



Monitoring the Bioeconomy

Inferring data on the bioeconomy from existing statistics

Stephan Piotrowski, nova-Institute
BioMonitor workshop, 14 November 2019, Cologne



This project has received funding from the
European Union's Horizon 2020 research and innovation
programme under grant agreement No. 773297

- In recent years, several studies have emerged that use existing statistics to determine shares that can be attributed to the bioeconomy.
- The different approaches can be categorised into:
 - **Output-based methodologies:**
 - Estimation of bio-based shares of production quantities
 - **Input-based methodologies:**
 - Shares of bio-based inputs in each sector are calculated and this share is transferred to the economic indicators of each sector
 - Shares of bio-based inputs into the different industries may be inferred from input-output tables or one could track biomass from its origin, imports or domestic production, through the value chains to its final use

- Examples of input-based studies:
 - Van Meijl et al. 2016: agricultural input-output tables to describe and measure the economic effects (turnover, value added and employment) of the bioeconomy in the Netherlands

Table 1 – Bio-based shares, turnover, value added and employment in bioeconomy sectors in the Netherlands in 2013

Sector	Bio-based shares		Direct effects			Multipliers	
	IO tables (van Meijl et al. 2016)	Kwant et al. 2014	Turnover (mill. Euro)	Value added (mill. Euro)	Employment (labour units)	Value added	Employment
Agriculture, forestry & fisheries	100%	100%	27,573	10,417	161,964	1.69	1.6
Food and Feed	100%	100%	63,697	13,180	131,523	2.18	2.48
Wood (bio-based)	80%	85-95%	4,197	1,606	27,105	1.88	1.65
Paper (bio-based)	77%	85-95%	4,592	1,199	13,240	1.87	1.92
Textile (bio-based)	13%	1-10%	465	153	1,949	2.14	2.14
Chemical (bio-based)	5%	3.7%	2,958	741	5,694	2.04	2.67
Energy (bio-based)	4%	1%	647	249	808	2.52	6.93
Construction (bio-based)	11%	n/a	632	205	2,549	2.28	2.21
Biotechnology	8%	n/a	362	289	2,475	1.39	1.59

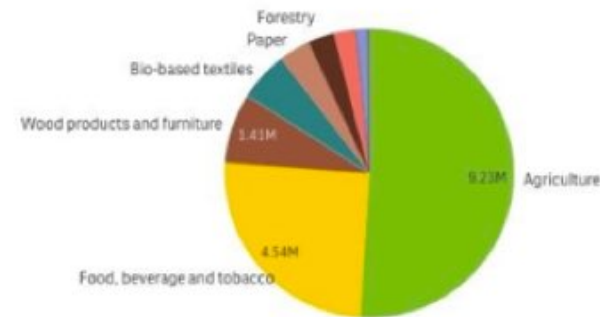
Source: Adapted from van Meijl et al. 2016

- Examples of input-based studies:
 - Campanini et al. 2018: use of input-output tables for the Italian sector of bio-based chemicals

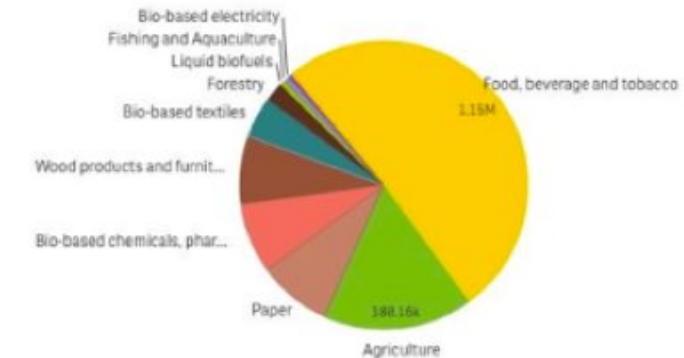


- Examples of output-based studies:
 - Ronzon et al. 2018
(<https://datam.jrc.ec.europa.eu>)

