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Assessing the International Interlinkages and Dependencies of the EU27 'Energy-renewables' Ecosystem

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Abstract

The energy-renewables ecosystem (ERES) plays a particularly important role in the green transition. This paper analyses its relevance in EU member states and the competitiveness for the EU27 as a whole vis-à-vis other global players and identifies structural dependencies and vulnerabilities. It does so by drawing on the Joint Research Centre's FIGARO dataset and detailed trade data, and by developing a novel approach that adapts input-output indicators to the analysis of industrial ecosystems. A number of key findings emerge from our analysis. First, the ERES is particularly relevant in new member states, Austria and Germany. At the global level, the EU27 is the second most important exporter after China. Second, in 2020 the EU ecosystem was dependent on imports of coal and lignite from Russia, as well as on a variety of other products from China (including medium- and high-tech electronic products). Third, analysis on the basis of detailed trade data indicates that a few products in the ERES supply chain are delivered by only a handful of countries, which could indicate some vulnerability. Most of the partner countries supply some products that may be characterised as 'risky', but China is a main source of such products.

Keywords: green transition; energy-renewables ecosystem; linkages; dependencies; open strategic autonomy

JEL classification: F10, F14

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1. Introduction

Accelerating the green transition and supporting Europe's open strategic autonomy are among the key objectives of today's industrial policy in the EU. While the relevance of these objectives was acknowledged in industrial policy documents as long ago as 2010, recent events – most notably the rising geopolitical tension between China and the US, the disruption caused by the COVID-19 pandemic and the attack on Ukraine – have magnified these concerns.

The European Commission has put in place a variety of initiatives to identify strategic dependencies and to analyse the challenges for the green transition. Within this framework, the concept of 'industrial ecosystems' has been adopted to take account of the complementarities between highly interrelated economic activities and to facilitate the design of systemic solutions to the issues at hand. Fourteen ecosystems have been identified, and work has started on each to create transition pathways towards more resilient, greener and more digital ecosystems.

While all ecosystems will crucially contribute to the successful achievement of the green transition, the energy-renewables ecosystem has a particularly important role to play. Indeed, the energy-renewables ecosystem is responsible for the production of wind and solar energy, hydropower, bioenergy (including sustainable biofuels), geothermal and ocean energy, and heat pumps (European Commission, 2021). The infrastructure required by these industries (e.g. sustainable energy storage solutions, smart infrastructure technologies and energy conversion technologies) is also an integral component of the ecosystem. In a way, all other ecosystems depend heavily on the energy-renewables ecosystem in the switch to greener production methods.

This ecosystem is crucial not just for the green transition, but also to promote the open strategic autonomy of the EU. Indeed, the ecosystem was impacted by the supply-chain bottlenecks triggered by the shutdowns during the COVID-19 pandemic (IEA, 2020). The markets most affected were the wind and solar (photovoltaic) industries, which were disrupted by the closure of manufacturing plants in Italy and Spain in April 2020, as well as in China (European Commission, 2021). Beyond the supply-chain disruptions, the rapid rise of China as a critical source of inputs and technologies for this ecosystem has created strategic dependencies and vulnerabilities that add to the long-standing issues related to the energy dependence on certain trade partners (most notably Russia).

For all these reasons, this paper focuses on the energy renewables ecosystem and provides an in-depth analysis of the trade performance of the EU and other global players, the interlinkages among them and the strategic dependencies that arise from the current trade patterns. The paper thereby contributes to the current policy debate on this ecosystem, by providing solid empirical evidence on its performance. This analysis complements existing analysis of technological challenges (European Commission, 2022a) and the use of renewables (e.g. European Commission, 2020a, 2022b; IEA, 2020).

Beyond contributing to the policy debate, this paper also tries to make an important contribution to the literature from a methodological perspective. First, we construct an ecosystem-wide aggregate which encompasses the main industries that constitute the ecosystem, and embed this information in a multi-country input-output table. This allows us to describe the trade performance of the ecosystem and identify its strategic dependencies and vulnerabilities. In particular, it enables us to focus in detail on the supply and value chain of this ecosystem, by exploring indicators of backward and forward linkages and patterns of revealed comparative advantage along the sourcing structures for this value chain. Finally, we try to identify vulnerabilities and dependencies at the detailed product level. While this novel approach is showcased for the energy-renewables ecosystem, it could be applied to any of the other 13 industrial ecosystems.

To undertake this complex analysis, we use a variety of data sources, as described in Section 2. These are used to proxy the ecosystem under consideration by accounting for this in a fully fledged multi-country input-output table (MC-IOT). The remainder of the paper is structured as follows. Section 3 sets the scene by analysing the relevance of this ecosystem over recent decades, by looking at value added and employment shares in the total economy of the EU27, as well as in each individual member state. In Section 4, we study the international competitiveness of the EU27 ecosystem, with a detailed analysis of trade that relies on export share, revealed comparative advantage (RCA) and bilateral trade flows. This provides a first analysis of the EU27 international competitiveness in this ecosystem. Following that, we then look at international backward and forward linkages, the better to understand the relationships among the different players of the EU energy-renewables ecosystem in the global economy; these linkages hint at some overall dependencies concerning the inputs needed for production purposes in this ecosystem. Section 5 then provides an in-depth analysis of the sourcing structures and global sourcing patterns, with a focus on backward linkages that enable the system to produce its output. Finally, in Section 6 we delve deeper into the dependencies and vulnerabilities of the ecosystem, tapping into detailed trade data, which are combined with information from MC-IOTs. This allows us to provide a detailed assessment of vulnerabilities at the product level (import concentration by product and intra-EU trade as a proxy for internal production). Section 7 summarises the findings, provides suggestions for future analysis and discusses some policy implications.

2. Data

As currently defined, industrial ecosystems are composed of a number of industries, which at times cannot be measured with any great precision, due to the low level of granularity of official statistics (particularly National Accounts). This prompted the Commission to design a methodology to attribute data at the 2-digit level to the different ecosystems, based on various weights (see European Commission, 2021). According to this methodology, the 'energy-renewables' ecosystem consists of two main industries, plus a few smaller ones, as follows:

› 'Manufacture of electrical equipment' (C27), with a share of 38%

› 'Electricity, gas, steam and air conditioning supply' (D35), with a share of 29%

› further 'horizontal' industries with relatively small shares:

- 'Manufacture of fabricated metal products, except machinery and equipment' (C25; 1.56%)
- 'Manufacture of machinery and equipment n.e.c.' (C28; 1.60%)
- 'Repair and installation of machinery and equipment' (C33; 1.64%)
- 'Water collection, treatment and supply' (E36; 1.13%)
- 'Sewerage' (E37-E39; 1.43%)
- 'Legal and accounting activities' (M69_M70; 0.97%)
- 'Architectural and engineering activities; technical testing and analysis' (M71; 1.17%)
- 'Scientific research and development' (M72; 0.83%)
- 'Rental and leasing activities' (N77; 0.85%) and
- 'Employment activities' (N78; 0.85%).[1]

We adopt this methodology to construct 'ecosystem-level' indicators, whenever the data allow.

The analysis is based on Eurostat National Accounts data, which provide information on output, value added and employment in the countries and industries of interest. These data are mainly used to assess the relative importance of the energy-renewables ecosystem in EU member states and determine how it has developed over time.

As a second source of information, we draw on the most recent release of the FIGARO database – a multi-country input-output database provided by the Joint Research Centre (JRC) of the European Commission and Eurostat – which enables us to analyse global dynamics in the ecosystem. In doing so, we first look at global trade patterns and international performances based on indicators of revealed comparative advantage and then explore inter-industry and inter-country linkages of this ecosystem (e.g. backward and forward linkages). This analysis allows us to: i) identify the most important players in this

[1] For details, see European Commission (2021). N77 and N78 are considered as an aggregate in this publication (N77_N78).

ecosystem; ii) benchmark the performance of the EU27 vis-à-vis other global players; and iii) study recent trends at the global level.

Indeed, both the National Accounts data and the FIGARO data are available for all EU member states at the detailed NACE Rev. 2 64-industry level (see Appendix Table A.2).[2] In addition, FIGARO provides data on 18 non-EU27 countries and a category for 'rest of the world' (RoW) (see Appendix Table A.1). These data are available for the period 2010-2020. Our analysis focuses on the years following the great financial crisis of 2008-2009, starting in 2012. In the descriptive analysis in Section 3 (which relies on data from National Accounts) we provide a long-term assessment of the relevance of this ecosystem, and therefore consider a longer time period.

To be able to analyse the energy-renewables ecosystem, we propose a novel approach of combining multiple industries into an 'ecosystem-level' aggregate. To this end, we have constructed an additional 'industry' (i.e. the ERES) for each country in the MC-IOT, using the shares indicated above. Thus, the newly constructed ERES industry is a combination of industry C27 (of which 38% is allocated to ERES), D35 (of which 29% is allocated to ERES) and so on for the other horizontal industries that belong to ERES (with much smaller shares). In this way, an additional column (in the intermediate block of the MC-IOT) and row (in the intermediate and final goods matrix) are added. Of course, the parts allocated to ERES are subtracted from the respective industries, thereby ensuring that the whole system remains balanced.[3] This novel approach allows us to consider the energy-renewables ecosystem as a separate industry in the MC-IOT, and thus to calculate the various indicators usually applied in the literature.

Finally, these data are then combined with detailed trade data at the Harmonised System (HS) 6-digit level. This allows us to assess the import structures and dependencies of this 'industry' at a granular level.

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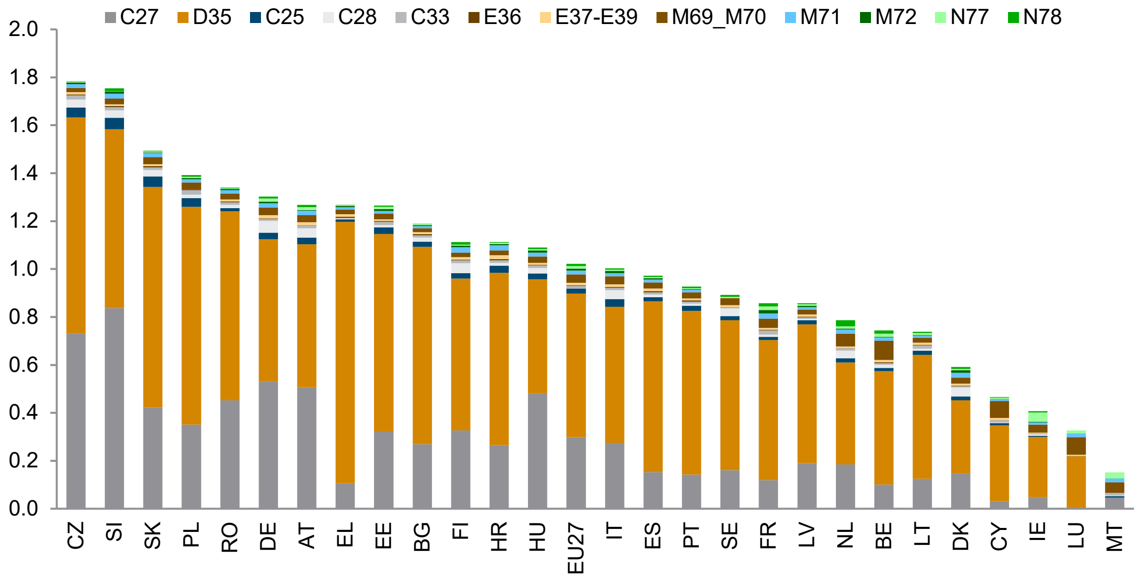
2 The FIGARO data are generally aligned with the National Accounts (NA); small differences between NA data and FIGARO data (Release 2020) may occur because of revisions.

3 This approach, however, serves only as a proxy for the relevance of the ecosystem in the input-output system; particularly, the intra-industry linkages might be underestimated, whereas the linkages to the original industries are relatively large.

3. The relative importance of the energy-renewables ecosystem in the EU27

We first assess the relative importance of this ecosystem in the EU economy in broad terms. When taking the exact definition of the ecosystem (i.e. when we consider the shares that the various industries contribute to the ecosystem and the role of the horizontal industries) one can present the relative importance of the whole ecosystem, as in Figure 3.1 for the year 2020. The value-added share of the ecosystem for the whole EU27 is slightly above 1%. Shares above the EU27 average are to be found in many new member states (particularly in Eastern Europe), as well as in Germany and Austria. Indeed, the share of the ERES ranges from 1.8% in Czechia and Slovenia to less than 0.5% in Cyprus and Ireland (Luxembourg and Malta are not considered, as they do not provide complete information). Furthermore, one can see that most of the value added of the ecosystem is produced by industry D35; the share of industry C27 is above average particularly in Czechia, Slovenia, Germany, Austria and Hungary – possibly reflecting those countries' specialisation in manufacturing activities.

Figure 3.1 / Share of the 'energy-renewables' ecosystem, 2020, in % of total value added



Note: Data for LU and MT are partly missing.
Source: Eurostat National Accounts; own calculations.

Table 3.1 reports data on employment shares for the ERES. Overall, about 0.6% of the total EU27 workforce is employed in the ERES, with the C27 portion of the ecosystem covering 0.27%. Also industry D35 contributes about this share of the employment of the ecosystem. Based on the data available, employment shares range from almost 1.2% in Czechia and Slovenia to around 0.3% in Spain and Ireland for example. In most EU member states, C27 employs more workers than D35. This is in contrast to the figures on value added, and points to the higher labour intensity of the manufacturing segments of the ecosystem.

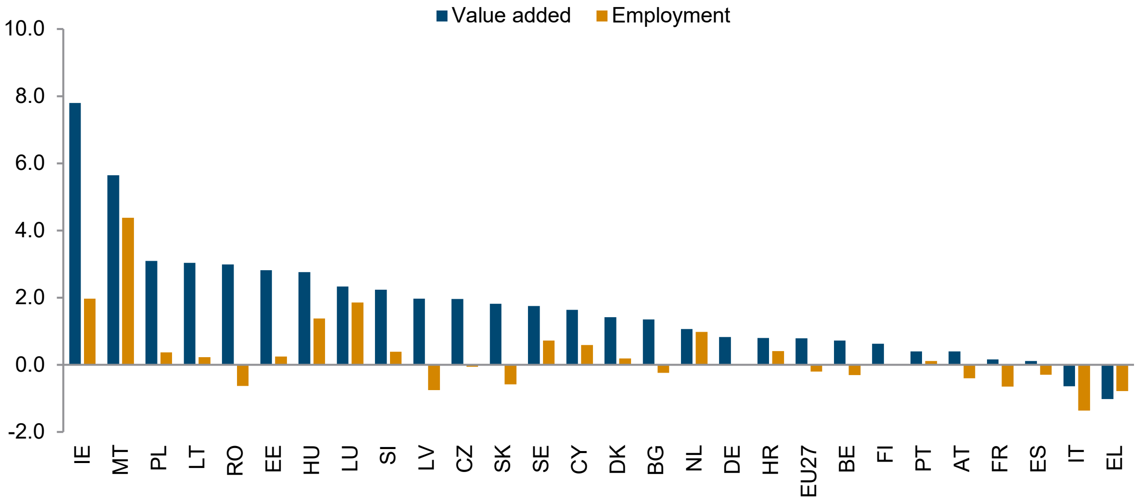
Table 3.1 / Employment shares in total economy, in %

	C27	D35	C25	C28	C33	E36	E37-E39	M69_M70	M71	M72	N77	N78	ERES
EU27	0.27	0.18	0.03	0.02	0.01	0.00	0.01	0.03	0.02	0.01	0.00	0.01	0.59
AT	0.40	0.18	0.03	0.03	0.01	0.00	0.01	0.04	0.02	0.00	0.00	0.02	0.74
BE	0.11	0.12		0.01						0.00			0.25
BG	0.32	0.27		0.02						0.00			0.62
CY	0.04	0.14	0.02	0.00	0.01	0.00	0.01	0.05	0.01	0.00	0.00	0.00	0.28
CZ	0.76	0.23	0.06	0.04	0.02	0.00	0.01	0.02	0.02	0.00	0.00	0.00	1.17
DE	0.43	0.20		0.04						0.00			0.68
DK	0.14	0.13	0.02	0.03	0.01	0.00	0.01	0.03	0.02	0.01	0.00	0.01	0.41
EE		0.25											0.25
EL	0.07	0.20	0.01	0.00	0.01	0.00	0.01	0.03	0.02	0.00	0.00	0.00	0.36
ES	0.14	0.06	0.02	0.01	0.01	0.00	0.01	0.03	0.02	0.00	0.00	0.01	0.32
FI	0.23	0.15	0.03	0.03	0.01	0.00	0.01	0.02	0.02	0.01	0.00	0.02	0.53
FR	0.11	0.14		0.01						0.02			0.28
HR	0.20	0.19	0.03	0.02	0.01	0.01	0.02	0.02	0.02	0.00	0.00	0.00	0.52
HU	0.44	0.20	0.03	0.02	0.01	0.00	0.01	0.03	0.02	0.01	0.00	0.01	0.79
IE	0.05	0.18	0.01	0.01	0.00	0.00	0.01	0.03	0.02	0.00	0.01	0.00	0.33
IT	0.24	0.11	0.04	0.03	0.01	0.00	0.01	0.04	0.02	0.00	0.00	0.01	0.51
LT	0.14	0.21		0.01						0.00			0.36
LU		0.11				0.00	0.01	0.07	0.02		0.00		0.22
LV		0.39											0.39
MT													0.00
NL	0.10	0.10	0.02	0.02	0.01	0.00	0.01	0.05	0.02	0.00	0.00	0.06	0.39
PL	0.32	0.31	0.03	0.01	0.02	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.73
PT	0.15	0.06	0.03	0.01	0.01	0.00	0.01	0.03	0.01	0.00	0.00	0.02	0.32
RO	0.40	0.33	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.81
SE	0.19	0.19	0.02	0.03	0.01	0.00	0.01	0.02	0.02		0.00	0.01	0.51
SI	0.74	0.25	0.05	0.03	0.02	0.01	0.01	0.03	0.02	0.01	0.00	0.02	1.18
SK	0.52	0.22	0.06	0.03	0.01	0.00	0.01	0.03	0.02	0.00	0.00	0.01	0.91

Source: Eurostat National Accounts; own calculations.

