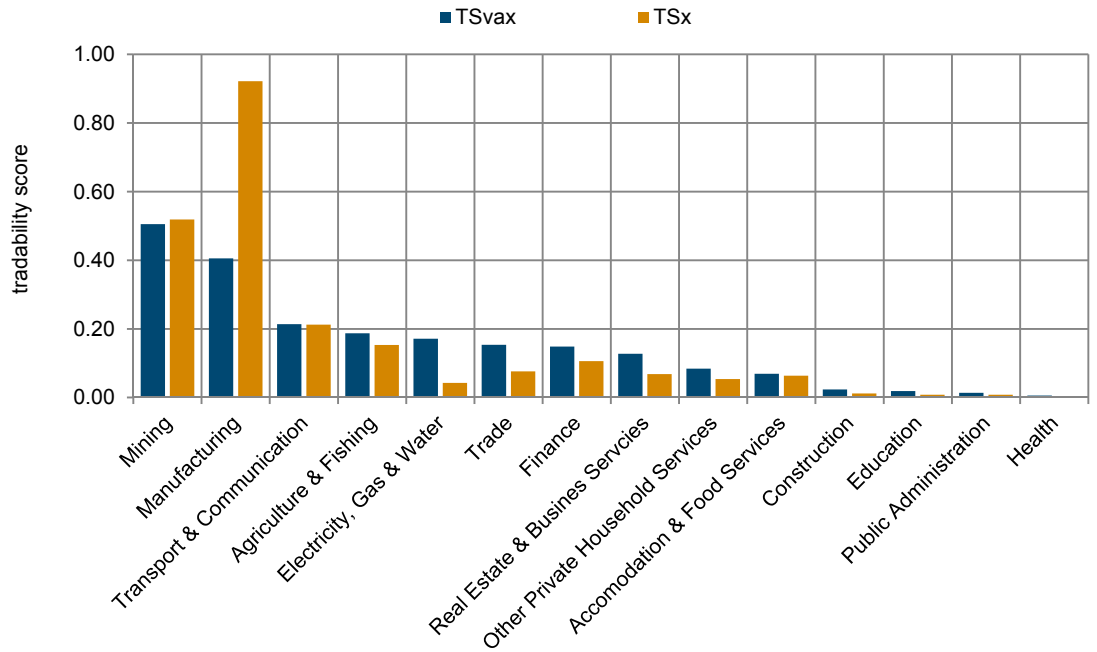
The tradability scores based on gross exports (TS^x) are higher by definition because the VAX correct for double counting of trade flows. Nevertheless, the ranking is very similar though with some important differences. The major difference is that mining and manufacturing switch position when moving from the VAX-based scores to the gross export scores. The reason is that manufacturing is characterised by intensive trade in intermediates, which leads to double counting of gross export flows. This double counting is corrected for in the value added based approach. If one considers a good that is crossing

[5] Another factor influencing the choice of the 14 sectors is that the calculation of the tradability score requires data based on both NACE Rev. 1 and NACE Rev. 2 sections. Since the sample period comprises years for which only either NACE Rev. 1 data or NACE Rev. 2 data are available, the only solution is to add up the broader aggregate. For example, while NACE Rev. 1 distinguishes between Agriculture (A) and Fisheries (B), NACE Rev. 2 does not. Hence, the project uses Agriculture and Fisheries as one sector. For details see Appendix.

[6] For the list of the resulting 14 sectors and the corresponding NACE Rev. 1 and NACE Rev. 2 industry codes see Appendix.

borders (i.e. is exported) several times as being more tradable than a good that crosses borders only once, then the gross exports based tradability scores is the appropriate indicator.

Figure 1 / Global tradability scores (TS) of sectors



Note: TSvax = tradability score based on value added exports. TSx = tradability score based on gross exports.
Source: wiiw Tradability Dataset.

The gravity literature emphasises that a particular product may face higher trade costs (which typically include various types of costs such as tariffs, non-tariff measures and transportation costs) in one country than in another. This implies that the tradability scores of sectors may differ across countries. Despite some potential differences, it is likely that if the output of industry A (say, the manufacturing industry) is more tradable than that of industry B (say, the health sector) in one country, then industry A also produces more tradable output than industry B in other countries. To verify that empirically, a Spearman rank correlation test between the sector rankings by TS for each country and the global sector ranking is run. Table 1 shows the results for all European countries covered in the WIOD.

Not surprisingly, a very strong rank correlation that exceeds 0.90 on average emerges from this test. One reason why the rank correlation is not perfect is that the differences in the tradability score between the sectors with very low scores are small. Hence, the ranking is not completely identical across countries. Another reason is that commodity-producing countries differ from the rest of the countries in the sample insofar as the tradability score of their mining sector exceeds that of the manufacturing sector whereas in all other countries the opposite is true.

A case worth mentioning is Malta, which has by far the lowest Spearman rank correlation. The reason for this is not entirely clear but may be associated with the availability and therefore the quality of the input-output data for Cyprus and Malta being not as good as for the other European countries in the

database.[7] The correlation coefficient of Ireland is also below average, which may be related to the country's role as a location of foreign headquarters. Given this information, in econometric application, robustness checks that exclude Malta, Ireland and potentially Lithuania are recommended.

