Measurement of the EU Bioeconomy and the Inclusion of Downstream and Upstream Linkages

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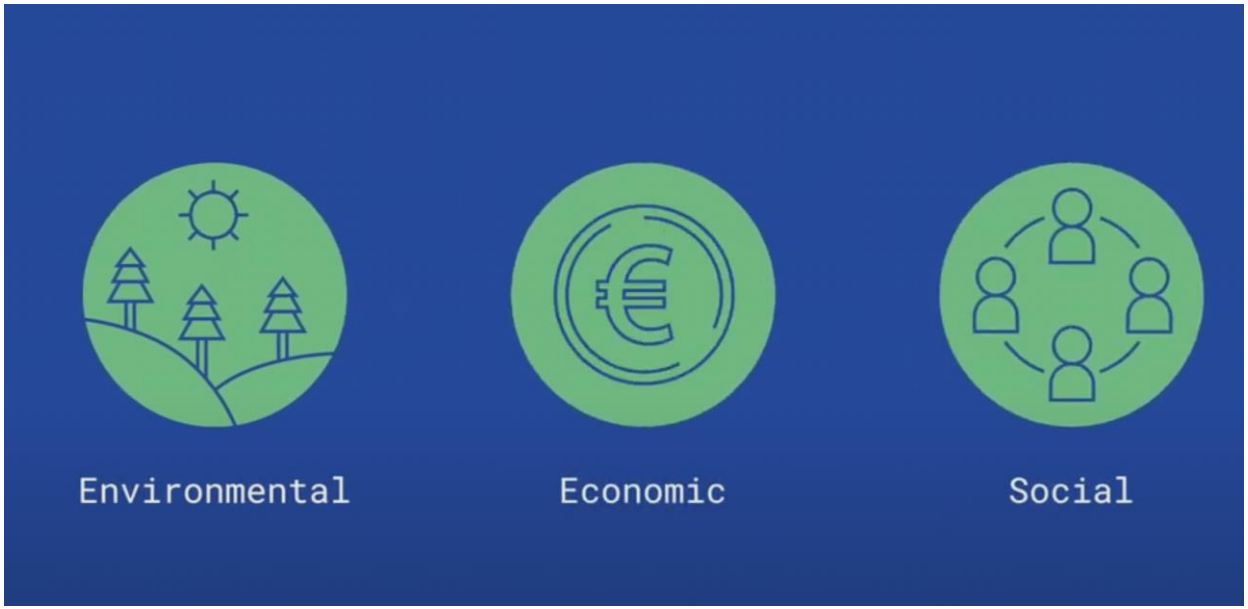
Challenges for Sustainable development



Can the Bioeconomy be the effective remedy for the challenges?

What is Bioeconomy?

Bioeconomy Strategy 2018
EU Green Deal

Through these policies Europe aims to solve

- Social inequality
- Climate change

Providing a better future

”The bioeconomy covers all **sectors and systems that rely on biological resources** (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles”
(Definition by the European Commission)

Hence the importance of the measurement of Bioeconomy.

Problems of measuring bioeconomy

- **Lack of standardized definitions and frameworks:** there is a lack of universally accepted definitions and frameworks.
- **Data availability and quality:** data collection and reporting systems may be fragmented, inconsistent, or unavailable across different regions and sectors.