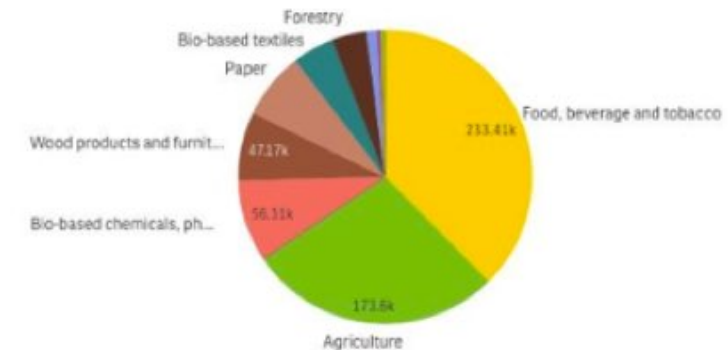
Employment in the bioeconomy by sectors in EU-28 (2015)
(number of people employed)



Turnover in the bioeconomy by sectors in EU-28 (2015)
(million €)

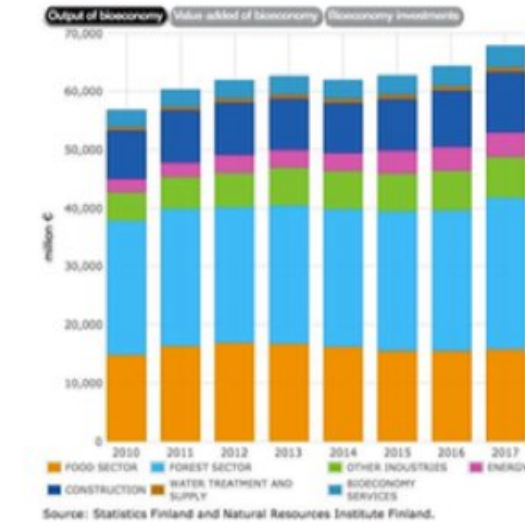


Value added in the bioeconomy by sectors in EU-28 (2015)
(million €)

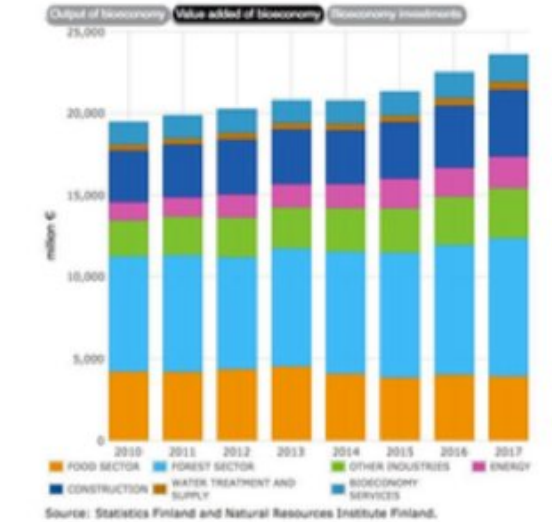


- Examples of output-based studies:
 - LUKE 2018
(<https://www.luke.fi/en/natural-resources/finnish-bioeconomy-in-numbers/>)

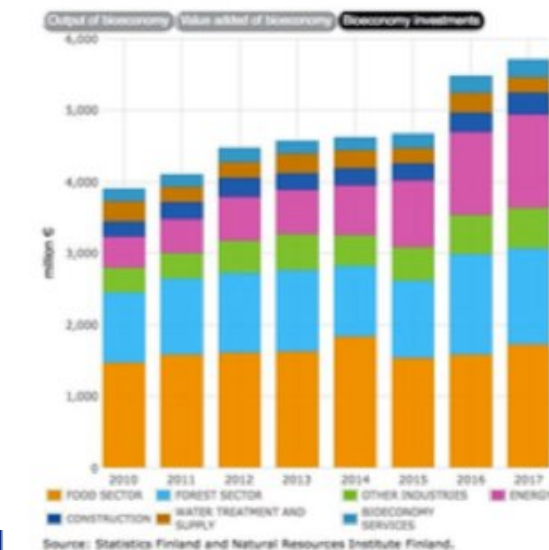
Output, value added and investments of the Finnish bioeconomy, 2010-2017.