The growth rates for the whole ecosystem (ERES) are presented in Figure 3.2. For the EU27, value-added growth was 0.8% and employment growth was -0.2% over the period 2012-2020. Again, one can observe large differences across countries. In about half of the countries (e.g. Poland, Hungary and Slovenia, but also Ireland and Sweden), both value added and employment registered positive growth rates (albeit value-added growth was higher). In other cases, positive value-added growth was accompanied by a shrinking employment base (e.g. Romania, Slovakia, Austria and France). Italy and Greece are the only countries where both value added and employment decreased.

Figure 3.2 / Growth rates of ERES 2012-2020, in %



Source: Eurostat National Accounts; own calculations.

4. International (value-chain) competitiveness

This section looks at the status quo and recent dynamics in terms of global trade patterns and the competitiveness of global players in the energy-renewables ecosystem. It does so by considering export data from the FIGARO database and computing standard competitiveness measures.

4.1. THE STATUS QUO OF ERES: GLOBAL TRADE PATTERNS IN 2020

The dominant players in the global ERES are China (with about 30% of the global export share in 2020) and the EU27 (with about 22%) (see Figure 4.1). These figures are consistent with previous estimates (European Commission, 2021). Indeed, China has a near monopoly on mining and processing of the rare-earth elements needed for clean energy technologies. It also holds a strong market position in the manufacturing segments of the ecosystem, and particularly in the manufacture of photovoltaics and batteries; and its market share is growing in other technologies, such as wind energy and heat pumps (European Commission, 2020b, 2022a). The US has a share of below 10%; it is followed by Japan (with about 7%) and South Korea (with less than 5%). The market shares of all other countries are below 5%.

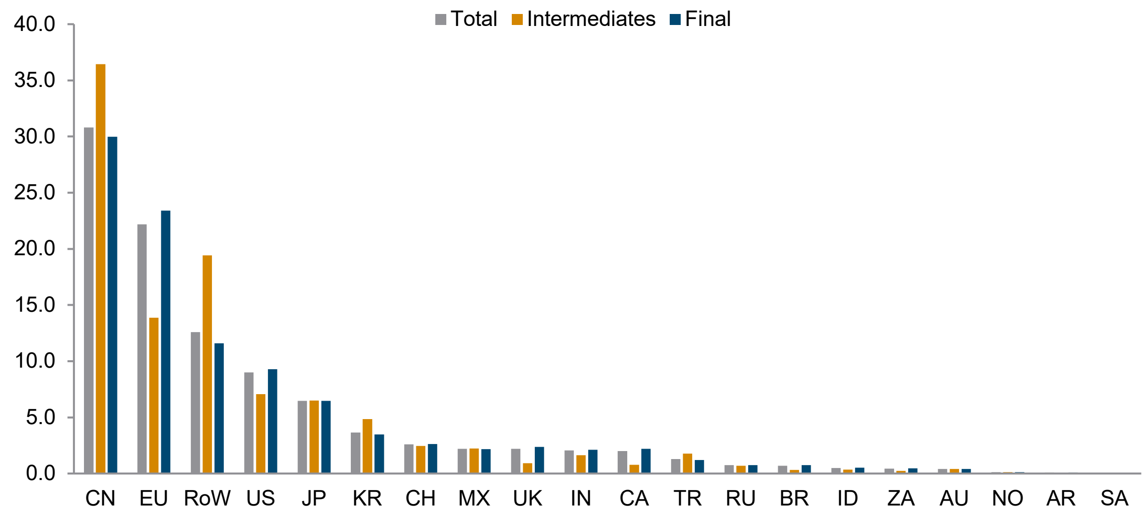
Thus, the market is dominated by just a few big players, which collectively account for about a quarter of global exports.[4] The relevance of Asia in this ecosystem is partly explained by the strong support that the governments of Japan, China and Korea have provided for investment in areas considered to be of strategic importance (e.g. batteries) (European Commission, 2020b).

The market shares are similar for most countries if we differentiate between intermediates and final goods. However, large differences can be seen for the EU, which has a global market share of 13% for intermediates, but 23% for final goods. A similar trend can be observed for other advanced economies, such as the US, the UK and Canada. This is in contrast to what can be observed in China and Korea, where exports of intermediates are higher than exports of final goods. A similar pattern is to be found in the RoW, which has a market share of 20% for intermediates and about 11% for final goods.

Despite these differences, export structures in this ecosystem are clearly dominated by final goods exports (Figure 4.2), with the share of final goods ranging from 80% in the RoW (and close to that figure in Turkey, Korea and China) to 95% in Canada. The share in the EU is about 88% – similar to the figure for the US or the UK.

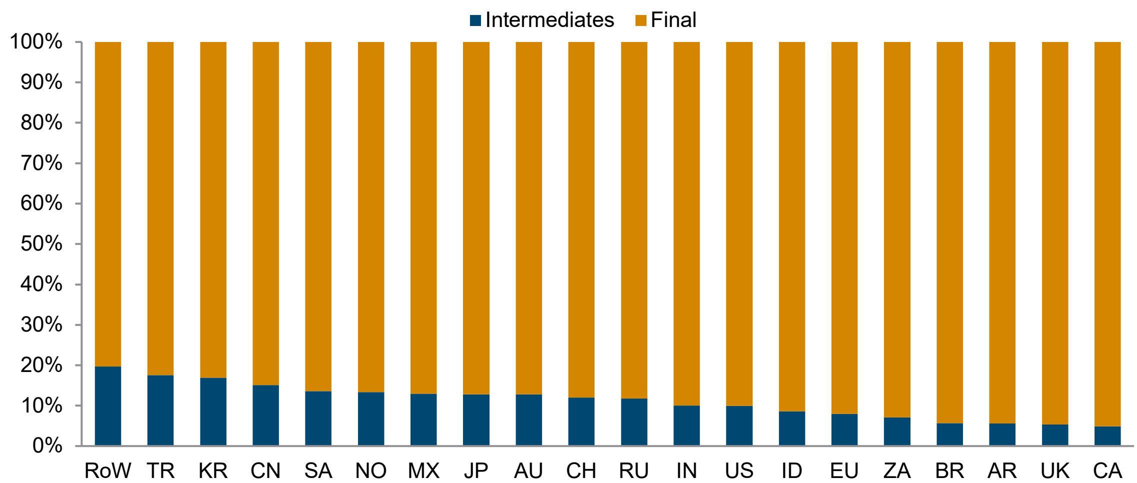
4 This includes the countries included in the category 'rest of the world' (RoW).

Figure 4.1 / World export market shares, in %, 2020



Note: excluding intra-EU trade.
Source: FIGARO; own calculations.

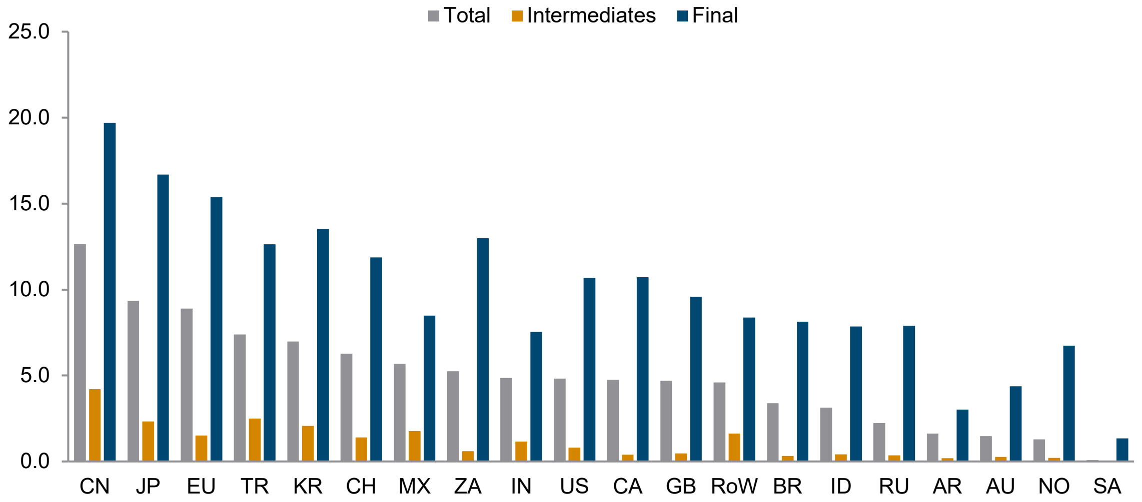
Figure 4.2 / Export structure by intermediates and final goods, in %, 2020



Note: excluding intra-EU trade.
Source: FIGARO; own calculations.

While the relevance of the ecosystem is not immediately evident from the value-added figures (for the EU27, see Section 3), this ecosystem does account for a significant share of the various countries' exports, as presented in Figure 4.3: it hovers at around 13% in China, 8-9% in Japan and the EU27, and around 7% in Turkey and Korea. In all countries, the share is higher for final goods exports than for intermediate exports. This means that for each country, the share of this ecosystem in final goods exports is much larger than in intermediate goods exports. For example, in China, the ecosystem's share of final goods exports in that country's total exports is about 20%. This is much higher than the share of intermediate goods (4%). The corresponding figures for the EU27 are 15% for the export of final goods and 3% for the export of intermediates.

Figure 4.3 / Share in total exports, in %, 2020



Source: FIGARO; own calculations.

4.2. AN ANALYSIS OF THE PATTERNS OF REVEALED COMPARATIVE ADVANTAGE IN EXPORTS

Using a country's export structures relative to the global export structures (or alternatively, a country's world market share for this ecosystem compared to the world market share in the country's overall exports) allows us to calculate the Balassa index of RCA. This is given by:

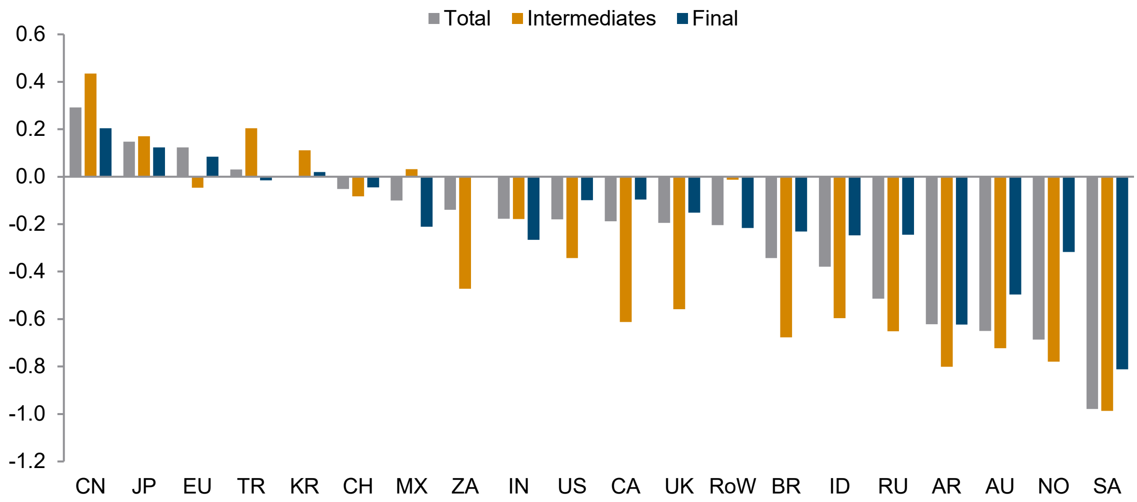
$$RCA_i^c = \frac{x_i^c / \sum_k x_k^c}{\sum_r x_i^r / \sum_{k,r} x_k^r} = \frac{x_i^c / \sum_r x_i^r}{\sum_k x_k^c / \sum_{k,r} x_k^r}$$

where i and c denote the industry (in our case, the ecosystem) and country under consideration, respectively. For presentational purposes, we present a normalised RCA, generally referred to as a symmetric RCA, given by:

$$SRCA_i^c = \frac{RCA_i^c - 1}{RCA_i^c + 1}$$

which lies in the interval [-1;1] and is symmetric around 0. A negative value indicates a revealed comparative disadvantage, while a positive one indicates a revealed comparative advantage. The results are presented in Figure 4.4. In line with the above finding, one can see that China, Japan and the EU enjoy a revealed comparative advantage in this ecosystem, while Turkey and Korea are on the cusp. Strong comparative disadvantages may be seen for Saudi Arabia, Norway, Australia and Argentina. Other global superpowers, such as the US and India, are also characterised by negative RCA. The differences in RCAs seem to be more pronounced for trade in intermediates than for final goods trade. A closer look at the EU reveals that its comparative advantage is in final goods, while for intermediate goods the value of the symmetric RCA is negative. In this respect, the EU is very different from China and Japan, but also from Turkey and Korea.

Figure 4.4 / Symmetric RCAs in ERES, in %, 2020



Note: excluding intra-EU trade.
Source: FIGARO; own calculations.

So far, we have analysed the global export structures in 2020, the last year for which data are available. We now present the changes in the global export structures between 2012 and 2020, i.e. from shortly after the global financial crisis to the beginning of the global pandemic (Table 4.1). Overall, there are only very small shifts in revealed comparative advantage over time. The most notable exceptions to this trend are for the US, Russia and Argentina, where mildly negative trends can be observed. By contrast, Canada experienced a relatively large increase in its RCA position. However, these shifts do not change the overall situation: China, Japan, EU27, Turkey and Korea are those countries that had a positive RCA in both 2012 and 2020 (though Korea came close to zero in 2020). With respect to global market share, one can observe a strong increase in China's position (+6.42pp), as well as some minor increases for other countries. The rise of China as an important player in this ecosystem is a well-documented phenomenon (e.g. European Commission, 2020b, 2022a). The US (-2.36pp), Japan (-1.63pp), and Korea (-0.93pp) are the countries that saw a big drop in market share; those three countries were followed by the EU27, with a loss in global market share of 0.68pp. Finally, one can see that most countries deepened their specialisation in goods of the energy-renewables ecosystem (i.e. for most countries the share of the ecosystem in their export basket increased). This shift was particularly strong for Canada (+1.7pp) and China (+1.35pp). The most notable exception to this trend was again the US (-0.48pp). The shift in the EU27 was rather modest, with an increase of only 0.11pp.

While imports will be discussed in more detail later in the paper, Table 4.2 presents the value of exports and imports and the net exports for the energy-renewables ecosystem.[5] China and the EU have the biggest trade surplus, followed by Japan and Korea. The US and the RoW face major trade deficits in the exports and imports of these industries. The bilateral trade flows are reported in Table 4.3 and the bilateral net exports in Table 4.4. The largest markets for the EU27 are the US (which absorbs 45% of EU net exports) and the RoW aggregate (with 25%).

[5] Here 'imports' are the imports by one country of output produced in the ERES industries of other countries, including intermediates and final goods. This should not be confused with the (intermediate) imports of ERES industries.