Problems of measuring bioeconomy

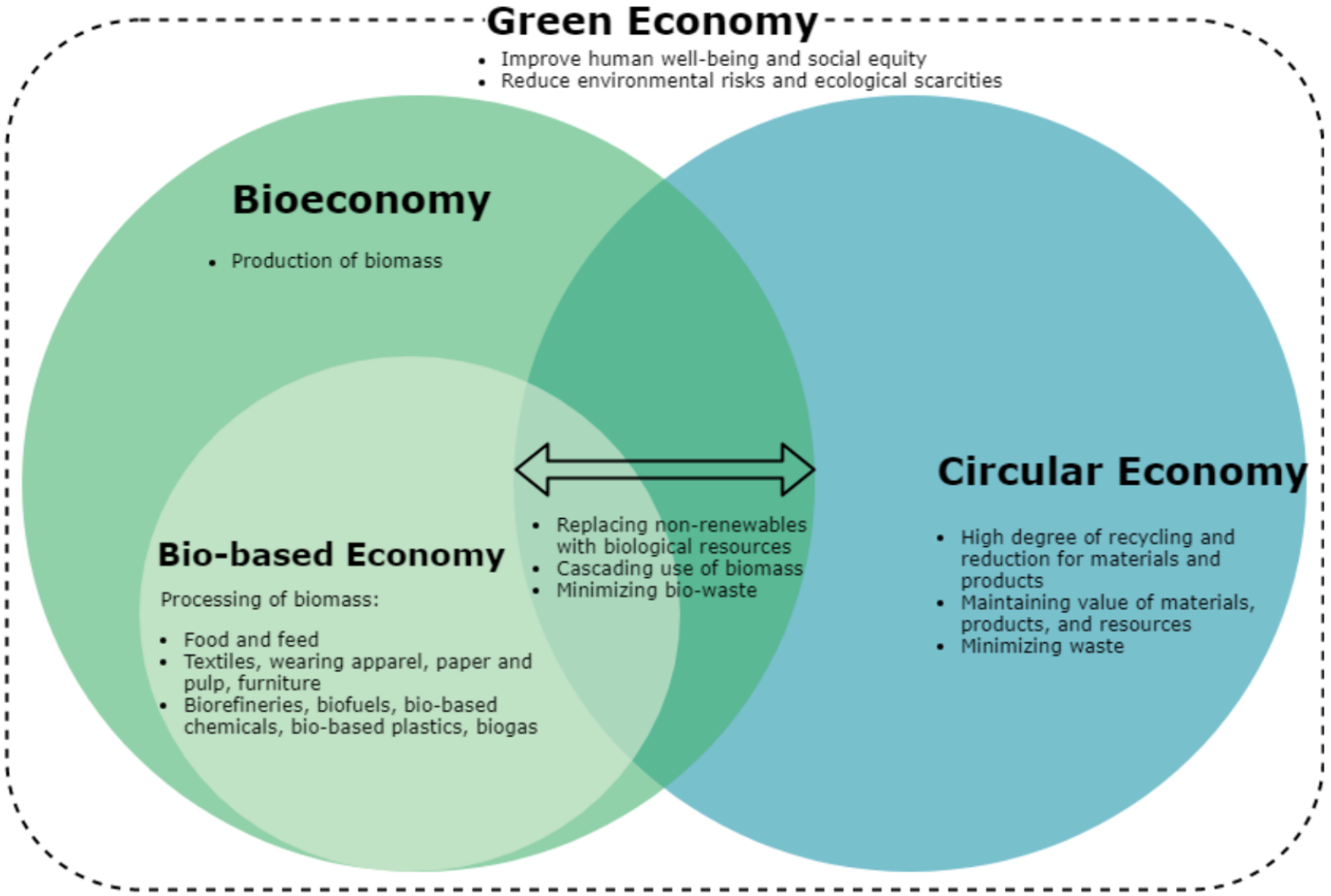
- **Scope and boundaries:** Determining the scope and boundaries of the bioeconomy is challenging.

- **Interconnectedness and indirect effects:** Measuring the direct and indirect effects of bioeconomy activities on other sectors can be complex and require sophisticated modeling techniques.

- **Dynamic nature and evolving technologies:** The bioeconomy is a rapidly evolving field, with new technologies and innovations continually emerging.

Source: Kardung et al. 2021

Problems of measuring bioeconomy



Source: Kardung et al. 2021

Measurement Methodologies I

- The “output-based” approach quantifies the value added generated by an industry in proportion to the bioeconomy nature of the outputs (output characteristics instead of the inputs).
    - Ronzon et al. (2022) identifies bioeconomy scope proportionally to the biomass content of tangible outputs and to the bioeconomy relevance of intangible outputs.
    - Iost et al. (2019) fully include biotechnology research into their bioeconomy scope - no matter the proportion of biomass inputs used by this activity.
- The “input-based” approach quantifies the value added generated by an industry in proportion to the inputs it uses in the form of biological renewable resources.
    - Kuosmanen et al. (2020, section 4) propose the use agriculture, forestry and fishing inputs to all economic services as a proxy for biomass input shares.