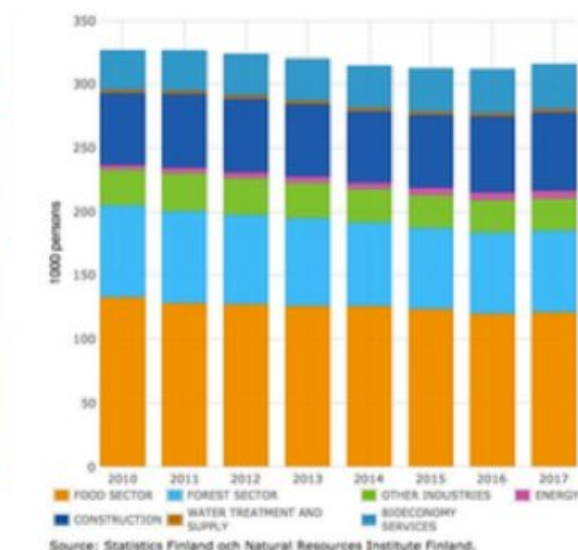
Output, value added and investments of the Finnish bioeconomy, 2010-2017.



Output, value added and investments of the Finnish bioeconomy, 2010-2017.



Number of people employed in the Finnish bioeconomy, 2010-2017.



- Examples of output-based studies:
 - Piotrowski et al. 2019
(<https://biconsortium.eu/library/bioeconomy-figures>)
 - Estimation of product-level bio-based shares in relevant manufacturing sectors (PRODCOM)
 - Calculation of economic indicators of the bioeconomy by linking PRODCOM to the Structural Business Statistics (SBS)

European Bioeconomy in Figures 2008 – 2016

Authors

Dr. Stephan Piotrowski, Michael Carus (nova-Institut), Dr. Dirk Carrez (BIC)