Table 1 / Spearman's rank correlation coefficients of European countries' tradability scores with the global tradability score (time invariant)

country	Code	ρ	Country	Code	ρ
Austria	AT	0.9560 ***	Italy	IT	0.9780 ***
Belgium	BE	0.9912 ***	Lithuania	LT	0.7275 ***
Bulgaria	BG	0.9209 ***	Luxembourg	LU	0.8330 ***
Cyprus	CY	0.9253 ***	Latvia	LV	0.9165 ***
Czech Republic	CZ	0.8198 ***	Malta	MT	0.5341 **
Germany	DE	0.9868 ***	Netherlands	NL	0.9516 ***
Denmark	DK	0.9868 ***	Poland	PL	0.9473 ***
Spain	ES	0.9560 ***	Portugal	PT	0.9692 ***
Estonia	EE	0.9341 ***	Romania	RO	0.8945 ***
Finland	FI	0.9429 ***	Russia	RU	0.8857 ***
France	FR	0.9736 ***	Slovakia	SK	0.8681 ***
United Kingdom	UK	0.9121 ***	Slovenia	SI	0.9516 ***
Greece	EL	0.9516 ***	Sweden	SE	0.9516 ***
Hungary	HU	0.9121 ***	Turkey	TR	0.9077 ***
Ireland	IE	0.6659 ***			

Note: ρ is the Spearman rank correlation coefficient, ***, ** and * indicate p-values being statistically significant at the 1%, 5% and 10% level respectively.
Source: wiiw Tradability Dataset.

To move from the (industry-level) tradability scores to the (country-level) tradability index, a second element is needed: the country-level value added shares. More precisely, to obtain the tradability index the tradability scores are weighted with the respective country's sectoral value added shares, i.e. the sector-specific value added ($VA_{i,t}^{j}$) over total value added ($\sum_i VA_{i,t}^{j}$). Note that the value added shares vary over time and over countries. Formally, the VAX-based TI of country *j* in any year *t* is defined as:

$$TI_{j,t}^{vax} = \sum_i TS_i^{vax} \cdot \frac{VA_{i,j,t}}{\sum_i VA_{i,j,t}}$$

The corresponding gross exports based TI is given by

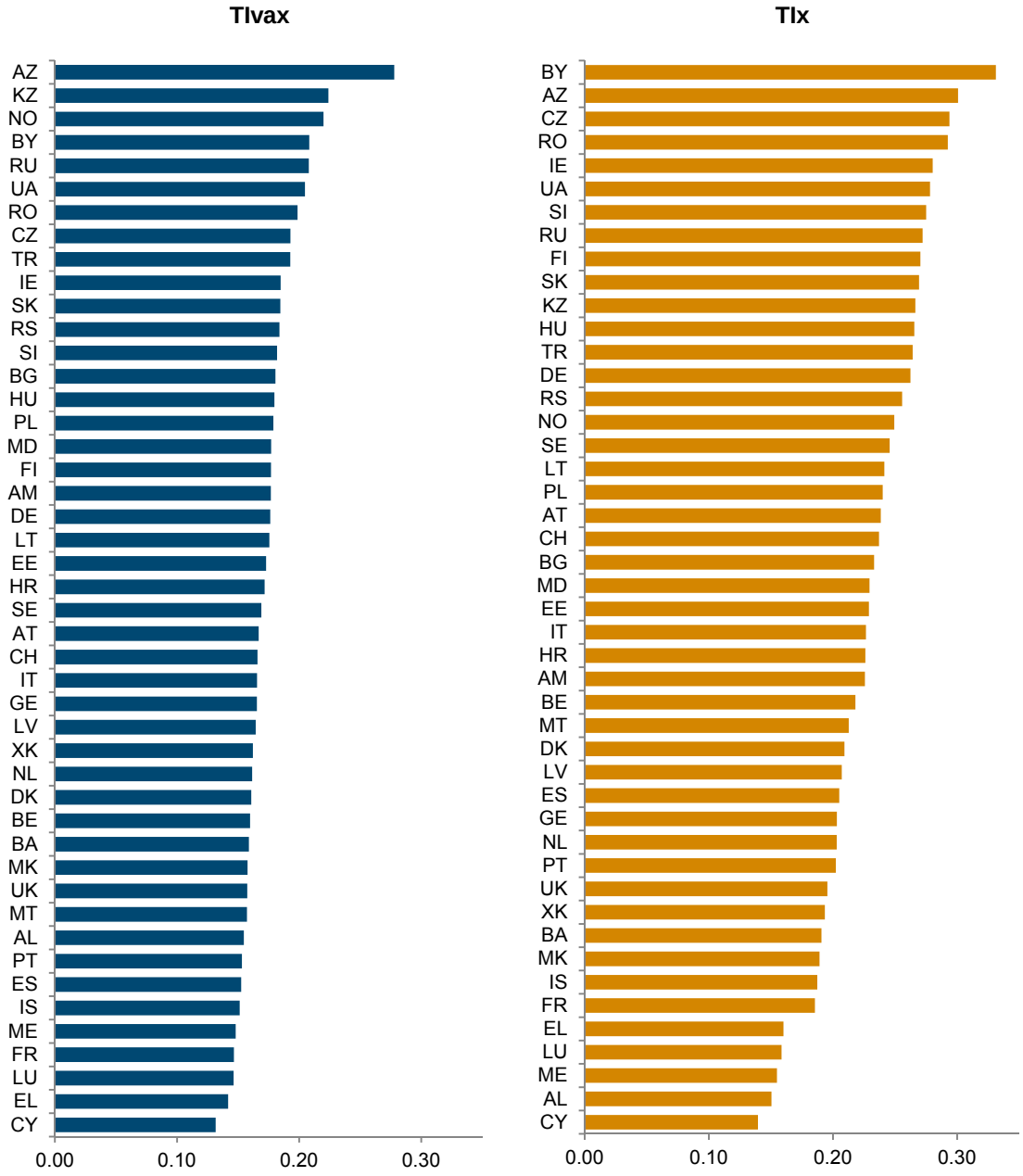
$$TI_{j,t}^{x} = \sum_i TS_i^{x} \cdot \frac{VA_{i,j,t}}{\sum_i VA_{i,j,t}}$$