Measurement Methodologies II

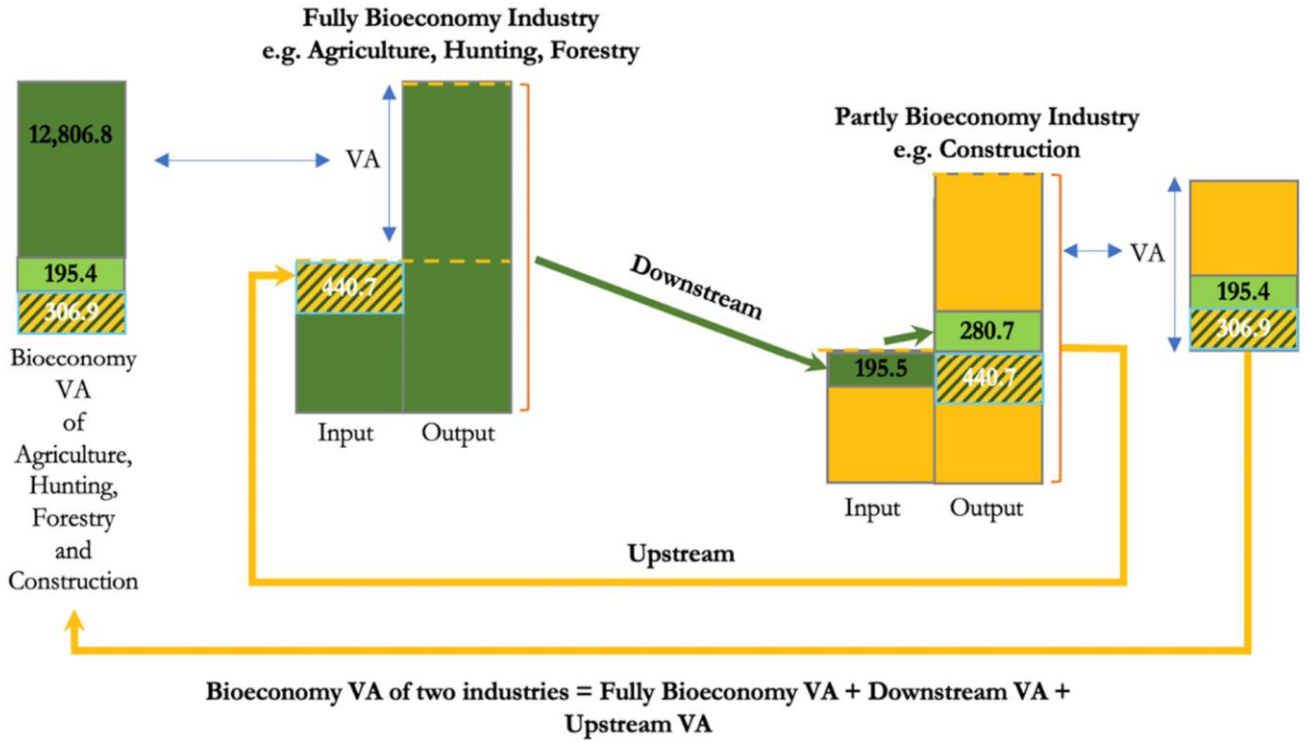
- The “weighted Input-Output” approach seeks providing a middle ground quantification of the bioeconomy value added, taking into account the parameters quantified by the output-based and the input-based approaches.
    - Kuosmanen et al. (2020, section 5) takes into account the bio-based content in both inputs and outputs
- The “Upstream-Downstream” approach measures the bioeconomy value added within the industries by using input flows to downstream and output flows to upstream between industries.
    - Cingiz et al. (2021), Cingiz et al. (2023) distinguish between a downstream and an upstream component in bioeconomy services for EU and OECD countries respectively.

Literature

Study	Region	Period	Measurement	Method	Sectors
Golden et al. (2015)	United States	2013	Value Added: 2.2% of GDP	IMPLAN software	Agriculture and forestry; Biorefining; Biobased chemicals; Enzymes; Bioplastic bottles and packaging; Forest products; Textiles. Excluding energy, livestock, food, feed, and pharmaceuticals.
Carlson (2016)	United States	2012	Turnover: around 2% of GDP	Combined data from financial, reports, and surveys.	Biologics (biotech drugs), GM crops and industrial biotech
Ronzon et al. (2017)	EU28	2014	Employment: 18.6 million, Value Added: 2.2 trillion euros	Input-output tables	NACE codes: A01-03, C10-17, C20-22, C31, D3511
Ronzon et al. (2020)	EU28	2008-2017	Value Added: food, beverages and tobacco provide 37%, agriculture provides 30%	Data from EUROSTAT and biobased shares from nova Institute.	NACE codes: A01-03, C10-17, C20-22, C31, D3511
Cingiz et al. (2021)	EU28	2005-2015	Value Added: 40–50% of GDP (most member states)	Up- and downstream effects	NACE codes: A01-03, C10-C22, C31, D35, E36, E38-39, G46-47, H, I55-56, M7211, R9104
Ronzon et al. (2022a)	EU27	2015-2017	Bioeconomy Services: Value Added, 5.0–8.6% of GDP; Employment, 10.2-16.9%	Data retrieved from biomass contents in the literature or derived from Eurostat statistics.	NACE codes: G to T
Efken et al. (2016)	Germany	2007	Value Added: 7.6% of GDP	Input-output tables	Primary sectors and all downstream sectors, but excluding upstream industries
Iost et al. (2019)	Germany	2014	3.7-4 million jobs, 116-135 billion euros value added and between 451-520 billion euros turnover	An output-based method with data from statistics and surveys	NACE codes: A, C, D, F, I, M
Heijman (2016)	Netherlands	2008-2012	Value Added: 6.6-7.2% of GDP	Input-output tables	All sectors
Loizou et al. (2019)	Poland	2010	Bioeconomy output, employment and income of each sector	National input-output tables	NACE codes: A01-03, C10-17, C20-22, C31, D3511
Vandermeulen et al. (2011)	Flanders, Belgium	2010	Value Added: 1.8% of GDP	Industry surveys with a focus on biobased energy and products.	Biobased energy and biobased products
Pellerin & Taylor (2008)	Canada	2007	Value Added: $78.3 billion, 6.4% of GDP	A three-phase approach	NAICS codes: 62, 111, 212233, 3254, 32519, 3251, 3121, 31151
Lazorcakova et al. (2022)	Visegrad countries	2015	13% of economic output, 10% of value added, 15% of employment, 20% of GHG emissions	Input-output analysis	CPA 01, 02, 03, 10, 11, ,12, 14, 16, 17, 13, 14, 20, 21, 22, 31, 35