Table 4.1 / RCAs and export structures of ERES, 2012-2020

	2012			2020			Changes 2012-2020		
	Sym-metric RCA	Global market share	Share in total exports	SRCA	Global market share	Share in total exports	SRCA	Global market share	Share in total exports
CN	0.30	24.37	11.30	0.29	30.80	12.65	-0.01	6.42	1.35
JP	0.21	8.10	9.20	0.15	6.46	9.35	-0.06	-1.63	0.14
EU	0.18	22.87	8.78	0.12	22.19	8.89	-0.06	-0.68	0.11
TR	0.04	1.22	6.56	0.03	1.28	7.38	-0.01	0.06	0.82
KR	0.06	4.58	6.76	0.00	3.65	6.98	-0.05	-0.93	0.22
CH	-0.01	2.73	5.96	-0.05	2.59	6.27	-0.04	-0.14	0.30
MX	-0.06	2.07	5.33	-0.10	2.19	5.68	-0.04	0.12	0.35
ZA	-0.14	0.53	4.60	-0.14	0.43	5.24	0.00	-0.10	0.65
IN	-0.21	1.71	3.93	-0.18	2.06	4.85	0.04	0.35	0.92
US	-0.07	11.36	5.30	-0.18	9.01	4.82	-0.11	-2.36	-0.48
CA	-0.33	1.64	3.05	-0.19	2.01	4.75	0.14	0.37	1.70
UK	-0.23	2.05	3.81	-0.19	2.18	4.68	0.03	0.14	0.88
RoW	-0.22	13.05	3.89	-0.20	12.58	4.59	0.01	-0.47	0.70
BR	-0.30	0.90	3.24	-0.34	0.70	3.40	-0.04	-0.20	0.16
ID	-0.41	0.56	2.52	-0.38	0.50	3.12	0.03	-0.06	0.60
RU	-0.41	1.44	2.51	-0.51	0.75	2.23	-0.10	-0.69	-0.28
AR	-0.54	0.16	1.80	-0.62	0.09	1.62	-0.08	-0.08	-0.18
AU	-0.70	0.33	1.07	-0.65	0.41	1.47	0.05	0.09	0.40
NO	-0.64	0.24	1.35	-0.69	0.11	1.29	-0.05	-0.13	-0.06
SA	-0.93	0.08	0.21	-0.98	0.01	0.08	-0.05	-0.07	-0.13

Note: excluding intra-EU trade; ranked according to SRCA in 2020.
Source: FIGARO; own calculations.

Table 4.2 / Exports, imports and trade balance of ERES in EUR million, 2012-2020

	Exports	Imports	Net exports
CN	300,659	93,144	207,515
EU	216,618	79,591	137,027
JP	63,100	44,366	18,735
KR	35,633	21,839	13,794
GB	21,330	15,035	6,295
CH	25,308	19,562	5,746
ZA	4,192	3,143	1,049
IN	20,096	21,095	-999
NO	1,114	4,781	-3,668
AR	870	4,632	-3,763
CA	19,596	24,931	-5,336
TR	12,467	18,243	-5,776
BR	6,854	13,229	-6,375
ID	4,911	12,132	-7,221
AU	4,035	12,789	-8,754
MX	21,346	33,493	-12,147
SA	121	15,356	-15,236
RU	7,292	24,988	-17,696
RoW	122,802	261,695	-138,893
US	87,936	252,233	-164,297

Note: Ranked according to net exports.
Source: FIGARO; own calculations.

Table 4.3 / Bilateral trade flows of ERES in EUR million, 2012-2020

	EU	AR	AU	BR	CA	CH	CN	RoW	GB	ID	IN	JP	KR	MX	NO	RU	SA	TR	US	ZA
EU	0	739	2,775	1,123	3,887	11,831	27,693	54,180	3,197	1,530	4,119	4,820	1,973	5,661	2,693	9,722	3,851	4,849	71,086	889
AR	43	0	6	4	7	16	7	268	4	4	11	14	6	27	1	3	8	4	435	2
AU	138	3	0	14	50	25	359	1,426	68	79	68	111	78	38	6	18	55	55	1,433	12
BR	323	17	40	0	106	96	154	1,510	41	26	55	74	43	348	22	44	63	10	3,854	27
CA	47	22	112	42	0	129	342	1,171	182	36	96	177	92	638	22	89	149	67	16,170	12
CH	7,118	27	148	51	277	0	2,731	3,542	316	151	311	601	105	442	122	389	230	221	8,488	38
CN	25,004	1,197	5,013	4,919	6,093	1,704	0	126,287	4,749	5,274	7,724	20,639	9,450	10,722	719	8,707	4,925	8,404	48,095	1,035
RoW	19,385	1,000	1,608	4,796	1,267	1,734	19,349	0	2,113	2,770	4,748	9,345	5,033	1,887	431	2,725	2,366	2,351	39,299	594
UK	2,423	17	201	61	232	572	660	3,002	0	72	331	388	230	112	148	161	510	218	11,947	45
ID	267	6	66	15	40	38	386	2,100	17	0	90	518	44	76	3	35	44	25	1,130	10
IN	167	34	202	64	223	164	1,332	6,730	212	276	0	305	142	527	31	466	581	291	8,219	128
JP	2,118	41	480	102	868	310	19,998	14,496	591	991	895	0	1,472	1,788	59	479	276	352	17,703	81
KR	4,063	2	210	4	364	58	9,786	9,043	166	271	628	1,706	0	869	71	583	357	8	7,423	22
MX	873	43	90	344	1,243	21	1,435	2,230	75	40	32	217	70	0	9	59	107	45	14,385	27
NO	364	2	6	16	15	19	68	204	32	8	8	24	15	4	0	24	14	20	270	2
RU	961	5	5	13	25	78	233	4,504	61	27	179	61	40	6	25	0	26	175	867	2
SA	10	0	0	0	1	0	3	87	-4	1	1	1	1	1	-1	0	0	2	17	0
TR	5,817	0	42	1	71	79	285	3,527	812	29	97	27	2	93	51	442	222	0	837	31
US	9,901	1,444	1,722	1,641	10,147	2,681	8,298	24,725	2,357	538	1,676	5,314	3,033	10,222	367	1,017	1,551	1,119	0	184
ZA	568	31	63	19	16	10	24	2,662	47	7	27	26	9	31	2	22	23	27	576	0

Source: FIGARO; own calculations.

Table 4.4 / Bilateral net trade flows in ERES in EUR million, 2012-2020

	EU	AR	AU	BR	CA	CH	CN	RoW	GB	ID	IN	JP	KR	MX	NO	RU	SA	TR	US	ZA	Net exports
EU	0	696	2,638	800	3,839	4,712	2,689	34,795	774	1,262	3,951	2,701	-2,089	4,788	2,330	8,761	3,840	-968	61,186	321	137,027
AR	-696	0	3	-14	-16	-11	-1,191	-731	-13	-2	-24	-28	5	-16	0	-1	8	4	-1,009	-30	-3,763
AU	-2,638	-3	0	-26	-62	-123	-4,654	-182	-134	13	-134	-369	-132	-52	0	14	55	13	-289	-51	-8,754
BR	-800	14	26	0	64	45	-4,765	-3,286	-20	11	-10	-28	39	4	6	31	63	10	2,214	8	-6,375
CA	-3,839	16	62	-64	0	-148	-5,750	-96	-50	-4	-127	-691	-272	-606	7	64	148	-4	6,023	-4	-5,336
CH	-4,712	11	123	-45	148	0	1,027	1,808	-256	112	147	292	47	422	103	311	230	142	5,807	29	5,746
CN	-2,689	1,191	4,654	4,765	5,750	-1,027	0	106,938	4,089	4,888	6,391	641	-336	9,287	650	8,475	4,921	8,118	39,797	1,011	207,515
RoW	-34,795	731	182	3,286	96	-1,808	-106,938	0	-889	671	-1,981	-5,151	-4,010	-342	226	-1,780	2,279	-1,176	14,574	-2,068	-138,893
UK	-774	13	134	20	50	256	-4,089	889	0	55	119	-203	64	37	116	99	515	-594	9,590	-2	6,295
ID	-1,262	2	-13	-11	4	-112	-4,888	-671	-55	0	-186	-474	-227	36	-5	9	43	-4	592	3	-7,221
IN	-3,951	24	134	10	127	-147	-6,391	1,981	-119	186	0	-590	-486	495	23	288	580	194	6,543	101	-999
JP	-2,701	28	369	28	691	-292	-641	5,151	203	474	590	0	-234	1,571	35	418	275	325	12,390	55	18,735
KR	2,089	-5	132	-39	272	-47	336	4,010	-64	227	486	234	0	799	56	543	356	6	4,389	13	13,794
MX	-4,788	16	52	-4	606	-422	-9,287	342	-37	-36	-495	-1,571	-799	0	5	53	106	-49	4,163	-4	-12,147
NO	-2,330	0	0	-6	-7	-103	-650	-226	-116	5	-23	-35	-56	-5	0	-1	15	-31	-97	-1	-3,668
RU	-8,761	1	-14	-31	-64	-311	-8,475	1,780	-99	-9	-288	-418	-543	-53	1	0	26	-267	-150	-20	-17,696
SA	-3,840	-8	-55	-63	-148	-230	-4,921	-2,279	-515	-43	-580	-275	-356	-106	-15	-26	0	-220	-1,535	-23	-15,236
TR	968	-4	-13	-10	4	-142	-8,118	1,176	594	4	-194	-325	-6	49	31	267	220	0	-282	4	-5,776
US	-61,186	1,009	289	-2,214	-6,023	-5,807	-39,797	-14,574	-9,590	-592	-6,543	-12,390	-4,389	-4,163	97	150	1,535	282	0	-392	-164,297
ZA	-321	30	51	-8	4	-29	-1,011	2,068	2	-3	-101	-55	-13	4	1	20	23	-4	392	0	1,049

Source: FIGARO; own calculations.

4.3. DOMESTIC AND INTERNATIONAL BACKWARD AND FORWARD LINKAGES

Of course, these imports and exports are made at the industry (or product) level. Specifically, the EU energy-renewables ecosystem depends on imports of particular products from partner countries and sends output to other industries within the EU and elsewhere. These flows can be traced from the multi-country input-output tables. One could either look at the direct inputs (by product and country) or take into account indirect linkages. The latter requires calculation of the global Leontief inverse, i.e.

$\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ with $\mathbf{A} = \hat{\mathbf{x}}^{-1}\mathbf{Z}$

where $\hat{\mathbf{x}}$ denotes the diagonalised gross output vector and $\mathbf{Z}$ the transactions matrix. Matrix $\mathbf{A}$ consequently shows the intermediate inputs per unit of gross output, from which the Leontief inverse can be calculated. From the Leontief inverse, the column sum of a specific industry is the gross output multiplier of that industry, i.e. it shows how much gross output will increase along the value chain if final demand for that industry increases by one unit (e.g. EUR 1m). Results are reported in Table 4.5. For the EU this indicates, first, that an increase of EUR 1m of final demand in the EU ERES in 2020 boosts gross output in the EU by about EUR 1.1m and in all other countries by EUR 0.014m. These numbers are in line with what we observe for other countries – both developed and emerging. Second, these results indicate that the share of the foreign multiplier is fairly small (in the EU it is 1.3% of the overall multiplier).[6] Third, the last two columns show that the changes between 2012 and 2020 were quite small, indicating that there was no strong trend for these interdependencies to change substantially from the post-financial crisis period up to the pandemic.

Table 4.5 / Domestic and foreign backward linkages of the ERES, 2012 and 2020

	2012		2020		Change	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
EU	1.093	0.013	1.090	0.014	-0.004	0.001
AR	1.043	0.020	1.038	0.015	-0.004	-0.005
AU	1.085	0.013	1.053	0.014	-0.032	0.000
BR	1.099	0.020	1.116	0.033	0.016	0.012
CA	1.014	0.016	1.011	0.020	-0.003	0.003
CH	1.119	0.037	1.108	0.026	-0.011	-0.011
CN	1.100	0.013	1.108	0.009	0.008	-0.003
RoW	1.157	0.014	1.116	0.018	-0.041	0.004
UK	1.209	0.011	1.243	0.008	0.034	-0.003
ID	1.020	0.020	1.022	0.015	0.002	-0.005
IN	1.044	0.016	1.059	0.012	0.015	-0.005
JP	1.064	0.016	1.063	0.013	-0.001	-0.003
KR	1.075	0.040	1.076	0.026	0.000	-0.014
MX	1.018	0.049	1.010	0.070	-0.008	0.021
NO	1.014	0.009	1.013	0.014	-0.002	0.005
RU	1.135	0.011	1.145	0.012	0.010	0.000
SA	1.013	0.013	1.004	0.008	-0.008	-0.005
TR	1.147	0.031	1.153	0.018	0.006	-0.013
US	1.014	0.005	1.012	0.002	-0.002	-0.004
ZA	1.017	0.020	1.020	0.026	0.003	0.005

Source: FIGARO; own calculations.

6 This includes the initial effect, however. If we only consider the indirect effects, the share of the foreign multiplier is about 12% for the EU.

Table 4.6 / Bilateral backward linkages of the ERES, 2020 and 2012

2020	EU	AR	AU	BR	CA	CH	CN	RoW	GB	ID	IN	JP	KR	MX	NO	RU	SA	TR	US	ZA
EU		0.002	0.002	0.001	0.002	0.012	0.002	0.003	0.003	0.001	0.001	0.001	0.001	0.008	0.006	0.003	0.001	0.003	0.000	0.005
AR	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AU	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BR	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CA	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CH	0.001	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CN	0.005	0.005	0.007	0.010	0.008	0.003		0.010	0.002	0.008	0.003	0.006	0.016	0.034	0.004	0.005	0.002	0.006	0.001	0.011
RoW	0.003	0.006	0.002	0.018	0.002	0.007	0.003		0.001	0.004	0.005	0.003	0.005	0.005	0.001	0.002	0.003	0.006	0.000	0.006
UK	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ID	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001
JP	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.000		0.001	0.004	0.000	0.000	0.000	0.000	0.000	0.000
KR	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.001		0.002	0.000	0.000	0.000	0.000	0.000	0.000
MX	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000
NO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
RU	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.001	0.000	0.000
SA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
TR	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
US	0.001	0.001	0.001	0.002	0.005	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.013	0.001	0.000	0.000	0.001		0.001
ZA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Contd.

Table 4.6 / Continued

2012	EU	AR	AU	BR	CA	CH	CN	RoW	GB	ID	IN	JP	KR	MX	NO	RU	SA	TR	US	ZA
EU		0.003	0.002	0.003	0.002	0.021	0.002	0.003	0.004	0.002	0.002	0.001	0.004	0.006	0.004	0.004	0.002	0.005	0.001	0.004
AR	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AU	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BR	0.000	0.003	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CA	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CH	0.002	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CN	0.004	0.005	0.005	0.004	0.005	0.003		0.006	0.002	0.006	0.002	0.006	0.020	0.017	0.001	0.003	0.002	0.003	0.002	0.006
RoW	0.003	0.006	0.003	0.011	0.002	0.008	0.005		0.002	0.008	0.008	0.005	0.008	0.005	0.001	0.003	0.006	0.019	0.001	0.007
UK	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ID	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
JP	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.001	0.000	0.002	0.000		0.004	0.003	0.000	0.000	0.000	0.000	0.000	0.001
KR	0.000	0.000	0.001	0.001	0.000	0.000	0.002	0.001	0.000	0.001	0.001	0.001		0.003	0.000	0.000	0.001	0.001	0.000	0.001
MX	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.001	0.000
NO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
RU	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000		0.000	0.001	0.000	0.000
SA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
TR	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
US	0.001	0.001	0.001	0.001	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.013	0.000	0.000	0.000	0.000		0.001
ZA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Source: FIGARO; own calculations.

Table 4.6 shows the bilateral backward foreign linkages by country. For the EU, the data show that dependencies are strongest in the case of China (with a slight increase from 2012) and the RoW. When we compare EU dependency with that of other important players, we notice that dependency on China is more pronounced for Japan and even more so for Korea (although for the latter it has declined over time).

Similarly, forward linkages can be calculated to understand how much of the EU inputs are used in other countries' production activities. Formally, these are calculated as:

$\mathbf{G} = (\mathbf{I} - \mathbf{B})^{-1}$ with $\mathbf{B} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$

where $\mathbf{G}$ denotes the Ghosh inverse. As one can see from Table 4.7, the magnitudes are similar to those of the backward linkages, with slightly lower magnitudes for foreign forward linkages.[7] As observed for backward linkages, no clear tendencies can be identified by comparing 2012 to 2020.