One of the key advantages of the tradability index is that it reflects the entire composition of production of each country. This makes it an interesting summary variable for an investigation of the nexus between the tradability of output and macroeconomic outcomes such as the current account balance or economic growth.

[7] See Timmer (2012) for details.

Note that the tradability index, TI_t^j, is country- and time-specific and that the variance over time is coming uniquely from the changes in the respective country's sector composition of value added. This is because we chose the tradability scores to be time-invariant.

Figure 2 / Tradability index across countries, averages 1995-2014



Note: TIvax = tradability index based on value added exports. TIx = tradability index based on gross exports.
Source: wiiw Tradability Dataset.

The left hand panel of Figure 2 presents the ranking of the 46 countries in the sample according to the value added exports based tradability index. There is quite some variation in the index across countries, ranging from 0.278 for Azerbaijan to a mere 0.132 in Cyprus. Next to Azerbaijan mainly other commodity

exporters are found at the top of the ranking. The bottom ranks are all occupied by EU countries: Cyprus, Greece, Luxembourg and France. Romania and the Czech Republic are the EU countries with the highest values for the tradability index. The sample average of the tradability index is 0.175, which is about the value found for Lithuania and Germany. A country with a TI of 0.175 implies that, given its production structure, this country is expected to export 17.5% of its value added to other countries (with the rest being absorbed domestically). The right-hand panel of Figure 2 shows that the country ranking for the TI based on gross exports is similar though not identical to the one according to the VAX-based TI. The Spearman rank correlation coefficient between the two alternative TI measures, when based on countries' year averages, is 0.915[8].

While it was emphasised that the TI can be interpreted as the *predicted* openness of a country given its production structure, it should equally be stressed that these predictions are for most countries nowhere near to their *actual* export openness. This is not surprising given that a country's trade openness does not only depend on its economic structure. It also depends, for example, on country size as smaller countries tend to be more open economies. A major advantage of the tradability index is that it is by construction independent of country size because it is derived using a global measure for trade openness, i.e. the tradability scores. Moreover, the tradability index also depends much less on trade policy than the actual trade openness. Indirectly, countries' trade policies may be reflected in the TI due to the resulting specialisation in production. But the latter is exactly what we intend to capture with our tradability index. Importantly, the tradability index of a country does not reflect its own exports. The only thing the tradability index reflects is the share of global value added exports in output. Hence, in contrast to export openness, which reflects many country characteristics such as country size, trade policy and the success of the latter, the tradability index is to a large extent purged from these influences and therefore basically reflects a country's specialisation in the production of tradable output.[9]

Table 2 shows that most of the variation in the TI stems from differences across countries.

Table 2 / Decomposition of variance into between and within components

variable	between	within	BSS	WSS	TSS	BSS	WSS
	variability					share	
TIvax	0.0256	0.0116	0.5789	0.1134	0.6923	0.8363	0.1637
TIx	0.0436	0.0225	1.6489	0.4268	2.0758	0.7944	0.2056

Note: BSS = between sum of squares. WSS = within sum of squares. TSS = total sum of squares.

Nevertheless, there is also variance over time though the trends are heterogeneous. This is illustrated using the development of the value added based TI for France and Germany between 1995 and 2014 (Figure 3).