Upstream-Downstream Linkages

Figure 1: Upstream, downstream input-output flow of the Netherlands, 2018



Downstream represents the input flow to the construction industry from the agriculture, forestry and fishery industries (green shaded).
Upstream represents the output flow from construction industries to the agriculture, forestry and fishery industries as input (yellow shaded)

Data: OECD Input-Output Tables 1995-2018

	Symmetric *industry-by-industry* I-O table	Intermediate demand			Final expenditure					Output (bp)
		Industry 1	...	Industry 45	Domestic demand	Exports (cross border)	Direct purchases by non-residents	Imports (cross border)	Direct purchases abroad	
1	Industry 1 (total, bp)									
..	...									
45	Industry 45 (total, bp)									
91	Taxes *less* subsidies in intermediate and final imported products									
92	Taxes *less* subsidies on intermediate and final products paid in the domestic territory									
93	Total intermediate / final expenditure (pu)	Sum of (1:92)	..	..						
94	Value-added (bp)									
95	Output (bp)									

GDP (expenditure approach)
GDP (output approach)
pu: purchasers' prices
bp: basic prices

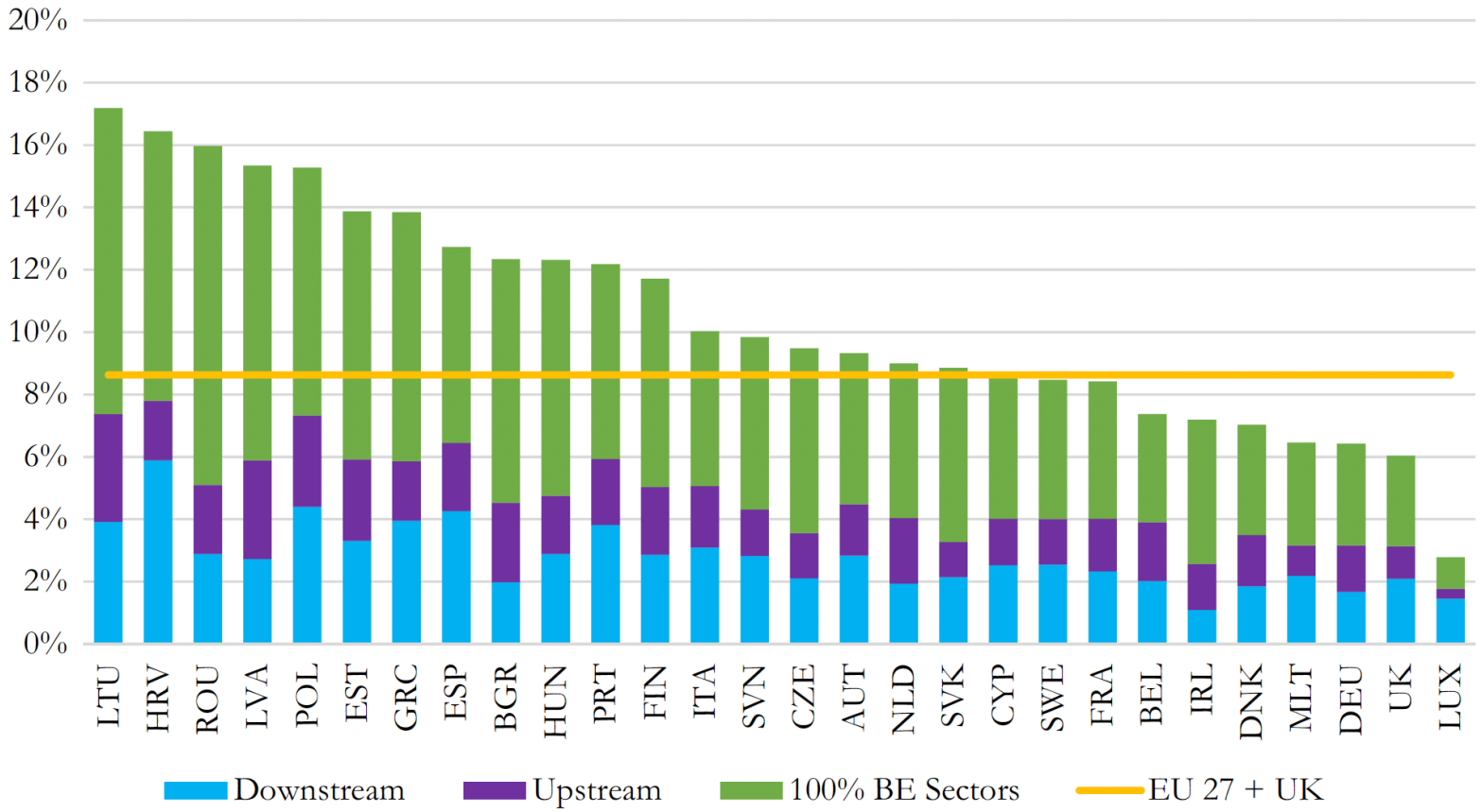
- 5 Fully bioeconomy sectors (ISIC Rev.4 codes):