Table 4.7 / Domestic and foreign forward linkages of the ERES, 2012 and 2020

	2012		2020		Change	
	Domestic	**Foreign**	**Domestic**	**Foreign**	**Domestic**	**Foreign**
EU	1.093	0.011	1.090	0.011	-0.004	0.000
AR	1.043	0.005	1.038	0.003	-0.004	-0.002
AU	1.085	0.014	1.053	0.020	-0.032	0.006
BR	1.099	0.005	1.116	0.006	0.016	0.001
CA	1.014	0.011	1.011	0.009	-0.003	-0.002
CH	1.119	0.051	1.108	0.034	-0.011	-0.017
CN	1.100	0.014	1.108	0.011	0.008	-0.003
RoW	1.157	0.021	1.116	0.018	-0.041	-0.002
UK	1.209	0.006	1.243	0.005	0.034	-0.001
ID	1.020	0.016	1.022	0.012	0.002	-0.004
IN	1.044	0.008	1.059	0.007	0.015	-0.001
JP	1.064	0.012	1.063	0.013	-0.001	0.001
KR	1.075	0.030	1.076	0.026	0.000	-0.004
MX	1.018	0.016	1.010	0.022	-0.008	0.005
NO	1.014	0.018	1.013	0.014	-0.002	-0.004
RU	1.135	0.018	1.145	0.016	0.010	-0.002
SA	1.013	0.005	1.004	0.001	-0.008	-0.004
TR	1.147	0.019	1.153	0.019	0.006	0.000
US	1.014	0.008	1.012	0.007	-0.002	-0.001
ZA	1.017	0.022	1.020	0.023	0.003	0.000

Source: FIGARO; own calculations.

Table 4.8 then shows the bilateral forward linkages. Looking at the row for the EU (in bold), it becomes clear that again China and the RoW are the most important users of EU inputs in the ERES.

[7] The domestic forward and backward linkages are identical by definition.

Table 4.8 / Bilateral forward linkages of ERES, 2020 and 2012

2020	EU	AR	AU	BR	CA	CH	CN	RoW	GB	ID	IN	JP	KR	MX	NO	RU	SA	TR	US	ZA
EU		0.000	0.000	0.000	0.000	0.001	0.004	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR	0.001		0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AU	0.001	0.000		0.000	0.000	0.000	0.011	0.003	0.000	0.000	0.001	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BR	0.001	0.000	0.000		0.000	0.000	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CA	0.001	0.000	0.000	0.000		0.000	0.003	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000
CH	0.018	0.000	0.000	0.000	0.000		0.008	0.004	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
CN	0.002	0.000	0.000	0.000	0.000	0.000		0.004	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
RoW	0.004	0.000	0.000	0.001	0.000	0.000	0.008		0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UK	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.001		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ID	0.001	0.000	0.000	0.000	0.000	0.000	0.005	0.003	0.000		0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN	0.001	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
JP	0.001	0.000	0.000	0.000	0.000	0.000	0.008	0.002	0.000	0.000	0.000		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
KR	0.005	0.000	0.000	0.000	0.000	0.000	0.014	0.004	0.000	0.000	0.000	0.001		0.001	0.000	0.000	0.000	0.000	0.000	0.000
MX	0.003	0.000	0.000	0.001	0.001	0.000	0.009	0.004	0.000	0.000	0.000	0.001	0.000		0.000	0.000	0.000	0.000	0.002	0.000
NO	0.006	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.001	0.000	0.000
RU	0.004	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.000	0.000	0.000	0.001	0.000	0.000	0.000		0.000	0.001	0.000	0.000
SA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
TR	0.011	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
US	0.001	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000		0.000
ZA	0.002	0.000	0.000	0.000	0.000	0.000	0.006	0.011	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Contd.

Table 4.8 / Continued

2012	EU	AR	AU	BR	CA	CH	CN	RoW	GB	ID	IN	JP	KR	MX	NO	RU	SA	TR	US	ZA
EU		0.000	0.000	0.000	0.000	0.001	0.003	0.003	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000
AR	0.001		0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AU	0.001	0.000		0.000	0.000	0.000	0.006	0.002	0.000	0.000	0.001	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BR	0.001	0.001	0.000		0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CA	0.001	0.000	0.000	0.000		0.000	0.002	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.003	0.000
CH	0.032	0.000	0.000	0.000	0.000		0.007	0.005	0.001	0.000	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.000
CN	0.003	0.000	0.000	0.000	0.000	0.000		0.004	0.000	0.000	0.000	0.002	0.002	0.001	0.000	0.000	0.000	0.000	0.001	0.000
RoW	0.004	0.000	0.000	0.001	0.000	0.001	0.007		0.000	0.000	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000
UK	0.003	0.000	0.000	0.000	0.000	0.000	0.001	0.001		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ID	0.001	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.000		0.000	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
IN	0.001	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
JP	0.001	0.000	0.000	0.000	0.000	0.000	0.006	0.002	0.000	0.000	0.000		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
KR	0.003	0.000	0.000	0.000	0.000	0.000	0.015	0.005	0.000	0.000	0.000	0.003		0.001	0.000	0.000	0.000	0.000	0.001	0.000
MX	0.002	0.000	0.000	0.000	0.001	0.000	0.003	0.002	0.000	0.000	0.000	0.001	0.001		0.000	0.000	0.000	0.000	0.005	0.000
NO	0.009	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.003	0.000	0.000	0.000	0.001	0.000		0.000	0.000	0.000	0.000	0.000
RU	0.006	0.000	0.000	0.000	0.000	0.000	0.004	0.005	0.000	0.000	0.000	0.001	0.001	0.000	0.000		0.000	0.001	0.000	0.000
SA	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000
TR	0.008	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000		0.000	0.000
US	0.001	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000		0.000
ZA	0.002	0.000	0.000	0.000	0.000	0.000	0.006	0.010	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	

Source: FIGARO; own calculations.

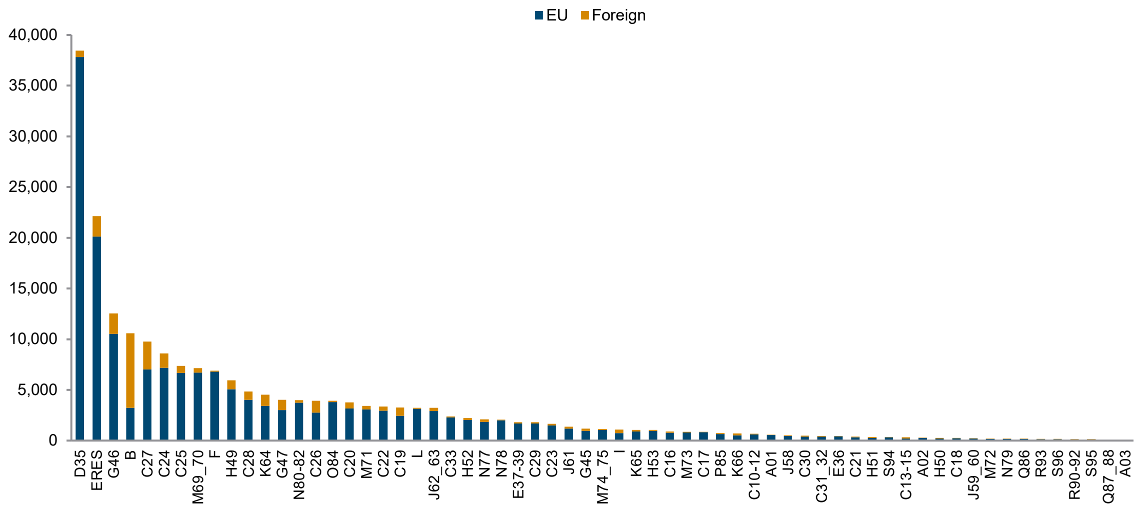
5. Sourcing structures of the EU energy-renewables ecosystem

Let us now consider in more detail the sourcing structure of the EU energy-renewables ecosystem. Specifically, we look at the ERES (as constructed in the FIGARO MC-IOT) as the using industry sourcing from industries i in countries c (including intra-EU sourcing), i.e. considering the upstream industries. Therefore, this analysis aims at understanding how much the EU ERES is sourcing products from, for example, the industry 'Manufacture of computer, electronic and optical products' (C26) in China. In doing so, it offers a snapshot of the dependencies of the EU ecosystem.

5.1. SOURCING STRUCTURES AND OVERALL DEPENDENCIES

Figure 5.1 shows the sourcing of the energy-renewables ecosystem by industry in million euro, split into intra-EU and extra-EU values. By far the most important industry from which the ecosystem sources its intermediate inputs is 'Electricity, gas, steam and air conditioning supply' (D35), followed by the ecosystem itself (intra-industry) and 'Wholesale trade, except of motor vehicles and motorcycles' (G46) and 'Mining of coal and lignite' (B). There then follow a couple of high- and medium-tech manufacturing industries: 'Manufacture of electrical equipment' (C27), 'Manufacture of fabricated metal products, except machinery and equipment' (C25) and 'Manufacture of basic metals' (C24). The magnitude of foreign sourcing is generally small, with the exception of intermediate inputs from the industry 'Mining of coal and lignite' (B).

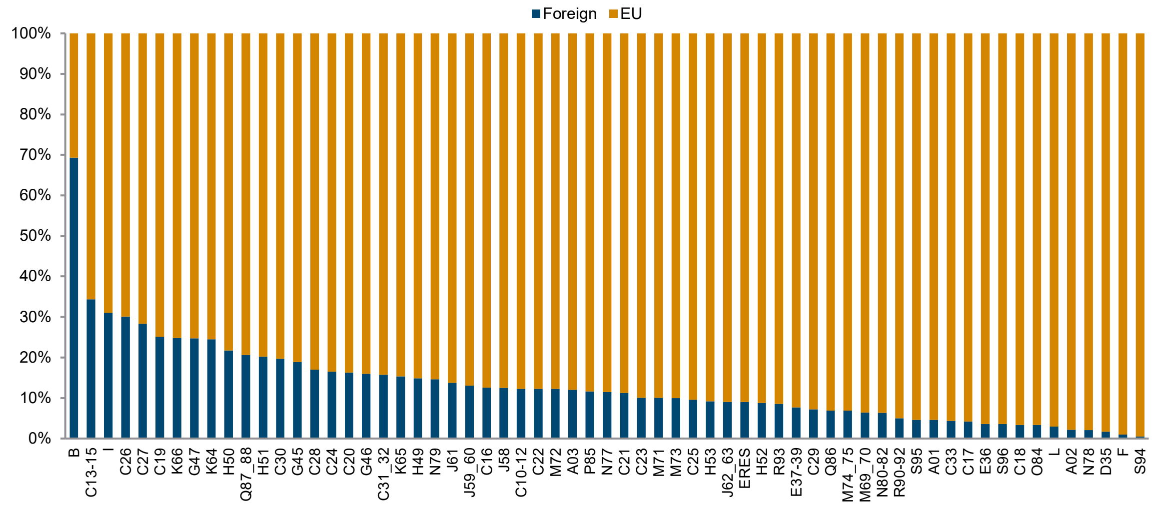
Figure 5.1 / EU ERES sourcing in EUR million, 2020



Source: FIGARO; own calculations.

The shares of foreign sourcing from upstream industries are presented in Figure 5.2. Disregarding the tiny industries (as identified in Figure 5.1), the share of foreign sourcing is high for the industry ‘Mining of coal and lignite’ (B) (about 70%) and medium-high for ‘Manufacture of computer, electronic and optical products’ (C26), ‘Manufacture of electrical equipment’ (C27) and ‘Manufacture of coke and refined petroleum products’ (C19) (at around 30%). A large range of industries source between 10% and 30% abroad. The share of intra-industry sourcing of ERES from non-EU countries is about 15%.

Figure 5.2 / Share of intra-EU and foreign sourcing, in %, 2020

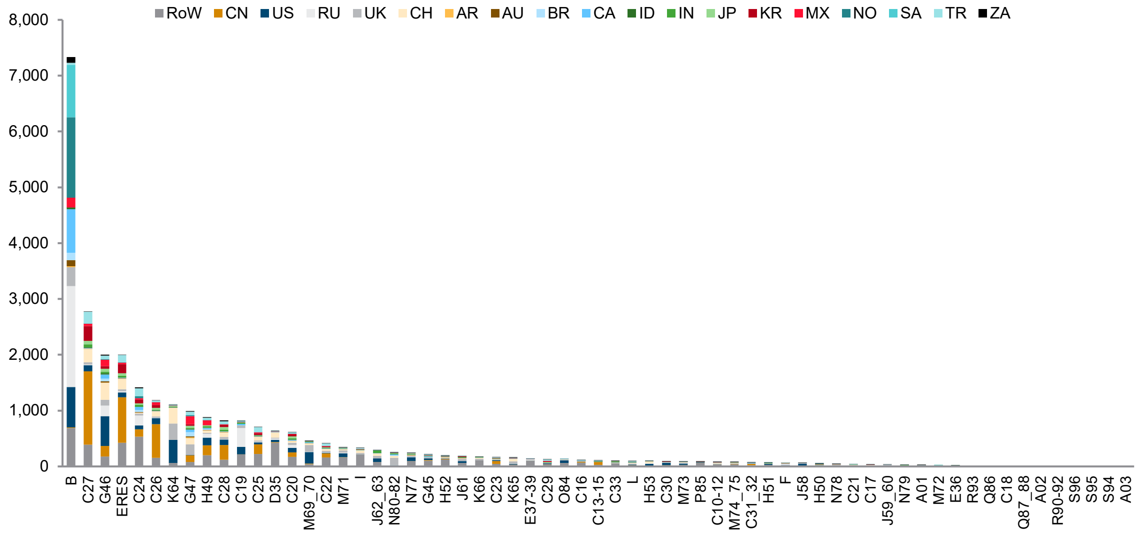


Source: FIGARO; own calculations.

These inputs from the various industries are sourced from the individual partner countries. Figure 5.3 presents the magnitude of total foreign sourcing (in million euro) and Figure 5.4 its share – both by industry. Looking at the industry with the largest amount of foreign sourcing (‘Mining of coal and lignite’ (B)), the EU’s sourcing is dominated by Russia, the US, Norway and Saudi Arabia.[8] Sourcing from the industry ‘Manufacture of electrical equipment’ (C27) is dominated by China (with almost 50%), Switzerland and Korea. A similar sourcing structure characterises another strategic industry – ‘Manufacture of computer, electronic and optical products’ (C26). Intra-industry sourcing of ERES is dominated by China and the RoW, accounting for about two thirds of all partner countries. Generally, the shares across all industries seem to be dominated by the RoW, China and US, while some other countries are also important in specific industries. This confirms the role of China in the global arena, as well as the importance of the US as a trading partner for the EU.

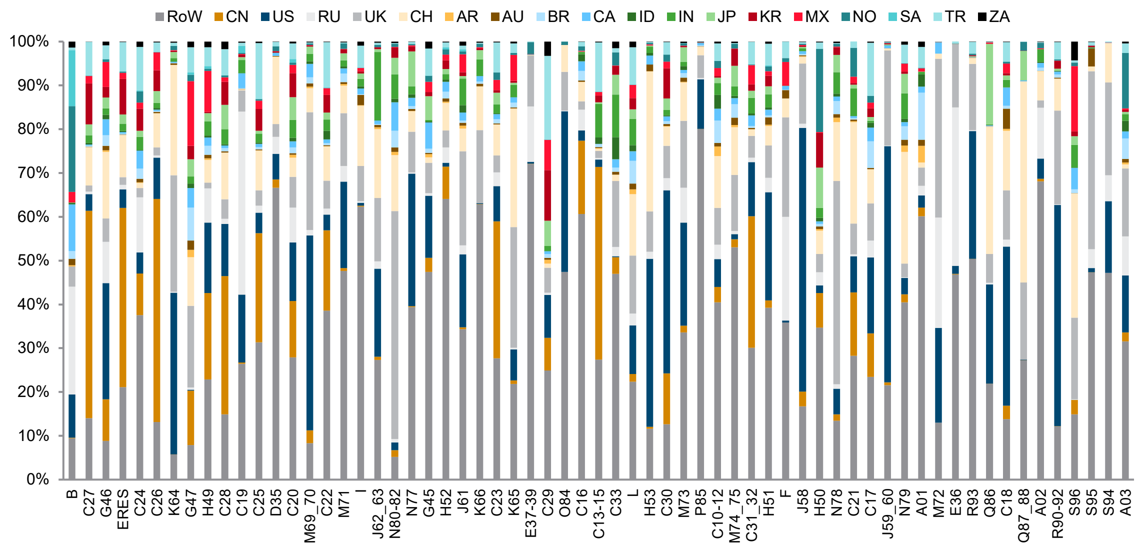
[8] Note that the data are from 2020; thus, Russia’s share has likely declined in more recent times.

Figure 5.3 / Foreign sourcing in EUR million, 2020



Source: FIGARO; own calculations.

Figure 5.4 / Shares of foreign sourcing by partner, in %, 2020



Source: FIGARO; own calculations.