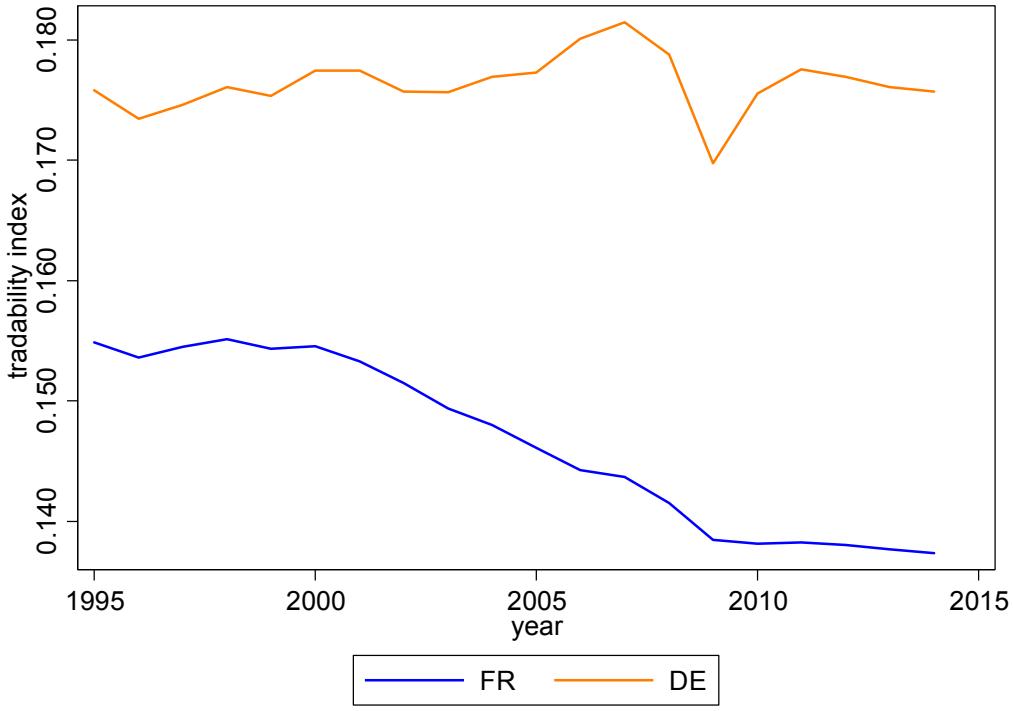
France's TI embarked on a negative trend at around the year 2000 while Germany's TI was growing until the onset of the crisis in 2008/2009. The crisis-related drop in the TI was much more pronounced in Germany but it recovered (at least partly) in the following years while France's downward trend, though

[8] The Spearman rank correlation between the yearly TI measures is similarly high, amounting to 0.909.

[9] One may argue that the tradability index reflects changes in the global stance to trade policy because it includes the ratio of global value added exports to value added. However, since the average over time of this ratio is used, the tradability index only reflects the world's long-term stance towards 'globalisation'.

softening, seems to have continued in the post-crisis years. These divergent trends imply that the already pronounced differential in the tradability of output produced by the two countries increased significantly, to approximately 4 percentage points in 2014.

Figure 3 / Development of the tradability index for France and Germany, 1995-2014



Note: Tradability index based on value added exports.
Source: wiiw Tradability Dataset.

In the wiiw Tradability Dataset information on the TI (both value added and gross export based) is found in the file labelled *'TI'*.

3. Tradability index with time-varying tradability scores

As mentioned above, the main version of the tradability index is calculated using the global averages over the sample period (1995-2014) of the value added exports (numerator) and the value added (denominator) to derive the tradability scores. The implicit assumption in that case is that the tradability of output is to a large extent intrinsic to the specific sectors and is only to a limited extent shaped by policies and changes in technology.

As a variant to this approach, the wiiw Tradability Dataset also contains a time series for the TI that used time-varying tradability scores. The time-varying tradability score (based on value added export[10]) is calculated as follows:

$$TS_{i,t}^{vax} = \frac{\sum_j VAX_{i,j,t}}{\sum_j VA_{i,j,t}}$$

Obviously, the time-varying version of the TS has also a time dimension. Apart from this adjustment, the definition of the TI remains unchanged leading to

$$TI_{j,t}^{vax,time-vary} = \sum_i TS_{i,t}^{vax} \cdot \frac{VA_{i,j,t}}{\sum_i VA_{i,j,t}}$$

The TI based on the time-varying TS is provided in the file *'TI_varyingTS'*.

The major difference between the standard TI and the time-variant version of the TI is that the latter has two sources for variation over time: the TS and the value added shares. One natural limitation of the time-varying TS is that the TI can only be calculated for the period 1995-2011 given the data availability in the WIOD database.[11]

The extent to which the TS have changed over the sample period is shown in Figure 4 for a selected number of sectors.

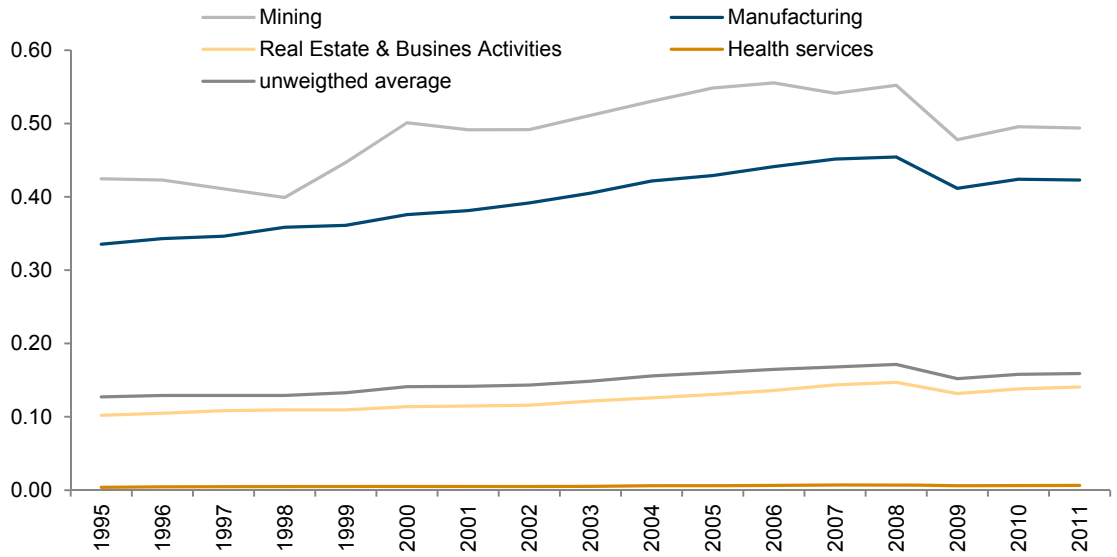
The main insight to be gained from Figure 4 is that while the tradability of sectors has increased over time, on average (unweighted) from 0.13 to 0.16, there is no change in ranking of sectors. In general, the increase in the tradability scores between 1995 and 2011 were highest in the most tradable sectors, i.e. mining and manufacturing. The development over time of real estate services and business activities, which are often argued to be a promising field of specialisation for advanced economies, coincides more or less with the average trend of sectors. For the classical 'non-tradable' sectors, which