D01T02 (Agriculture, hunting, forestry), D03 (Fishing and aquaculture), D10T12 (Food products, beverages and tobacco), D16 (Wood and products of wood and cork), D17T18 (Paper products and printing);

- 40 Partly bioeconomy sectors: all other sectors

Results

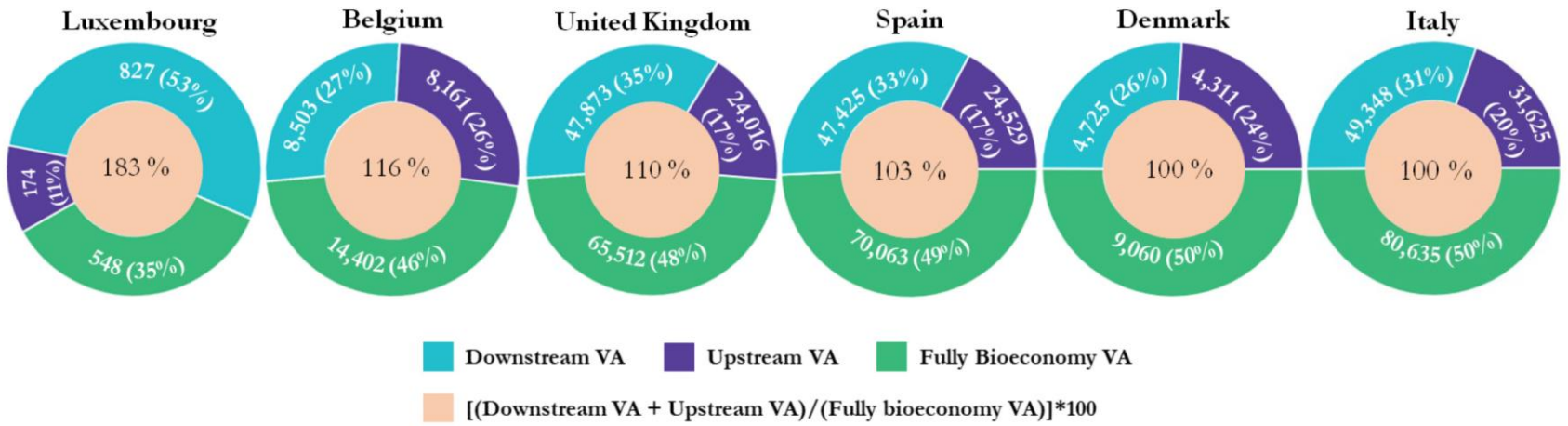
Figure 2: EU Member States bioeconomy shares in value added, 2016–2018 average



Source: Cingiz et al. 2021

Results

Figure 3: Countries where downstream and upstream VA constitutes at least 50% of the total bioeconomy, 2018