July 2019

Commissioned by



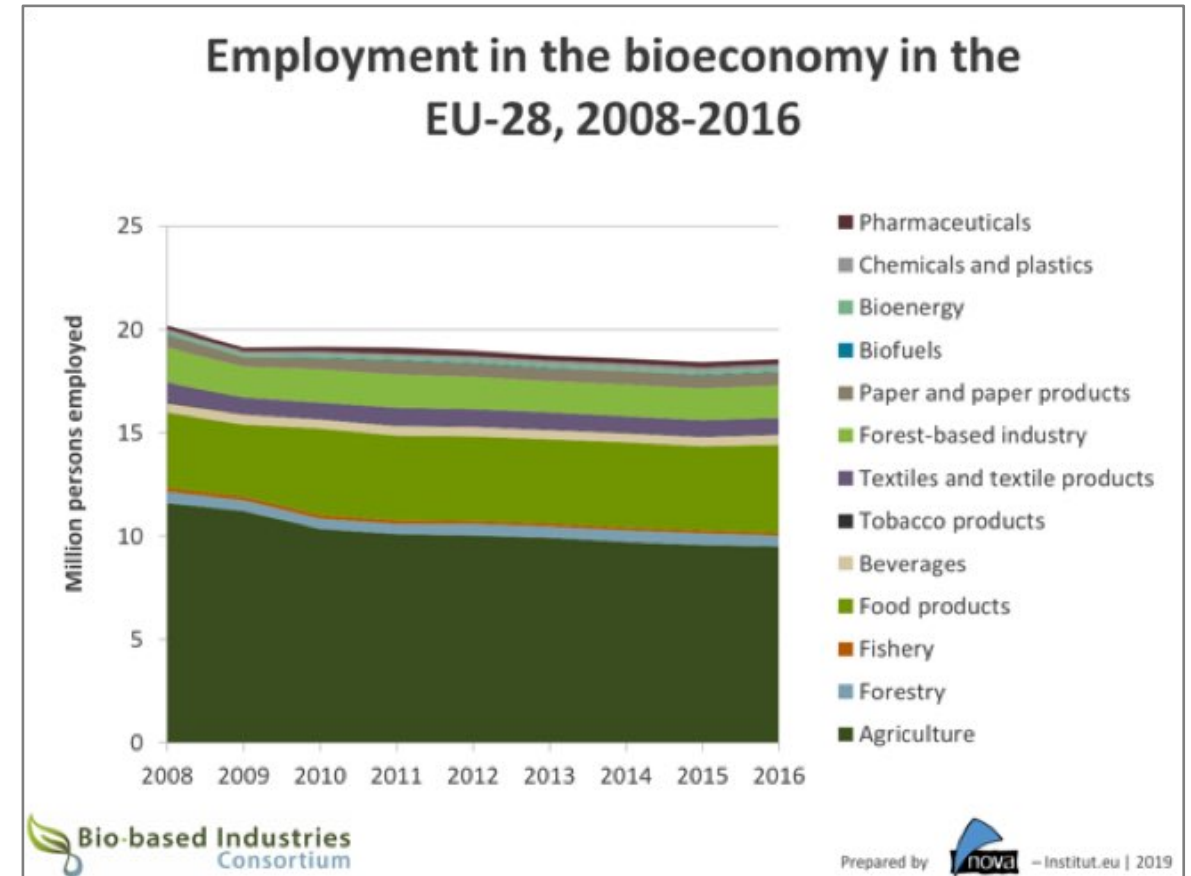
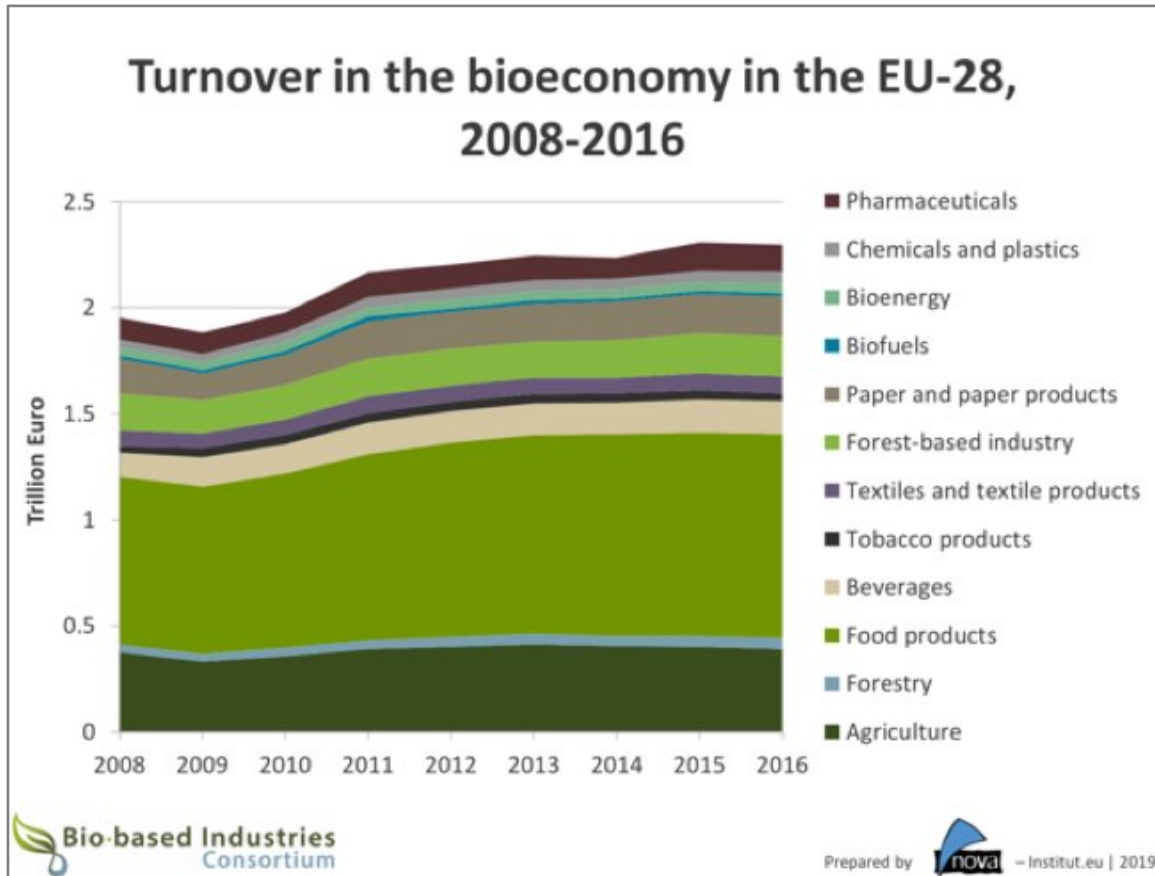
Forestry House, Rue du Luxembourg 66, B-1000 Brussels, Belgium
info@biconsortium.eu, www.biconsortium.eu

nova-Institute for Ecology and Innovation

Chemiepark Knapsack
Industriestraße 300
50354 Hürth
Germany

Tel. +49-2233-48-12 40
Fax +49-2233-48-14 50
Email: contact@nova-institut.de
Internet: www.nova-institute.eu