[10] The definition for the TS based on gross exports has to be adjusted likewise.

[11] This it at least true for the 2013 release of the WIOD.

in our methodology have the lowest TS, the values have hardly changed as is shown for the health sector.

Figure 4 / Development of the time-varying TS for selected sectors, 1995-2011

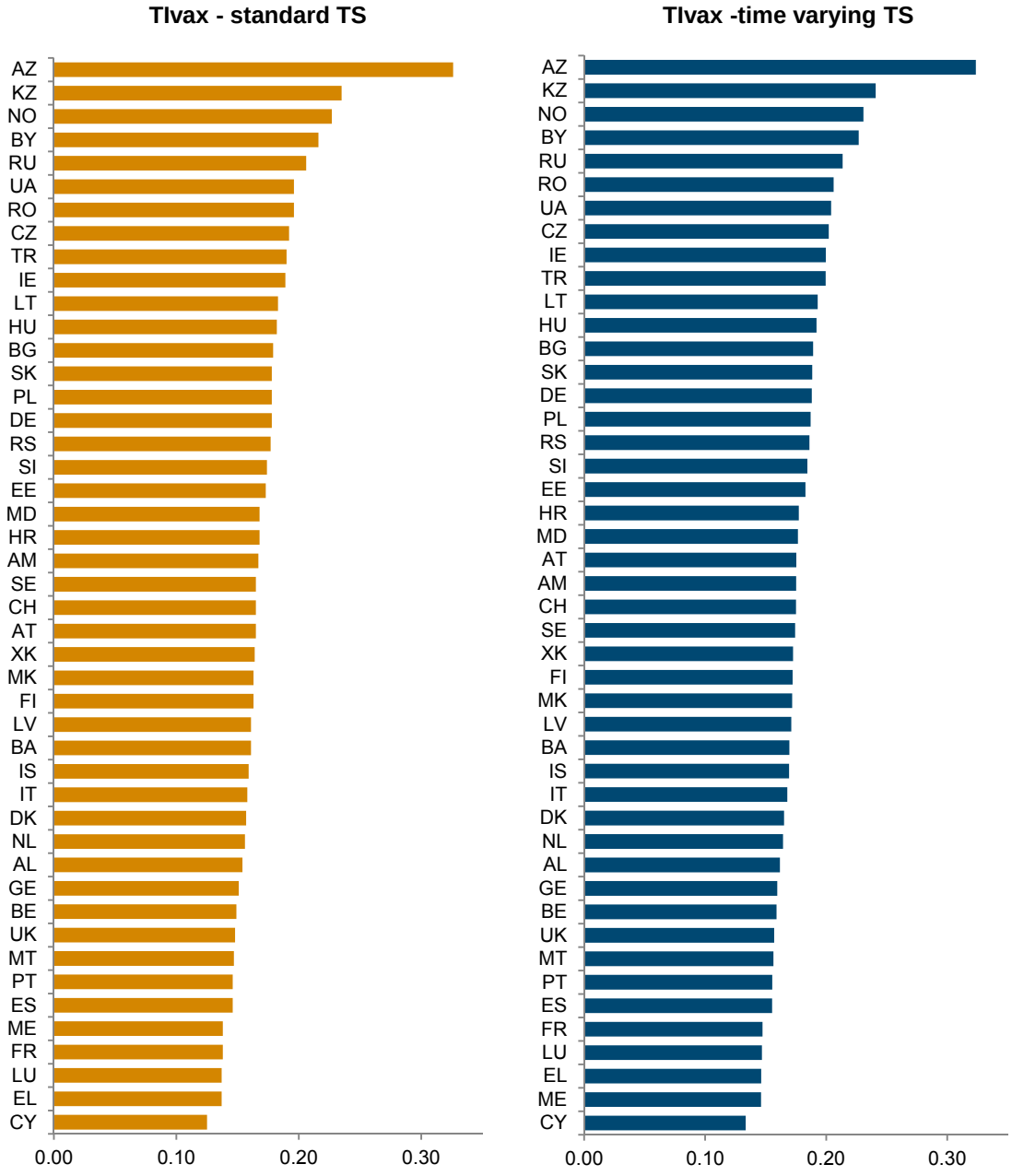


Note: Tradability index based on value added exports.
Source: wiiw Tradability Dataset.