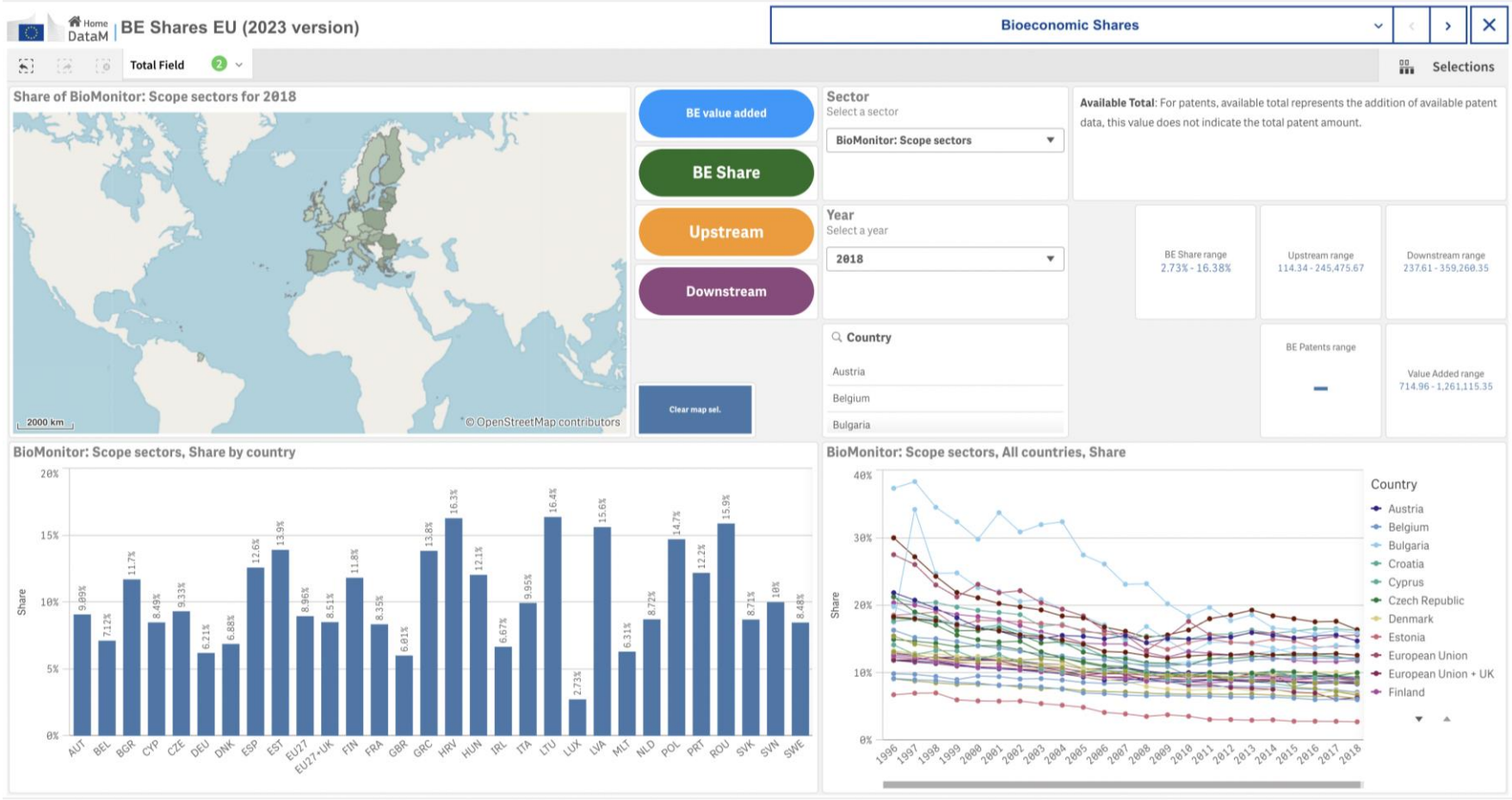


The centre indicator is the ratio of bioeconomy downstream and upstream VAs to fully bioeconomy industries VA in percentage. The figures in the ring represent the value of each component in million Euros, with their relative contribution to total bioeconomy VA in parentheses.