5.2. STRUCTURAL DEPENDENCIES THROUGH THE LENS OF RCAS ALONG THE EU ERES GLOBAL VALUE CHAIN

In this section we analyse the RCAs in the ERES global value chain (GVC). Formally, we start with the sourcing of the EU ERES ecosystem by partner and industry (product), including sourcing from within the EU.[9] This corresponds to the respective showing the use of intermediates of the EU ERES industry. Using this information, we calculate a Balassa RCA measure for this GVC, given by

$$\mathrm{GVC}_{\mathrm{ERES}}^{\mathrm{EU}} - \mathrm{RCA}_{\mathrm{i}}^{\mathrm{c}} = \frac{x_i^c / \sum_k x_k^c}{\sum_r x_i^r / \sum_{k,r} x_k^r} = \frac{x_i^c / \sum_r x_i^r}{\sum_k x_k^c / \sum_{k,r} x_k^r}$$

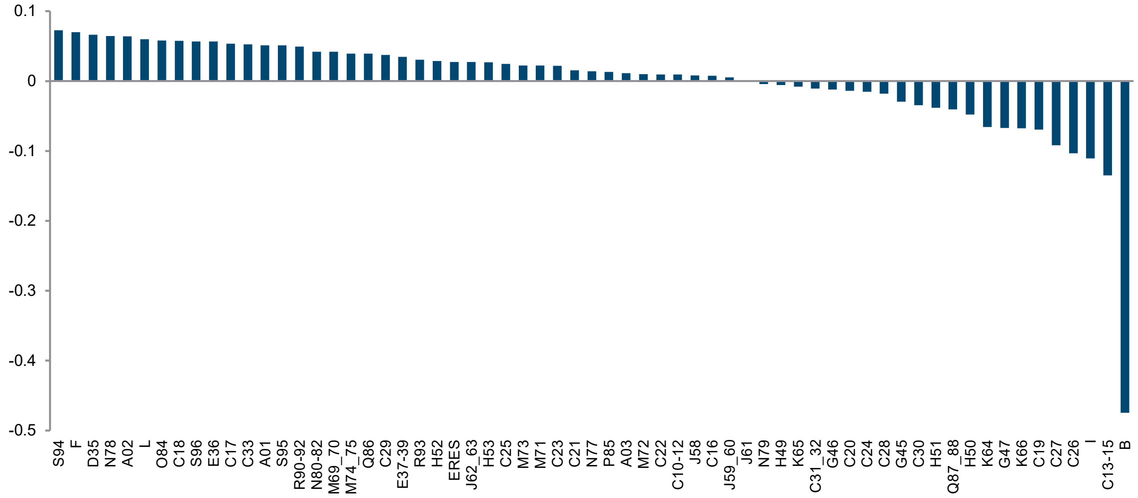
Here, x_i^c denotes the use by the EU ERES GVC of an intermediate input imported from country c and industry i. The numerator in the first term expresses these imports as a share of all imports from country c. The denominator shows the imports of industry i from all countries, relative to the total use of intermediate inputs in the EU ERES GVC. The second term shows the market share of country c in the sourcing of industry i, whereas the denominator indicates the share of country c in the overall sourcing by the EU ERES GVC. Note that in these calculations we also account for intra-EU sourcing. Accordingly, in Figure 5.5, we show the industry-specific RCA of the EU in its energy-renewables ecosystem, i.e.

$$\mathrm{GVC}_{\mathrm{ERES}}^{\mathrm{EU}} - \mathrm{RCA}_{\mathrm{i}}^{\mathrm{EU}} = \frac{x_i^{EU} / \sum_k x_k^{EU}}{\sum_r x_i^r / \sum_{k,r} x_k^r} = \frac{x_i^{EU} / \sum_r x_i^r}{\sum_k x_k^{EU} / \sum_{k,r} x_k^r}$$

The EU itself has small RCAs in a large range of industries, and relatively small comparative disadvantages in a couple of industries. The strongest disadvantages (not considering services inputs) in the EU ERES GVC are to be found in B ('Mining of coal and lignite') and C13-C15 ('Manufacture of textiles'), followed by C26 ('Manufacture of computer, electronic and optical products'), C27 ('Manufacture of electrical equipment') and C19 ('Manufacture of coke and refined petroleum products'). As indicated in Figure 5.5, imports of industry B products are large (about EUR 7bn), whereas imports from C13-C15 are relatively small in absolute values. Nonetheless, these revealed comparative disadvantages indicate that the EU ERES GVC has some structural dependencies on products not available from EU markets. As the list shows, such dependencies are related not just to natural resources or low-tech products, but also to strategic high- and medium-high-tech sectors, which are also key to the digital and green transition (twin transition).

9 In standard RCA calculations, intra-country trade is not included.

Figure 5.5 / EU RCA in EU ERES GVC, 2020



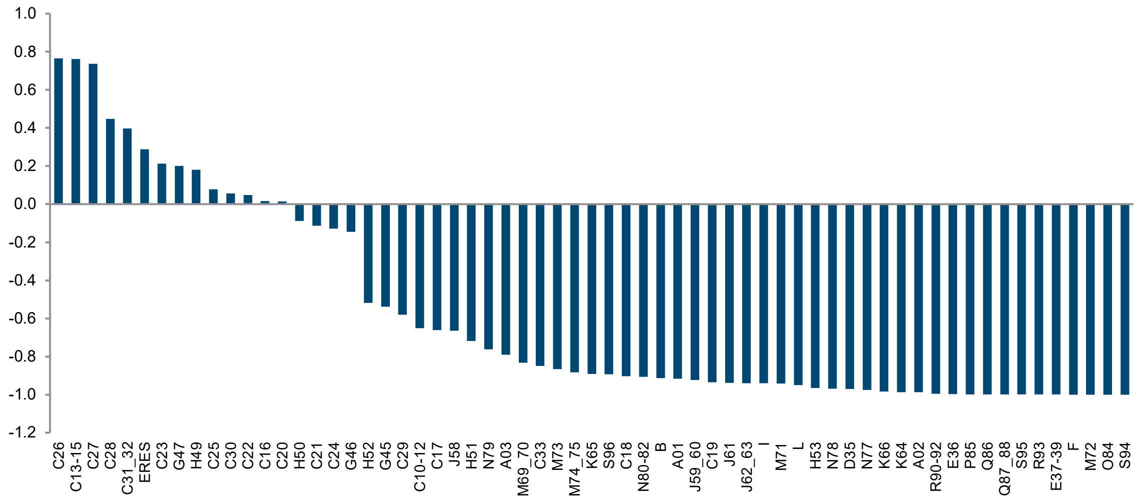
Source: FIGARO; own calculations.

An analogous calculation can be made, for example, with respect to imports from China, i.e.:

$$GVC_{ERES}^{EU} - RCA_i^{CN} = \frac{x_i^{CN} / \sum_k x_k^{CN}}{\sum_r x_i^r / \sum_{k,r} x_k^r} = \frac{x_i^{CN} / \sum_r x_i^r}{\sum_k x_k^{CN} / \sum_{k,r} x_k^r}$$

The results are presented in Figure 5.6. China has a strong RCA in the EU ERES GVC in industries C26 ('Manufacture of computer, electronic and optical products'), C13-C15 ('Manufacture of textiles') and C27 ('Manufacture of electrical equipment'). Relatively strong Chinese comparative advantage also exists for some additional industries, which indicates a structural dependence on China.

Figure 5.6 / CN RCA in EU ERES GVC, 2020



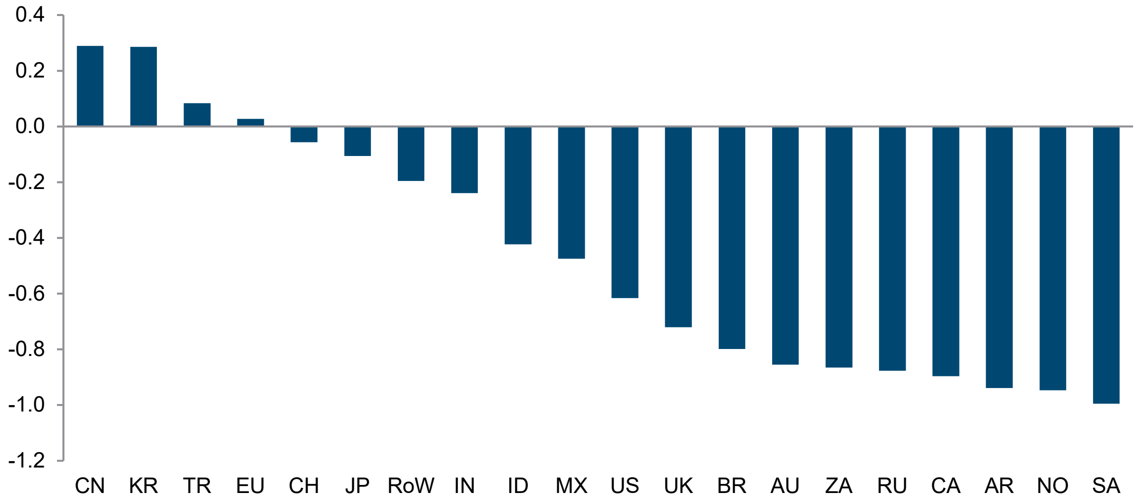
Source: FIGARO; own calculations.

One might also be interested in the GVC RCAs of specific products within the EU ERES GVC. For example, the RCAs of intermediates use by the ERES from the ERES industries itself are calculated as:

$$GVC_{ERES}^{EU} - RCA_{ERES}^{CN} = \frac{x_{ERES}^{c} / \sum_k x_k^{CN}}{\sum_r x_{ERES}^{r} / \sum_{k,r} x_k^{r}} = \frac{x_{ERES}^{c} / \sum_r x_{ERES}^{r}}{\sum_k x_k^{c} / \sum_{k,r} x_k^{r}}$$

and can be expressed by source country, as in Figure 5.7. In these intra-industry inputs, China and Korea have the strongest RCAs, followed by Turkey. The EU itself has a small comparative advantage, while Switzerland and Japan have a small disadvantage. Interestingly, the US and the UK have a considerable disadvantage (though not among the highest), of a magnitude comparable to that of Brazil.[10]

Figure 5.7 / RCAs ob ERES by the EU ERES GVC, 2020

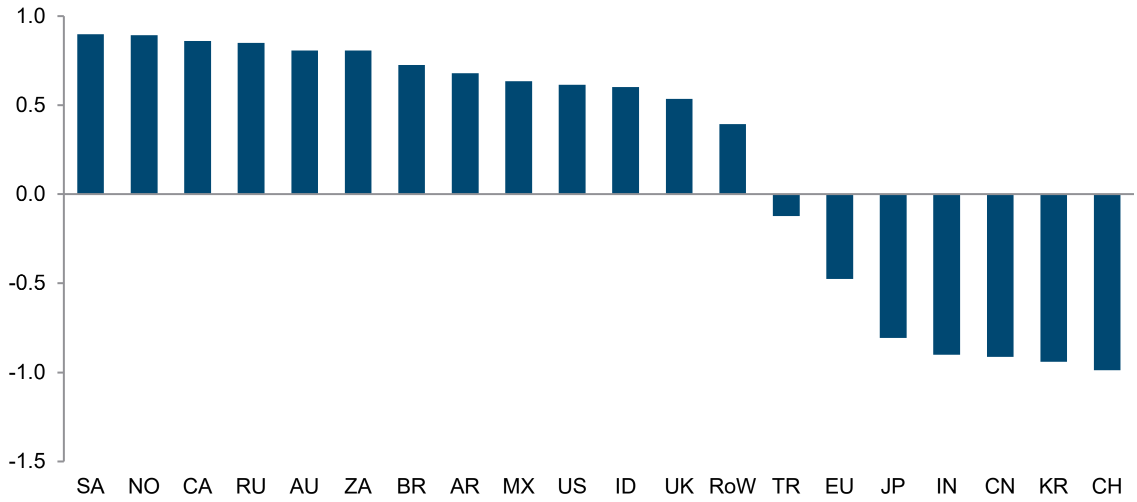


Source: FIGARO; own calculations.

Considering the two industries for which the EU ERES has the largest comparative disadvantages (e.g. industry B), one can determine the RCAs for these by partner country. With respect to sourcing from industry B, the EU ERES GVC has strong comparative disadvantages with respect to Saudi Arabia (SA), Norway (NO), Canada (CA), Russia (RU), Australia (AU) and others which are exporters of raw materials. In conjunction with the information provided in Figure 5.6 and Figure 5.7 one can see that, in terms of size, Russia, Norway and Saudi Arabia are the most important source partners. Though this is not surprising, these graphs could also indicate the potential for substitution (e.g. away from Russia).

10 The explanation for such patterns might, however, lie in the fact that none of these countries is strong on the assembly of electrical equipment products (NACE C27), which accounts for a large part of this ecosystem trade.

Figure 5.8 / RCAs of industry B in the EU ERES GVC, 2020



Source: FIGARO; own calculations.

These patterns could be considered in detail for each partner country and each industry, as shown in Figure A.1 and Figure A.2 in the Appendix, which offer an overview for all industries and countries.[11]

[11] Such information could be used to take those industries in Figure 5.1 with relatively high foreign sourcing and check for which of them the EU has a disadvantage (e.g. industries C27, C24, C26, C19 and C28). Or one could analyse in more detail how it is that the ecosystem is so heavily dependent on China, i.e. what are the sectors where the EU has a strong disadvantage and China has a strong advantage? Having identified these, one can check which other countries have a strong advantage. These could then be potential alternative sourcing partners to reduce the dependency on a single producer.

6. External dependencies by product

Finally, we look at the structural dependencies of the ERES from a detailed product-level perspective. For this, we use detailed bilateral goods trade data (sourced from BACI) which provide information on the EU's imports from all partner countries c (those available in FIGARO) by HS 6-digit product j – i.e. x_j^c. We should emphasise that these data only include goods trade data. A product can be classified as 'risky' (or 'vulnerable') according to various indicators. Here, we rely on a classification of 'risky' products (in global trade) that was developed by Reiter and Stehrer (2021, 2023).[12] We further use a correspondence of products j to the corresponding NACE industries according to the FIGARO data (NACE Rev. 2 2-digit).[13]

6.1. DEPENDENCIES AT THE PRODUCT LEVEL

First, we look at dependencies, defined as products being delivered from only a few countries. Note that such an analysis is not specific to the ecosystem (or industry) under consideration, but applies to overall imports, as the risk assessment by product is not differentiated by the using industries.[14] Table 6.1 provides an overview of the number of products – differentiated according to whether they are risky, non-risky or unclassified – and the number of partner countries (not including EU countries) from which they are sourced. In total 4,760 products are identified, of which 4,267 (90.7%) are classified as non-risky, 435 (9.3%) are classified as risky. Within the group of non-risky products, 14 are imported from only two partner countries and 15 from three partner countries; 880 products are imported from all 19 partner countries (available in the FIGARO data, including RoW as an aggregate covering several countries).

12 Here, alternative product-level assessments could be applied to classify products in terms of riskiness, vulnerability, essential/non-essential, etc. An example is Arjona et al. (2023), who isolate 204 products as foreign dependent (for a summary, see https://cepr.org/voxeu/columns/eus-strategic-dependencies-unveiled).

13 We use a correspondence table between HS 6-digit and NACE Rev. 2 classification and split out the energy-renewables ecosystem using the shares already discussed above.

14 In the final version, we will provide this risk analysis only for intermediate products (e.g. as classified via broad economic categories (BEC)).

Table 6.1 / Number of partner countries by product

Number of partner countries	Classified as non-risky	Classified as risky
2	14	
3	15	
4	20	
5	36	
6	48	
7	77	
8	105	
9	134	
10	154	
11	174	
12	261	
13	265	1
14	302	2
15	308	1
16	407	3
17	456	19
18	611	45
19	880	364
	4267	435

Source: BACI, own calculations, based on Reiter and Stehrer (2021).

6.2. DEPENDENCIES OF THE ENERGY-RENEWABLES ECOSYSTEM

So far, we have not used information specific to the ERES supply. Merging the bilateral trade to the intermediate inputs matrix of the FIGARO data[15] provides us with the information about which products j are brought in as part of the imports from industry i of country c.[16] Using this procedure, one can assess the magnitude of risky imports in this 'industry' in terms of their value (million euro) or their share.

Figure 6.1 shows the share of imports of intermediate goods by the EU ERES that are classified according to this assessment as 'risky' or 'non-risky', by partner country. The remaining category of 'not classified' covers intermediate service imports.[17] Almost 45% of the ERES's imports from China are classified as risky; and that figure is also high for imports from Turkey, South Korea and Switzerland.[18] The lower part of the graph shows the import of risky products in value terms. As this also reflects the size of the trading partner, the ranking is slightly different. About EUR 2bn worth of imports from China

[15] Technically, we apply this information at the product level to all columns in the transaction matrix, using a proportionality assumption. This means, for example, that a product classified as 'risky' is 'risky' for all industries that use it (and for final consumption). Differences across industries emerge due to differences in the sourcing structures of each industry. For a deeper analysis one would have to use company-level data.