Given these patterns and trends in the time-varying TI, the index is not very sensitive to the choice of indicator, either standard or time-varying TS. This is depicted in Figure 5, which shows the two versions of the TI: one based on the standard TI and the other based on the time-varying TS for the year 2011.

As can easily be seen, there is very little difference in the countries' TI and the ranking of countries is almost unchanged with occasional rank switches such as between Ukraine and Romania. This implies that the relative changes in the TI of countries over time are driven primarily by changes in the economic structures which are exactly what the TI is supposed to capture.

Figure 5 / Comparison of the TI based on standard TS vs. time-varying TS, 2011



Note: Tradability index based on value added exports.
Source: wiiw Tradability Dataset.

4. Data

The wiiw Tradability Dataset comprises basically the whole of Europe resulting in a sample of 46 countries[12]. The countries represent a mix of developed and emerging countries ('emerging Europe') which we classify according to the categorisation of European countries as 'Advanced' and 'Emerging and Developing' by the IMF as of April 2014. The sample period generally stretches from 1995 to 2014; given that all European countries are covered, this implies that the sample will be slightly unbalanced for reasons of lacking data availability back to 1995 for countries that have gained independence more recently, such as Montenegro.[13]

The primary sources for the sector-level value added data are the wiiw Annual Database (wiiw ADB) and Eurostat. For the countries covered neither by the wiiw ADB nor by Eurostat, information was retrieved from the United Nations SNA database. Several countries are covered by two or more databases and the data series are not always identical.[14] As a general rule we use the data source with the most recent methodology. Apart from this, we use the wiiw ADB as our preferential source of data. If a country is not covered in the wiiw ADB, data from Eurostat are used. The details concerning data sources for the value added data required for calculating the TI are found in Appendix 4.

As explained in the previous section, the calculation of the tradability index based on value added exports also requires global input-output data, which we get from the World Input-Output Database (WIOD), 2013 release (Timmer et al., 2015).[15] The methodology for calculating the value added exports is explained in Appendix 3.

[12] Exceptions are Lichtenstein, Monaco, San Marino and the Vatican. See Appendix for the list of countries.

[13] See Appendix for details on data availability.

[14] Some discrepancies between data sources are explained by reporting in different SNA series (e.g. ESA 1995 vs. ESA 2010).

[15] See: http://www.wiod.org/release13.

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Appendix 1: List of countries

Abbreviation	Country	Country category
AL	Albania	Emerging
AM	Armenia	Emerging
AT	Austria	Developed
AZ	Azerbaijan	Emerging
BY	Belarus	Emerging
BE	Belgium	Developed
BA	Bosnia and Herzegovina	Emerging
BG	Bulgaria	Emerging
HR	Croatia	Emerging
CY	Cyprus	Emerging
CZ	Czech Republic	Developed
DK	Denmark	Developed
EE	Estonia	Developed
FI	Finland	Developed
FR	France	Developed
GE	Georgia	Emerging
DE	Germany	Developed
EL	Greece	Developed
HU	Hungary	Developed
IS	Iceland	Developed
IE	Ireland	Developed
IT	Italy	Developed
KZ	Kazakhstan	Emerging
LV	Latvia	Developed
LT	Lithuania	Emerging
LU	Luxembourg	Developed
MK	Macedonia	Emerging
MT	Malta	Emerging
MD	Moldova	Emerging
ME	Montenegro	Emerging
NL	Netherlands	Developed
NO	Norway	Developed
PL	Poland	Emerging
PT	Portugal	Developed
RO	Romania	Emerging
RU	Russia	Emerging
RS	Serbia	Emerging
SK	Slovakia	Developed
SI	Slovenia	Developed
ES	Spain	Developed
SE	Sweden	Developed
CH	Switzerland	Developed
TR	Turkey	Emerging
UA	Ukraine	Emerging
UK	United Kingdom	Developed
XK	Kosovo	Emerging

Note: The distinction between ‘Developed’ and ‘Emerging’ mirrors the categorisation of European countries as ‘Advanced’ and ‘Emerging and Developing’ by the IMF as of April 2014.

Appendix 2: List of sectors for the calculation of the tradability index

Number	Sector	NACE Rev. 1	NACE Rev. 2
1	Agriculture, hunting and forestry + Fishing	A+B	A
2	Mining and quarrying	C	B
3	Manufacturing	D	C
4	Electricity, gas and water supply	E	D+E
5	Construction	F	F
6	Wholesale, retail trade, repair of motor vehicles etc.	G	G
7	Hotels and restaurants	H	I
8	Transport, storage + Communication	I	H + J
9	Financial intermediation	J	K
10	Real estate, renting and business activities	K	L+M+N
11	Public administration, defence, compuls.soc.security	L	O
12	Education	M	P
13	Health and social work	N	Q
14	Other community, social and personal services + Private households with employed persons	O+P	R+S+T

Appendix 3: Methodology for calculating value added exports and the tradability scores

Deriving the tradability score requires the calculation of the value added exports (VAX) at the industry-country level. This appendix illustrates the basic input-output methodology to calculate the VAX, including a 3-country, 2-sector example.