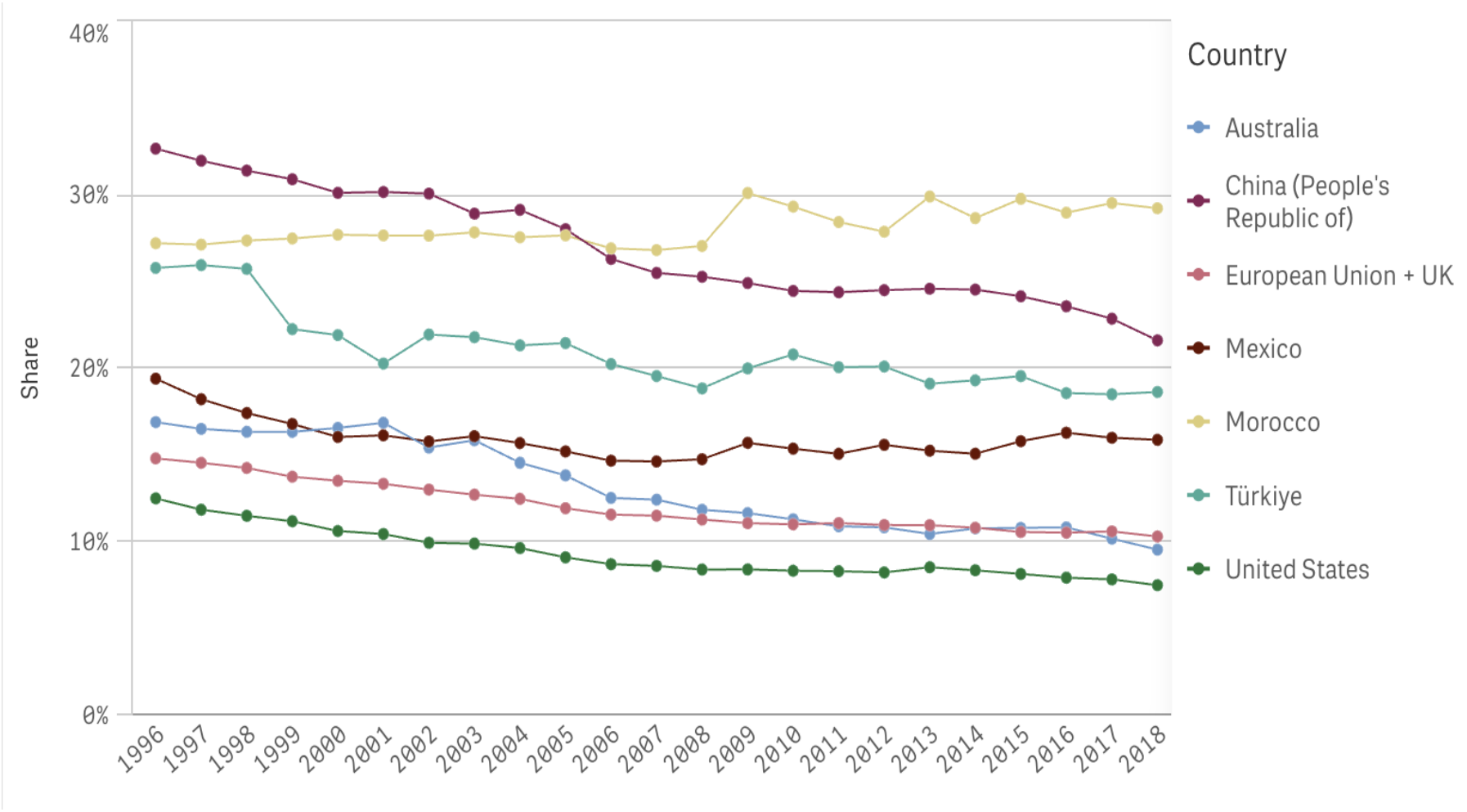
Source: Cingiz et al. 2021

Dashboard- Results (1996-2018)

https://datam.jrc.ec.europa.eu/datam/mashup/BM_BIOECONOMIC_SHARES/index.html



Bioeconomy shares around the world



The Hypothetical Extraction Method (HEM)

The basic principle of HEM is to quantify how much the total economy would decrease if a particular sector were removed from the input-output table (Miller & Blair 2009).

	Sector 1	**…**	**Sector n**	**Final Demand**	**Total**
Sector 1	z_{11}		z_{1n}	f_1	x_1
…	…	…	…	…	…
Sector n	z_{n1}	…	z_{nn}	f_n	x_n
Value Added	v_1	…	v_n		
Total	x_1	…	x_n		

$$\text{We have } Z = [z_{ij}] = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & z_{ij} & \vdots \\ z_{n1} & \cdots & z_{nn} \end{bmatrix}, f = [f_i] = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix}, V = [v_i] = \begin{bmatrix} v_1 \\ \vdots \\ v_n \end{bmatrix}, X = [x_i] = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}$$

$$X = Ze + f$$

The Hypothetical Extraction Method (HEM)

	Sector 1	…	Sector n	Final Demand	Total
Sector 1	z_{11}		z_{1n}	f_1	x_1
…	…	…	…	…	…
Sector n	z_{n1}	…	z_{nn}	f_n	x_n
Value Added	v_1	…	v_n		
Total	x_1	…	x_n		

The Leontief direct input coefficient matrix

$$A = [a_{ij}] = \begin{bmatrix} z_{11}/x_1 & \cdots & z_{1n}/x_n \\ \vdots & z_{ij}/x_j & \vdots \\ z_{n1}/x_1 & \cdots & z_{nn}/x_n \end{bmatrix}$$

The Leontief input inverse matrix

$$L = (I - A)^{-1}$$

$$X = Lf$$

We wish to produce final demand. To do so would suggest perhaps $X = f$. However, this does not consider the fact that we need to produce not just f but also enough to feed the internal demand, so perhaps $X = f + Af$. But we also need to feed the internal demand to feed that internal demand, this is $A(Af) = A^2 f$, and so on, so really:

$$X = f + Af + A^2 f + \ldots + A^n f + \ldots = (I - A)^{-1} f$$

The Hypothetical Extraction Method (HEM)