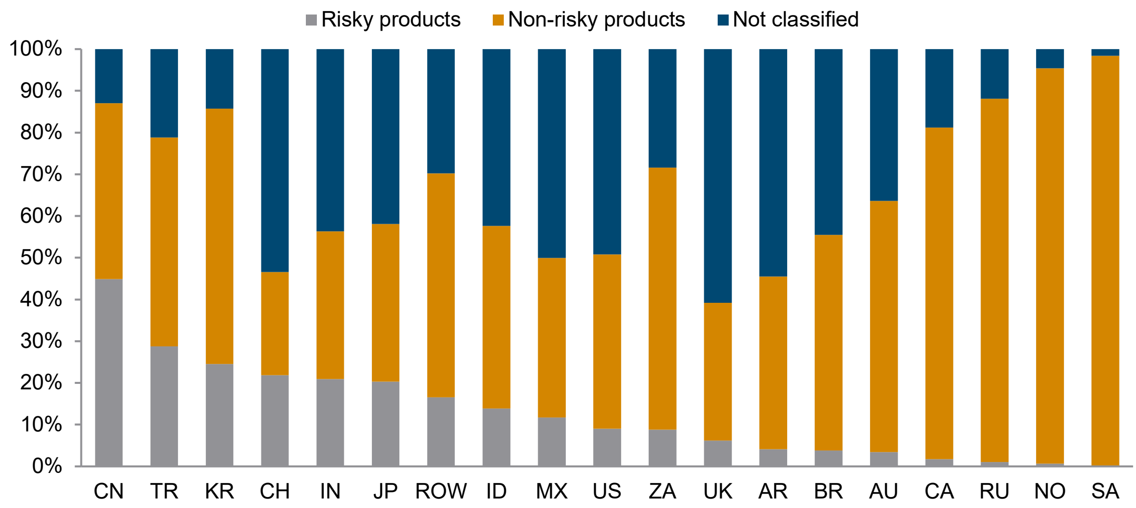
[16] This applies to industries with goods trade only. There is no such distinction for trade in services: in such cases these services are included as a unique product in this analysis.

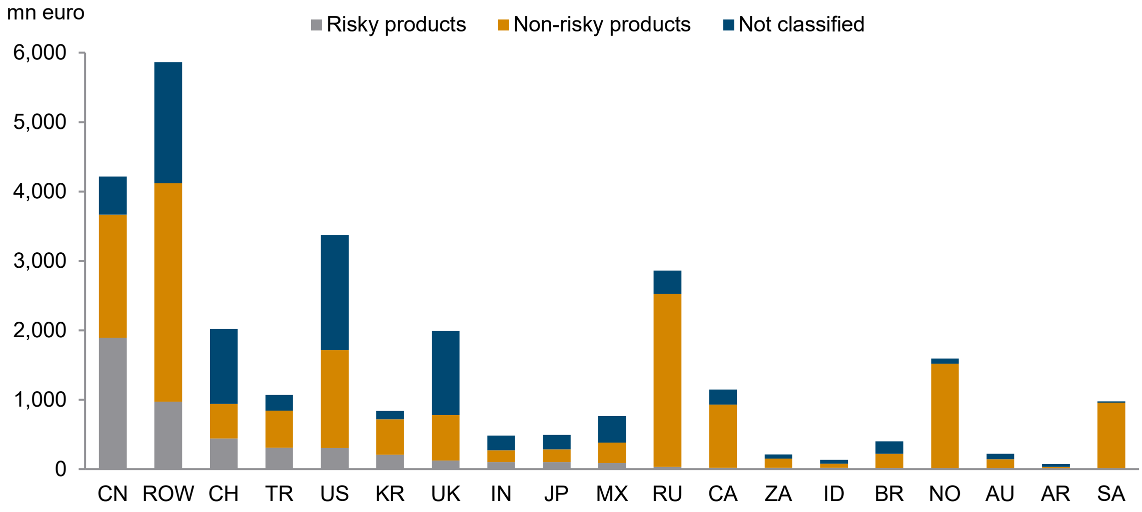
[17] This information comes from the FIGARO MC-IOTs. As these imports cannot be linked to detailed trade data, one cannot classify them as risky or non-risky according to this methodology.

[18] One could, of course, also classify countries according to potential supply-chain risks.

are classified as risky (according to the definition in Reiter and Stehrer, 2021), while that figure is about EUR 1bn for imports from RoW countries.[19]

Figure 6.1 / Share of risky products in total intermediate inputs to EU ERES, 2020





Note: 'Not classified' is imports of services.
Source: Own calculations.

[19] Let us again stress some caveats using this approach. First, applying product-level trade data to the supply chains (the columns in the MC-IOT) relies on a proportionality assumption (consequently, these results might apply in a similar way for different industries. Second, different definitions of 'riskiness' and 'vulnerabilities' at the product level can be applied. In particular, one should bear in mind that any specific product can render a production process vulnerable (O-ring theory).

6.3. DEPENDENCIES OF THE ENERGY-RENEWABLES ECOSYSTEM AT THE PRODUCT LEVEL

From a policy perspective, it is important to look at the patterns at a very detailed product level. Here we provide as an example the most important risky product that the EU ERES imports from China: 'Data processing machines: portable, digital and automatic, weighing not more than 10kg, consisting of at least a central processing unit, a keyboard and a display' (HS 847130). China accounts for more than 90% of extra-EU imports of this product; apart from RoW, the remaining countries account for less than 1% each. However, over 60% of imports in this value chain are from within the EU (i.e. the product is assembled in one EU country and exported to another). For comparison, according to BACI data, the six largest exporters of this product (accounting for almost 90% of global exports) are China (73.7%), the Netherlands (4.8%), Germany (3.4%), the US (2.8%), Vietnam (2.6%) and Czechia (2.3%). Reducing dependency on China for this product would then imply either shifting production back to Europe or strengthening ties with other countries that have a relatively large share. Taking the latter option, for example, Great Britain, Japan, the US, Switzerland, Turkey and South Korea together account for almost 4% of imports of this product (see Table 6.2).[20]

This suggests that an assessment of EU27 vulnerabilities must consider (i) the concentration of imports from a specific supplying country, (ii) the share of intra-EU imports (as a proxy for local production) and (iii) the classification of a product as 'risky' or 'non-risky' (as exemplified here, using the classification provided in Reiter and Stehrer (2022).[21,22]

Table 6.2 / ERES imports of HS 847130

	Import value	Share	Share excl. intra-EU imports
EU27	233.2	62.4	
CN	131.3	35.1	93.4
RoW	3.7	1.0	2.6
GB	1.3	0.3	0.9
JP	1.2	0.3	0.9
US	1.2	0.3	0.9
CH	0.8	0.2	0.6
TR	0.3	0.1	0.2
KR	0.3	0.1	0.2
RU	0.1	0.0	0.1
MX	0.1	0.0	0.1
AU	0.1	0.0	0.1
NO	0.1	0.0	0.0
ZA	0.0	0.0	0.0
CA	0.0	0.0	0.0
ID	0.0	0.0	0.0
IN	0.0	0.0	0.0
AR	0.0	0.0	0.0
BR	0.0	0.0	0.0
SA	0.0	0.0	0.0

Source: BACI, own calculations (based on Reiter and Stehrer, 2023).

20 An analogous exercise could be undertaken for other products.

21 Other criteria might be whether a product is classified as 'necessary' or 'unnecessary' and an assessment of country risks.

22 One should note here that such an analysis has to make a proportionality assumption concerning the use of imports across industries. Thus, whereas dependencies in terms of size (values) differ across industries (or ecosystems), the overall structures are likely to be similar.

7. Conclusions

The energy-renewables ecosystem plays a crucial role as an enabler of the green transition: a great number of products and technologies that other sectors require to become greener are produced within this ecosystem. Given its strategic relevance, it is essential for the EU to strengthen its competitiveness, maintaining its stronghold in global value chains while possibly reducing its external dependencies and sources of vulnerability. This paper provides solid empirical evidence that contributes to a better understanding of the current performance of the EU in this ecosystem. It also presents a novel methodology of using input-output and trade data to study industrial ecosystems.

To conduct this analysis, a variety of data sources and indicators are used. First, the paper analyses the relevance of the ecosystem in EU member states by drawing on value-added and employment data from Eurostat National Accounts. The analysis then moves to the trade sphere, computing standard indicators of international competitiveness for the EU27 as a whole, vis-à-vis other global players and drawing on the JRC-FIGARO dataset. By combining input-output data with detailed trade data, and by computing indicators showing the dependency of industrial ecosystems, we identify strategic dependencies and vulnerabilities.

The key findings of this paper can be summarised as follows. In 2020, the ecosystem accounted for 1% of total value added produced in the EU27 and 0.59% of its employment. The ecosystem is particularly relevant in the new member states (most notably, Czechia, Slovenia, Slovakia, Poland and Romania), as well as in Germany and Austria. At the global level, the EU27 is the second most important exporter in the world, with a market share of 22% in 2020 (by and large stable since 2012). China is the global leader of this ecosystem, with a market share of 30.8% (up from 24% in 2012). Other important players are Japan, Korea and the US. Of all these players, only China, Japan and the EU27 show a revealed comparative advantage in the products of the ecosystem. In 2020, the EU energy-renewables ecosystem was heavily dependent on imports from the industry ‘Mining of coal and lignite’, particularly from Russia. Beyond this industry, China emerges as the EU’s key sourcing partner, providing the energy-renewables ecosystem with a variety of products, including from medium- and high-tech industries such as computers and electronics. These conclusions also emerge from a more in-depth approach to assessing dependencies based on detailed trade data.

The paper thus contributes to the existing evidence in a methodological perspective through its attempt to embed information on ecosystems in multi-country input-output tables and to derive certain indicators on revealed comparative advantage, interlinkages and dependencies specific to the ecosystem under consideration.[23] The analysis performed in this paper could be expanded in a wide range of directions – for example, by studying the competitiveness and positioning of the individual EU member states within the ecosystem or by opening the ecosystem up into its various industry components. A third dimension that could be exploited is the time dimension, which would allow emerging players other than China to

23 In addition, a couple of methodological improvements will be introduced. These include, *inter alia*, calculations of GVC RCAs in value-added terms, assessing different classifications of the ‘riskiness’ of products, and splitting the detailed trade data into imports of intermediates and of final goods.

be identified. Depending on data availability, similar indicators could be computed for other ecosystems, in order to gain a complete overview of the competitiveness of the EU, as well as of its dependencies and vulnerabilities.

The analysis conducted here thus shows the importance of considering the linkages both between the ecosystem and other ecosystems and in the international arena. The policy initiative that has set the pace and direction of change in this ecosystem is the REPowerEU. The ERES is one of six ecosystems (out of the 14 identified by the European Commission) not to have undergone a co-creation process to design a transition pathway. Instead, the REPowerEU plan is said to cover the transition pathway of this ecosystem. The plan was conceived as a response to the hardships and energy market disruptions caused by Russia’s invasion of Ukraine. Its key objectives are, therefore, to end the EU’s dependence on Russian fossil fuels and accelerate the transition towards a greener EU. The measures in the REPowerEU plan involve energy savings, diversification of energy suppliers and an accelerated roll-out of renewable energy to replace fossil fuels in homes, industry and power generation.

As usually occurs in policymaking, a plethora of other initiatives revolve around REPowerEU. For example, the EU Solar Energy Strategy aims to increase solar photovoltaic capacity, while the Biomethane Action Plan sets out financial incentives to increase the production of biomethane (including through the Common Agricultural Policy). Some of these initiatives complement the efforts of the REPowerEU plan by promoting the resilience and strategic autonomy of the ecosystem. In doing so, the policies provide a framework of action to strengthen production and (re)create value chains. Examples of such initiatives are the various industry alliances established for the ecosystem. The most recent is the European Solar Photovoltaic Industry Alliance, which was launched to maintain and regain technological and industrial leadership in the solar photovoltaic value chain. This follows the experience of prior alliances established for this ecosystem, namely the Battery Alliance and the Clean Hydrogen Alliance. Along the same lines, of the eight Important Projects of Common European Interest (IPCEIs) approved so far, five involve products of this ecosystem (two for batteries and three for hydrogen). In this regard, an observatory to trace re-shoring events and new investment to install or increase production in these value chains could provide valuable data to help us understand the effectiveness of these initiatives and the actual feasibility of restoring these value chains in the EU.

While this is not an exhaustive list of the measures in support of the ecosystem, this discussion already shows that the resilience and autonomy of the ecosystem are not left completely at the mercy of market forces. Nevertheless, a few policy considerations may be derived from the analysis conducted in this study.

First, the ecosystem approach was promoted as a new framework for EU industrial policymaking to move away from sectoral policies and consider that economies are systems in which all sectors are linked and contribute to each other’s success. The linkages to the rest of the economy are particularly strong and meaningful for an ecosystem such as the energy-renewables ecosystem – an upstream ecosystem (literally) fuelling the rest of the economy. Given this centrality of the ecosystem, initiating a proper co-creation process for the transition pathway for this ecosystem could be beneficial. Indeed, one of the key elements of the transition pathway process is the involvement of stakeholders; in the case of the ERES, that would also imply the involvement of local communities – and possibly all sectors involved in the value chain. Taking the approach even one step further on from the previous situation and involving all major industries linked to the ecosystem could also be beneficial in better understanding the bottlenecks in the value chain.

Second, the REPowerEU correctly places considerable emphasis on energy diplomacy as a tool to help Europe diversify its energy sources and forge new global partnerships. In this regard, linking energy supplies to broader initiatives that promote friend-shoring of manufacturing activities relevant to this ecosystem might create win-win scenarios, especially where re-shoring is not feasible.

Finally, monitoring the ecosystem's trade linkages might help to reveal vulnerabilities that slip under the radar and to develop a more proactive (rather than reactive) approach to industrial policymaking. Indeed, several current initiatives (including the trade negotiations with Mercosur to strike a deal on critical raw materials) appear to be reacting to the current geopolitical scenario and to the moves of other players.

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Appendix

Table A.1 / FIGARO country list

ISO code	Country
EU27 member states	European Union member states
AR	Argentina
AU	Australia
BR	Brazil
CA	Canada
CH	Switzerland
CN	China
UK	United Kingdom
ID	Indonesia
IN	India
JP	Japan
KR	South Korea
MX	Mexico
NO	Norway
RoW	Rest of the world
RU	Russia
SA	Saudi Arabia
TR	Turkey
US	United States of America
ZA	South Africa

Source: FIGARO; own elaboration.

Table A.2 / NACE Rev. 2 industry classification

No.		A21		A64	Description	
1	1	A	A	A01	Crop and animal production, hunting and related service activities	
2	2	A	A	A02	Forestry and logging	
3	3	A	A	A03	Fishing and aquaculture	
4	5	B	B	B	Mining of coal and lignite	
5	10	C	CA	C10-C12	Manufacture of food products	
6	13	C	CB	C13-C15	Manufacture of textiles	
7	16	C	CC	C16	Manufacture of wood and of products of wood and cork, except furniture manufacture of articles of straw and plaiting materials	
8	17	C	CC	C17	Manufacture of paper and paper products	
9	18	C	CC	C18	Printing and reproduction of recorded media	
10	19	C	CD	C19	Manufacture of coke and refined petroleum products	
11	20	C	CE	C20	Manufacture of chemicals and chemical products	
12	21	C	CF	C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	
13	22	C	CG	C22	Manufacture of rubber and plastic products	
14	23	C	CG	C23	Manufacture of other non-metallic mineral products	
15	24	C	CH	C24	Manufacture of basic metals	
16	25	C	CH	C25	Manufacture of fabricated metal products, except machinery and equipment	1.56%
17	26	C	CI	C26	Manufacture of computer, electronic and optical products	
18	27	C	CJ	C27	Manufacture of electrical equipment	38%
19	28	C	CK	C28	Manufacture of machinery and equipment n.e.c.	1.60%
20	29	C	CL	C29	Manufacture of motor vehicles, trailers and semi-trailers	
21	30	C	CL	C30	Manufacture of other transport equipment	
22	31	C	CM	C31_C32	Manufacture of furniture	
23	33	C	CM	C33	Repair and installation of machinery and equipment	1.64%
24	35	D	D	D35	Electricity, gas, steam and air conditioning supply	29%
25	36	E	E	E36	Water collection, treatment and supply	1.13%
26	37	E	E	E37-E39	Sewerage	1.43%
27	41	F	F	F	Construction of buildings	
28	45	G	G	G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	
29	46	G	G	G46	Wholesale trade, except of motor vehicles and motorcycles	
30	47	G	G	G47	Retail trade, except of motor vehicles and motorcycles	
31	49	H	H	H49	Land transport and transport via pipelines	
32	50	H	H	H50	Water transport	
33	51	H	H	H51	Air transport	
34	52	H	H	H52	Warehousing and support activities for transportation	
35	53	H	H	H53	Postal and courier activities	
36	55	I	I	I	Accommodation	
37	58	J	JA	J58	Publishing activities	
38	59	J	JA	J59_J60	Motion picture, video and television programme production, sound recording and music publishing activities	
39	61	J	JB	J61	Telecommunications	
40	62	J	JC	J62_J63	Computer programming, consultancy and related activities	
41	64	K	K	K64	Financial service activities, except insurance and pension funding	
42	65	K	K	K65	Insurance, reinsurance and pension funding, except compulsory social security	
43	66	K	K	K66	Activities auxiliary to financial services and insurance activities	
44	68	L	L	L68	Real estate activities	
45	69	M	MA	M69_M70	Legal and accounting activities	0.97%
46	71	M	MA	M71	Architectural and engineering activities; technical testing and analysis	1.17%
47	72	M	MB	M72	Scientific research and development	0.83%