Following the trade in value added concept in Johnson and Noguera (2012) and the expositions in Stehrer (2012) we require three components in order to calculate the value added exports. For any country *r*, these components are the value added requirements per unit of gross output, v_i^r; the Leontief inverse of the global input-output matrix, $\boldsymbol{L}$; and the final consumption vector, c_i^r. Both vectors as well as the Leontief inverse have an industry dimension i. The industry index is omitted in order to facilitate the exposition.

Country *r*'s value added coefficients are defined as $v_i^r = \frac{value\ added_r}{gross\ output_r}$. The value added coefficients are arranged in a diagonal matrix of dimension 1435 x 1 (41 countries x 35 industries). This matrix contains the value added coefficients of country *r* for all industries along the diagonals. The remaining entries of the matrix are zero because the interest here is with the value added created in country *r*.

The second element is the Leontief inverse of the global input-output matrix, $\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1}$ where $\boldsymbol{A}$ denotes the coefficient matrix. In the World Input-Output Database (WIOD) the coefficient matrix (and hence the Leontief matrix) is of dimension 1435 × 1435 which contains the technological input coefficients of country *r* in the diagonal elements and the technological input coefficients of country *r's* imports (from a column perspective) and exports (from a row perspective) in the off-diagonal elements.

The final building block is the global final consumption vector. This vector is also industry-specific and is of dimension 1435 × 1. Most importantly, for our purposes, final consumption must be split into separate blocks indication the origin of the consumed goods though within the elements in the column vector. As usual, each row is associated with one source of the final demand. The full consumption vector, f_i^J, in the 3-country, 2-sector case, with *m* (for manufacturing) and *s* (for services) indicating the sector, then has the following form:

$$f_i^J = \begin{pmatrix} f_m^{r,r} + f_m^{r,2} + f_m^{r,3} \\ f_s^{r,r} + f_s^{r,2} + f_s^{r,3} \\ f_m^{2,r} + f_m^{2,2} + f_m^{2,3} \\ f_s^{2,r} + f_s^{2,2} + f_s^{2,3} \\ f_m^{3,r} + f_m^{3,2} + f_m^{3,3} \\ f_s^{3,r} + f_s^{3,2} + f_s^{3,3} \end{pmatrix}$$

where the subscript *J* indicates that the vector comprises the consumption of all countries $j \in J$. The typical element of this vector contains the final consumption from all possible sources. For example, the

element $f_m^{r,3}$ captures the value of final goods that country 3 demands from the manufacturing sector in country *r*. Since the idea of value added exports is that they comprise only value added that is created in one country but absorbed in another, the final demand from country *r* itself needs to be eliminated for the calculation of country *r*'s VAX. Therefore an adjusted final demand vector, $f_i^{j\neq r}$, is used in which country *r*'s final demand (i.e. the first column in the above matrix) is set to zero. Country *r*'s value added exports can then be calculated as

(1) $$VAX_i^{r,*} = \boldsymbol{v_i^r} \cdot \boldsymbol{L} \cdot f_i^{j\neq r}$$

where $VAX^{r,*}$ are the sector-specific value added exports of country *r* to all partner countries.

To illustrate this, the detailed matrices in the 3 country, 2-sector case, where country *r* acts as the model country are shown. Equation (1) then has the following form:

$$\begin{pmatrix} VAX_{m,*}^{r,*} \\ VAX_{s,*}^{r,*} \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} v_m^r & 0 & 0 & 0 & 0 & 0 \\ 0 & v_s^r & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \cdot \begin{pmatrix} l_{m,m}^{r,r} & l_{m,s}^{r,r} & l_{m,m}^{r,2} & l_{m,s}^{r,2} & l_{m,m}^{r,3} & l_{m,s}^{r,3} \\ l_{s,m}^{r,r} & l_{s,s}^{r,r} & l_{s,m}^{r,2} & l_{s,s}^{r,2} & l_{s,m}^{r,3} & l_{s,s}^{r,3} \\ l_{m,m}^{2,r} & l_{m,s}^{2,r} & l_{m,m}^{2,2} & l_{m,s}^{2,2} & l_{m,m}^{2,3} & l_{m,s}^{2,3} \\ l_{s,m}^{2,r} & l_{s,s}^{2,r} & l_{s,m}^{2,2} & l_{s,s}^{2,2} & l_{s,m}^{2,3} & l_{s,s}^{2,3} \\ l_{m,m}^{3,r} & l_{m,s}^{3,r} & l_{m,m}^{3,2} & l_{m,s}^{3,2} & l_{m,m}^{3,3} & l_{m,s}^{3,3} \\ l_{s,m}^{3,r} & l_{s,s}^{3,r} & l_{s,m}^{3,2} & l_{s,s}^{3,2} & l_{s,m}^{3,3} & s_{s,s}^{r,3} \end{pmatrix} \cdot \begin{pmatrix} 0 + f_m^{r,2} + f_m^{r,3} \\ 0 + f_s^{r,2} + f_s^{r,3} \\ 0 + f_m^{2,2} + f_m^{2,3} \\ 0 + f_s^{2,2} + f_s^{2,3} \\ 0 + f_m^{3,2} + f_m^{3,3} \\ 0 + f_s^{3,2} + f_s^{3,3} \end{pmatrix}$$

The coefficients in the Leontief matrix represent the total direct and indirect input requirements of any country in order to produce one dollar worth of output for final demand. For example, the coefficient $l_{m,s}^{r,r}$ indicates the input requirement of country *r*'s services sector from country *r*'s manufacturing sector for producing one unit of output. Likewise, the coefficient $l_{m,m}^{r,3}$ indicates country *r*'s input requirement in the manufacturing sector supplied by country 3's manufacturing sector.