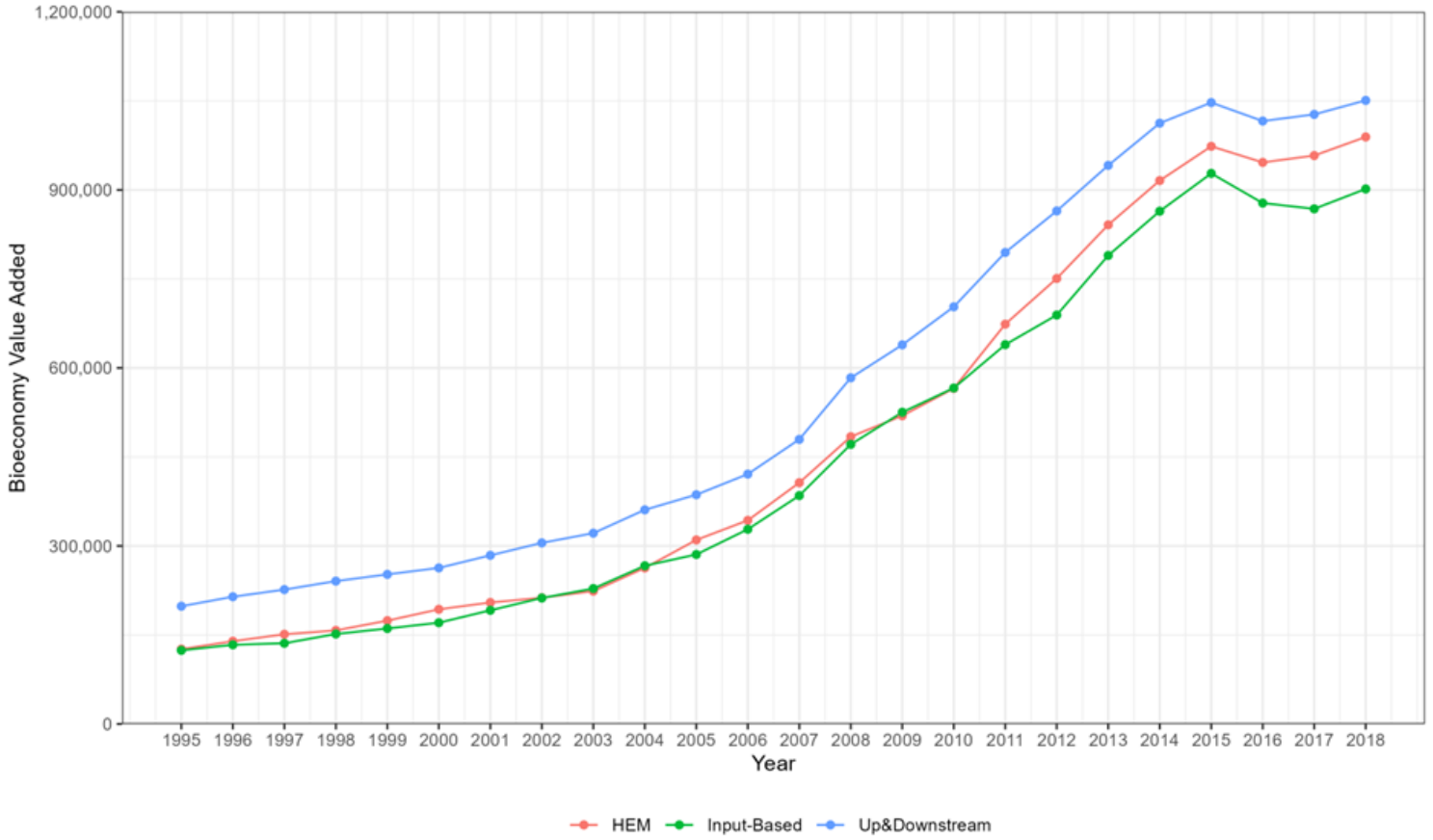
To identify how important some sectors, for example, the first k sectors are, now we partition A with the sector in the upper left (square) submatrix.

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \xrightarrow{\text{Remove}} \bar{A} = \begin{bmatrix} 0 & 0 \\ 0 & A_{22} \end{bmatrix}$$

$$\bar{L} = (I - \bar{A})^{-1} \longrightarrow \bar{X} = \bar{L}f$$

$$\Delta\bar{X} = e(X - \bar{X}) = e'(L - \bar{L})f \longrightarrow \Delta\bar{V} = \left[\frac{V}{X}\right]'(\bar{X} - X) = \left[\frac{V}{X}\right]'(L - \bar{L})f$$

The Hypothetical Extraction Method (HEM)



The Chinese bioeconomy value added measured by HEM, the input-based approach (Kuosmanen et al. 2020) and the up- and downstream (Cingiz et al. 2021) approach (unit: 1,000 dollars).

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Source: Zhu et al. (2023)

Thank you!

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