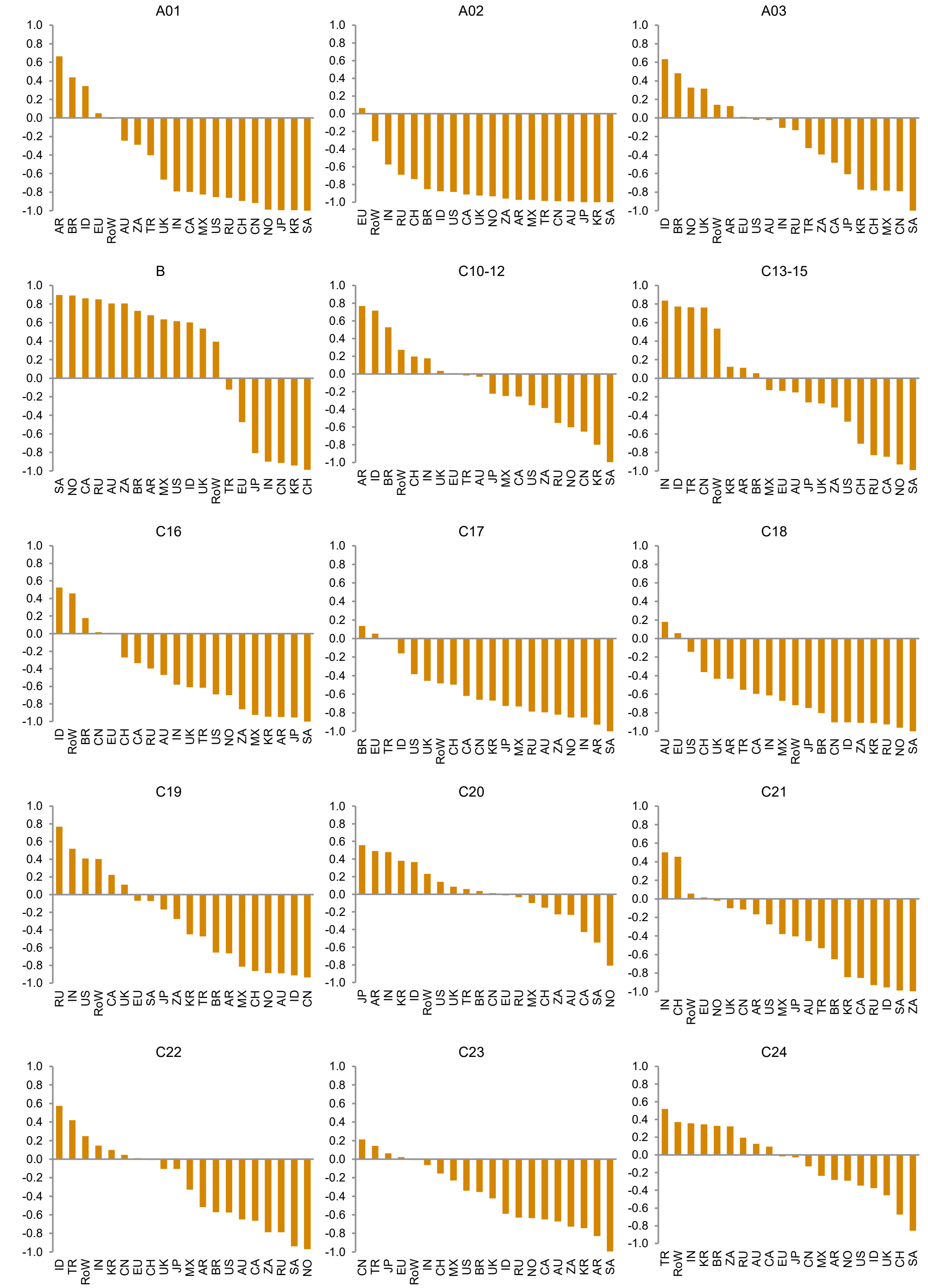
Contd.

Table A.2 / Continued

No.		A21		A64	Description	
48	73	M	MC	M73	Advertising and market research	
49	74	M	MC	M74_M75	Other professional, scientific and technical activities	
50	77	N	N	N77	Rental and leasing activities	0.85%
51	78	N	N	N78	Employment activities	0.85%
52	79	N	N	N79	Travel agency, tour operator and other reservation service and related activities	
53	80	N	N	N80-N82	Security and investigation activities	
54	84	O	O	O84	Public administration and defence; compulsory social security	
55	85	P	P	P85	Education	
56	86	Q	QA	Q86	Human health activities	
57	87	Q	QB	Q87_Q88	Residential care activities	
58	90	R	R	R90-R92	Creative, arts and entertainment activities	
59	93	R	R	R93	Sports activities and amusement and recreation activities	
60	94	S	S	S94	Activities of membership organisations	
61	95	S	S	S95	Repair of computers and personal and household goods	
62	96	S	S	S96	Other personal service activities	
63	97	T	T	T	Activities of households as employers of domestic personnel	
64	99	U	U	U	Activities of extraterritorial organisations and bodies	

Note: Dark shaded industries are those classified as being part of ERES; light shaded ones are horizontal industries related to the eco-systems.
Source: Eurostat.

Figure A.1 / RCAs by industry over partners, 2020



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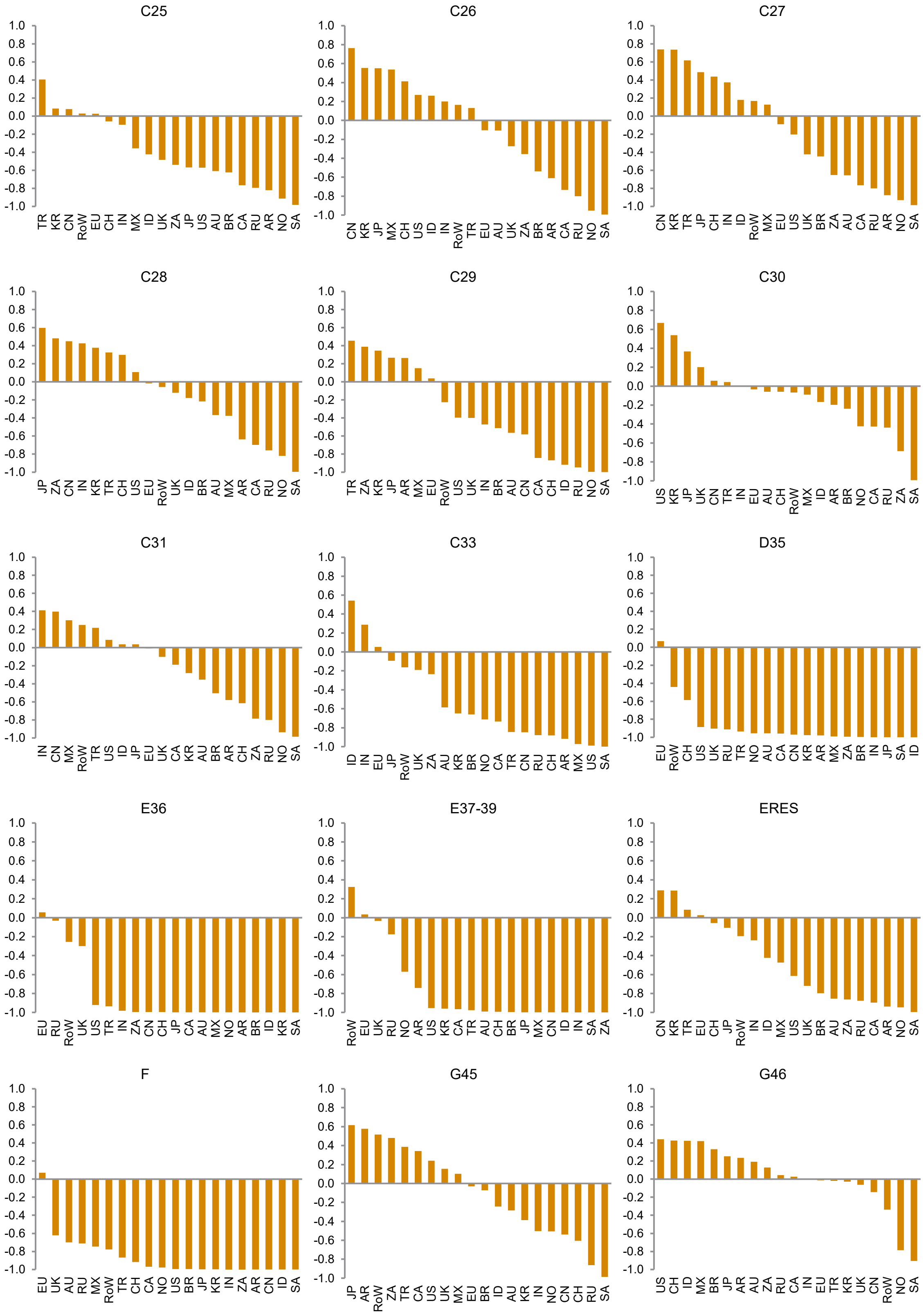

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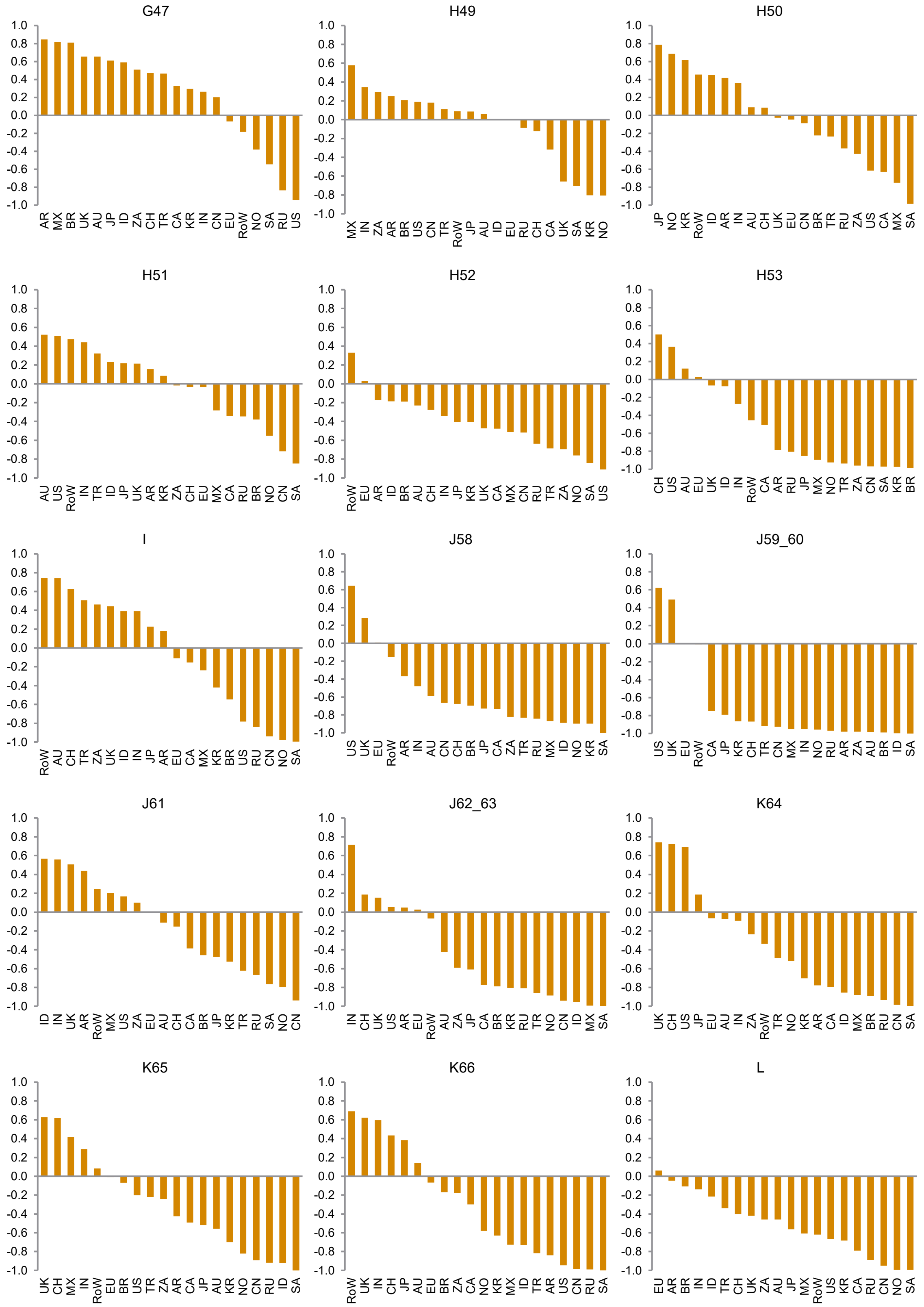

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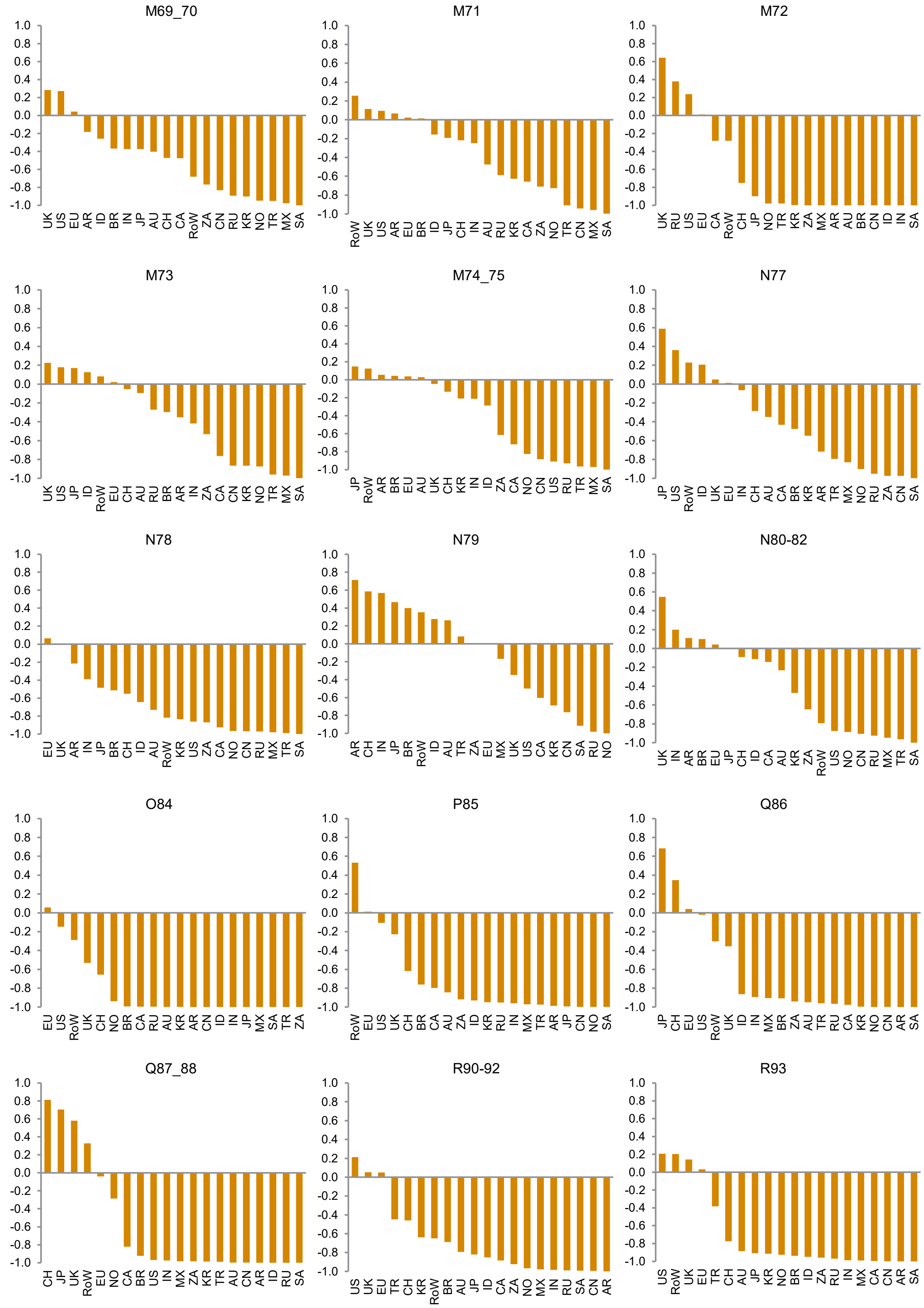