The resulting elements in this example, $VAX_{m,*}^{r,*}$ and $VAX_{s,*}^{r,*}$, are the total value added exports of country *r*'s manufacturing and services sectors, respectively, to all other sectors of all partner countries.

The VAX are not only calculated for country *r* but for all 40 countries plus the rest of the world. Hence, the final step needed to arrive at the global industry-level VAX is to sum up the VAX of all countries for each individual sector *i*. Dividing the global industry-specific VAX by the corresponding industry-specific value added yields the tradability score by sector. In that process, also the more detailed industry structure (35 industries) is aggregated to the 14 broad sectors on which the tradability index is based.

Appendix 4: Data sources and data availability for the tradability index, 1995-2014

Tradability index: data sources and data availability for the required sector-level data for value added

reporter	country	data source	years	industry structure
AL	Albania	UN wiiwADB	1995-2013	NACE Rev. 1 1995-2007 NACE Rev. 2 2008-2014
AM	Armenia	UN	1995-2013	NACE Rev. 1 1995-2008 NACE Rev. 2 2009-2014
AT	Austria	Eurostat	1995-2013	NACE Rev. 2 1995-2014; ESA2010
AZ	Azerbaijan	UN	1995-2013	NACE Rev. 1 1995-2004 NACE Rev. 2 2005-2013
BA	Bosnia and Herzegovina	UN wiiwADB wiiwADB	1999-2014	NACE Rev. 1 1995-2007 NACE Rev. 1 2008-2004 NACE Rev. 2 2005-2014
BE	Belgium	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
BG	Bulgaria	UN wiiwADB wiiwADB	1995-2013	NACE Rev. 1 1995 NACE Rev. 1 1996-1999 NACE Rev. 2 2000-2013 ESA 2010
BY	Belarus	UN wiiwADB	1995-2014	NACE Rev. 1 1995-1999 NACE Rev. 1 2000-2014
CH	Switzerland	UN Eurostat	1995-2013	NACE Rev. 1 1995-1997 NACE Rev. 2 1997-2013 ECA 2010
CY	Cyprus	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
CZ	Czech Republic	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
DE	Germany	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
DK	Denmark	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
EE	Estonia	wiiwADB	1995-2014	NACE Rev. 2 1995-2014 ESA 1995: 1995-1999 ESA2010: 2000-2014
EL	Greece	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
ES	Spain	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
FI	Finland	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
FR	France	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
GE	Georgia	UN	1995-2014	NACE Rev. 1 1995-2014
HR	Croatia	wiiwADB	1995-2013	NACE Rev. 2 1995-2014; ESA2010
HU	Hungary	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
IE	Ireland	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010

ctd.

ctd.

reporter	country	data source	years	industry structure
IS	Iceland	Eurostat	1997-2013	NACE Rev. 2 1997-2013; ESA2010
IT	Italy	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
KZ	Kazakhstan	UN UN wiiwADB wiiwADB	1995-2014	NACE Rev. 1 1995-1997 NACE Rev. 1 1998 NACE Rev. 1 1998-2005 NACE Rev. 2 2006-2014
LT	Lithuania	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
LU	Luxembourg	Eurostat	1995-2014	NACE Rev. 2 1995-2014 ESA1995: 1995-1999 ESA2010: 2000-2014
LV	Latvia	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
MD	Moldova	UN	1995-2014	NACE Rev. 1 1995-2014
ME	Montenegro	wiiwADB	2000-2014	NACE Rev. 1: 2000-2009 NACE Rev. 2: 2010-2014
MK	Macedonia	wiiwADB	1997-2013	NACE Rev. 1: 1997-1999 NACE Rev. 2: 2000-2013
MT	Malta	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
NL	Netherlands	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
NO	Norway	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
PL	Poland	Eurostat wiiwADB	1995-2014	NACE Rev. 2 1995-2014 ESA1995: 1995-2001 ESA2010: 2002-2014
PT	Portugal	Eurostat	1995-2013	NACE Rev. 2 1995-2013; ESA2010
RO	Romania	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
RS	Serbia	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
RU	Russia	UN wiiwADB	1995-2014	NACE Rev. 1 1995-2001 NACE Rev. 1 2002-2014
SE	Sweden	Eurostat	1995-2014	NACE Rev. 2 1995-2014; ESA2010
SI	Slovenia	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
SK	Slovakia	wiiwADB	1995-2014	NACE Rev. 2 1995-2014; ESA2010
TR	Turkey	UN wiiwADB	1995-2014	NACE Rev. 1 1995-1997 NACE Rev. 1 1998-2014
UA	Ukraine	UN wiiwADB wiiwADB	1995-2014	NACE Rev. 1 1995-1999 NACE Rev. 1 2000 NACE Rev. 2 2001-2014
UK	United Kingdom	Eurostat	1995-2014	NACE Rev. 2 1995-2014 ESA1995: 1995-1997 ESA2010: 1998-2014
XK	Kosovo	wiiw ADB	2006-2014	NACE Rev. 1 2006-2007 NACE Rev. 2 2008-2014

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