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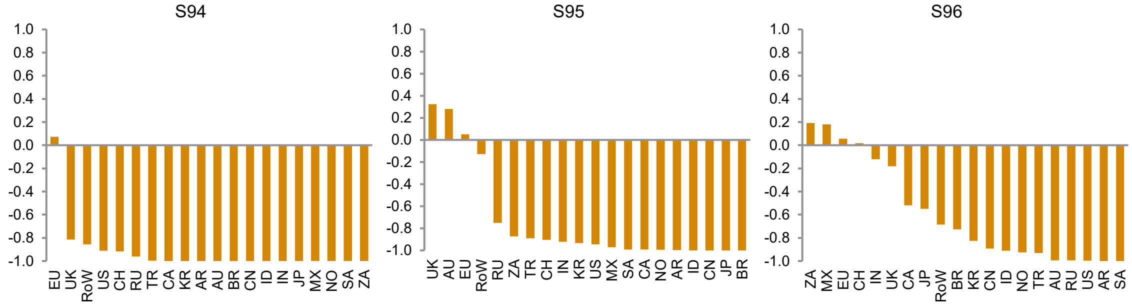
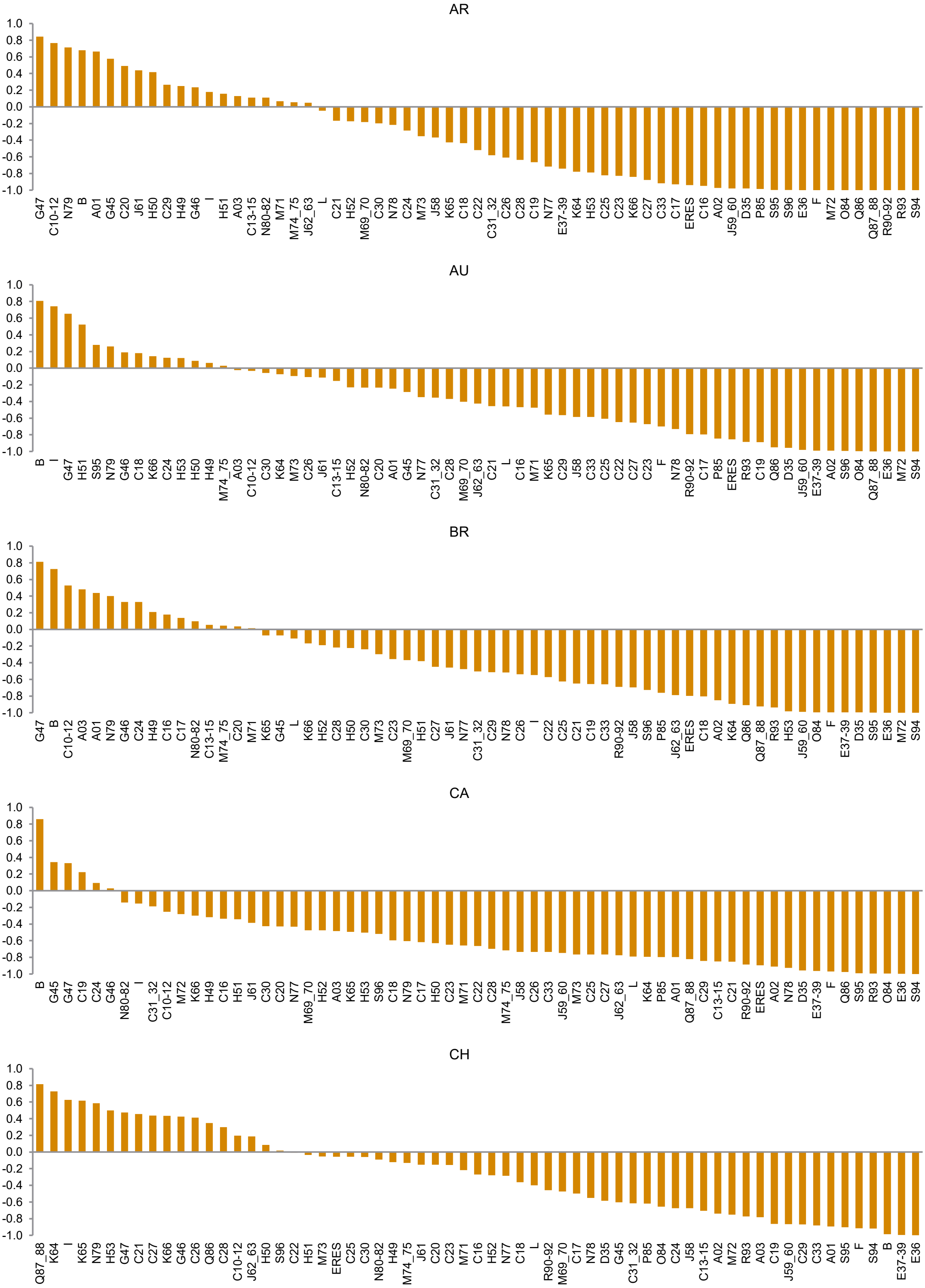


Source: FIGARO; own calculations.

Figure A.2 / RCAs by partner over industries, 2020



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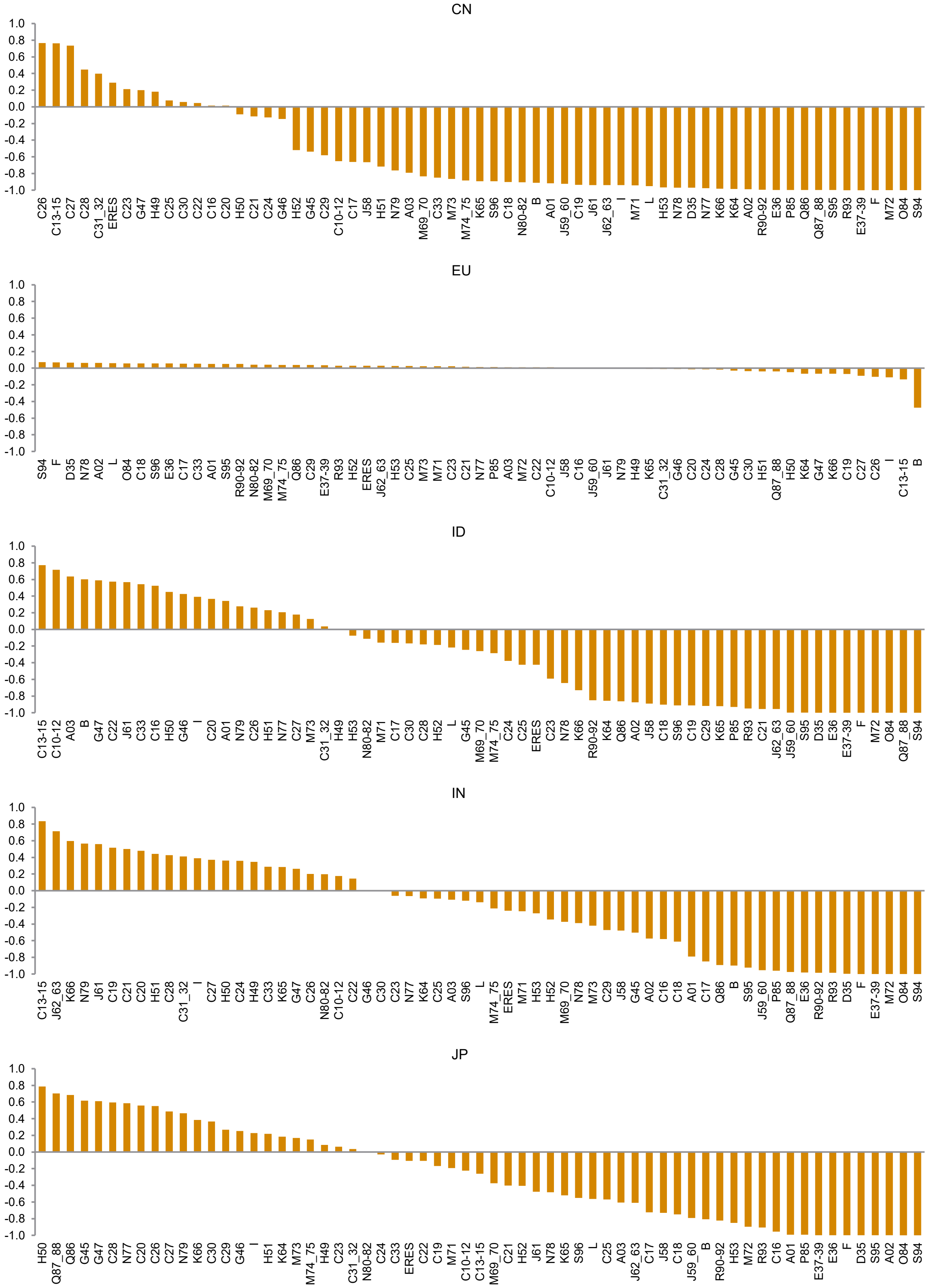

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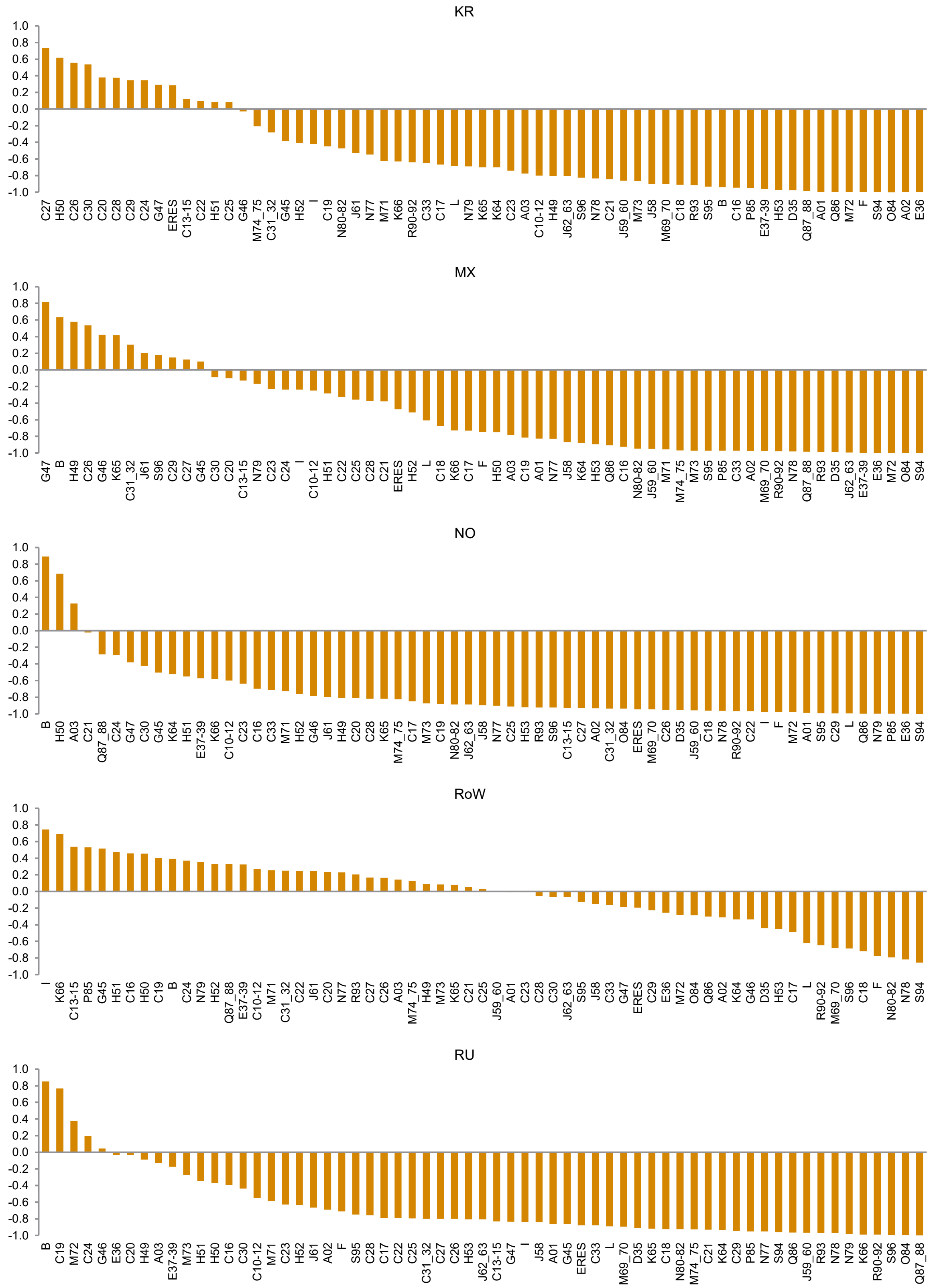

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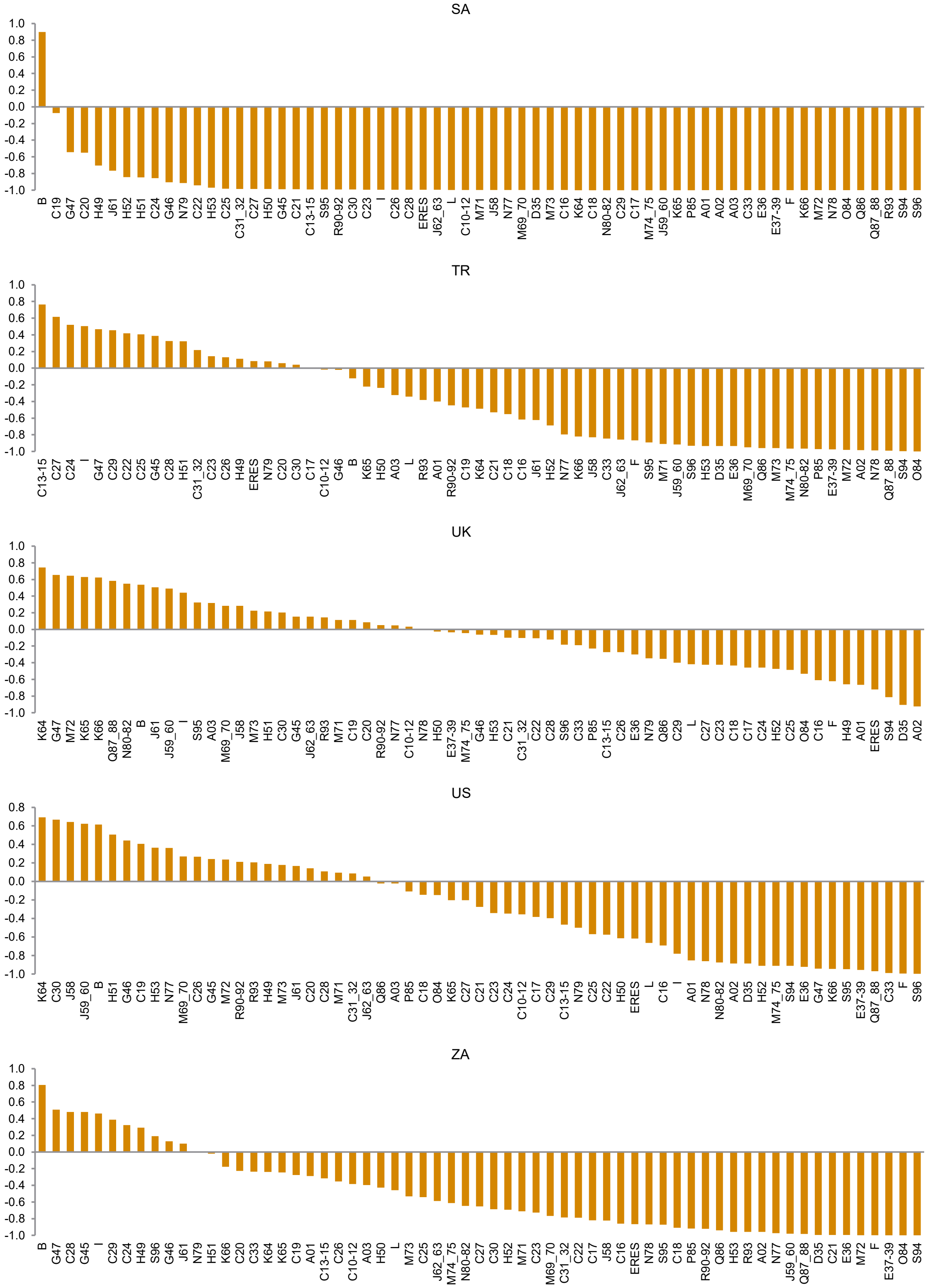

Source: FIGARO; own calculations

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