- This approach has generated useful results, as documented in several studies; recently with a case study on the oleochemical industry in Germany



Determination of Economic Indicators and Indicators for Monitoring the Progress of the Bio-Economy, 04/16-03/19, study for the Federal Ministry for Economic Affairs and Energy (BMWi)

- The outlined approach of estimating bio-based shares from production statistics is only applicable to the **manufacturing sectors** (section C of the NACE system) and the **electricity, gas, steam and air conditioning supply** (section D).
- These are the sectors where the BioMonitor project focusses on. For other sectors that are included in the scope of the bioeconomy, existing databases and methods will be reviewed and used with less focus on improving data, methods, and models.

Table 2: Sectors of the bioeconomy included in previous studies and in the BioMonitor project

	NACE	Fumagalli and Trenti (2014)	SAT-BBE (2015)	Effken et al. (2016)	European Commission (2018a)	Piotrowski et al. (2018)	Ronzon et al. (2017)	BioMonitor project
A01	Crop and animal production, hunting and related service activities	✓	✓	✓	✓	✓	✓	✓
A02	Forestry and logging	✓	✓	✓	✓	✓	✓	✓
A03	Fishing and aquaculture	✓	✓	✓	✓	✓	✓	✓
C10	Manufacture of food	✓	✓	✓	✓	✓	✓	✓✓
C11	Manufacture of beverages	✓	✓	✓	✓	✓	✓	✓✓
C12	Manufacture of tobacco	✓	✓	✓	✓	✓	✓	✓✓
C13	Manufacture of textiles	X	✓	✓	✓	✓	✓	✓✓
C14	Manufacture of wearing apparel	X	✓	✓	✓	✓	✓	✓✓
C15	Manufacture of leather and related products	X	✓	✓	✓	✓	✓	✓✓
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	✓	✓	✓	✓	✓	✓	✓✓
C17	Manufacture of paper and paper products	✓	✓	✓	✓	✓	✓	✓✓
C19	Manufacture of coke and refined petroleum products	X	✓	X	X	X	X	✓✓
C20	Manufacture of chemicals and chemical products	✓	✓	✓	✓	✓	✓	✓✓
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	X	X	✓	✓	✓	✓	✓✓
C22	Manufacture of rubber and plastic products	X	✓	X	✓	✓	✓	✓✓
C2365	Manufacture of fibre cement	X	X	X	X	X	X	✓✓
C31	Manufacture of furniture	X	✓	X	✓	✓	✓	✓✓
C7211	Research and experimental development on biotechnology	X	X	X	X	X	X	✓✓
D35	Electricity, gas, steam and air conditioning supply	X	✓	X	✓	✓	X	✓✓
D3511	Production of electricity	X	✓	X	X	X	✓	✓✓
E36	Water collection, treatment and supply	X	X	X	X	X	X	✓
E37	Sewerage	X	X	X	X	X	X	✓
E38	Waste collection, treatment and disposal activities; materials recovery	X	X	X	X	X	X	✓
E39	Remediation activities and other waste management services	X	X	X	X	X	X	✓
F41	Construction of buildings	X	✓	X	X	X	X	✓
F42	Civil engineering	X	✓	X	X	X	X	✓
G46	Wholesale trade, except of motor vehicles and motorcycles	X	X	✓	X	X	X	✓
G47	Retail trade, except of motor vehicles and motorcycles	X	X	✓	X	X	X	✓
H	Transportation and storage	X	X	X	X	X	X	✓
I55	Accommodation	X	X	✓	X	X	X	✓
I56	Food and beverage service activities	X	X	✓	X	X	X	✓
R9104	Botanical and zoological gardens and nature reserves activities	X	X	X	X	X	X	✓

✓ = Included, ✓✓ = Focus

- For the complete list of estimated bio-based shares, see the excel file:

Chemicals and chemical products											
Class	CPA	PRODCOM Code	Year of PRODCOM list	PRODCOM Name	Share of total production volume in the EU that has any bio-based content			Only for the bio-based share of production: share of bio-based content			Comments
					2008	2016	2024	2008	2016	2024	
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.10	2008 - 2016	Acrylic acid and its salts and other monocarboxylic acid	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.20	2008 - 2016	Esters of acrylic acid	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.30	2008 - 2016	Methacrylic acid and its salts	0%	0-5%	0-5%		100%	100%	Spekreijse et al. 2018
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.40	2008 - 2016	Esters of methacrylic acid	0%	0-5%	0-5%		100%	100%	Spekreijse et al. 2018
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.50	2008 - 2016	Oleic, linoleic or linolenic acids; their salts and esters	100%	100%	100%	100%	100%	100%	100% derived from animal and vegetable oil
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.63	2008 - 2016	Benzoic acid; its salts and esters	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.65	2008 - 2016	Benzoyl peroxide and benzoyl chloride	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.67	2008 - 2016	Phenylacetic acid; its salts and esters	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.70	2008 - 2016	Aromatic monocarboxylic acids, (anhydrides), halides, peroxides, peroxyacids, deriv	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.81	2016 -	Oxalic, azelaic, malonic, other, cyclanic, cylenic or cycloterpenic polycarboxylic acids	25-50%	25-50%	25-50%	100%	100%	100%	Azelaic acid is 100% bio-based; derived from
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.82	2016 -	Ethane-1,2-dicarboxylic acid or butanedioic acid (succinic acid) having a bio-based c	100%	100%	100%	100%	100%	100%	Bio-based by definition
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.83	2008 - 2015	Oxalic, azelaic, malonic, other, cyclanic, cylenic or cycloterpenic polycarboxylic acids	25-50%	25-50%	25-50%	100%	100%	100%	Azelaic acid is 100% bio-based; derived from
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.85	2008 - 2016	Adipic acid; its salts and esters	0%	0%	0-5%			100%	DSM is starting to produce small amounts of
20.14 Other organic basic chem	20.14.33 Unsaturated	20.14.33.87	2008 - 2016	Maleic anhydride	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.34 Aromatic pol	20.14.34.10	2008 - 2016	Dibutyl and dioctyl orthophthalates	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.34 Aromatic pol	20.14.34.20	2008 - 2016	Other esters of orthophthalic acid	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.34 Aromatic pol	20.14.34.30	2008 - 2016	Phthalic anhydride; terephthalic acid and its salts	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share
20.14 Other organic basic chem	20.14.34 Aromatic pol	20.14.34.40	2008 - 2016	Aromatic polycarboxylic acids, their anhydrides, halides, peroxides, peroxyacids and	0%	0%	0.2%			100%	After 2019 bio-naphtha derived share

- Practical example of the approach as adopted in Piotrowski et al. 2019 for the manufacturing sectors: class 13.10 Preparation and spinning of textiles (EU-28, 2016)

PRODCOM code	Name	Production value (mln Euro)	Production volume (t)	Share of total production volume that has any bio-based content	Share of bio-based content in the bio-based production volume	Bio-based production value (mln Euro)	Bio-based production volume (t)
13.10.25.00	Cotton, carded or combed	209.94	92,723	100%	100%	209.94	92,723
...	...						
13.10.31.00	Synthetic staple fibres, carded, combed or otherwise processed for spinning	300.00	170,000	0%	0%	0.00	-
13.10.32.00	Artificial staple fibres, carded, combed or otherwise processed for spinning	8.78	10,000	100%	50%	4.39	5,000
13.10		7.84	1,603,036			4.31	986,154

Bio-based share of class 13.10 of 55% in terms of production value

- The Structural Business Statistics (SBS) contain a number of economic indicators at the NACE class level (in million Euro), such as:
 - Turnover
 - Value added
 - Gross operating surplus
 - Number of employees
 - ...
- The calculated bio-based share in the total production value of a NACE class could be applied to the economic indicators at the class level.

- Then, it is possible to make a rough calculation to generate economic indicators for the bio-based sectors:

Economic indicators in SBS	Unit	Values for class 13.10	Share attributed to bio-based textiles in class 13.10 (55%)
Turnover	mIn Euro	8,378	4,608
Number of employees	Employees	51,908	28,549
Value added at factor cost	mIn Euro	2,034	1,119
Gross operating surplus	mIn Euro	730	402
Personnel cost	mIn Euro	1,300	715
...

- Cross-check with market report:

EU(28): Fiber and Yarn Production Profile

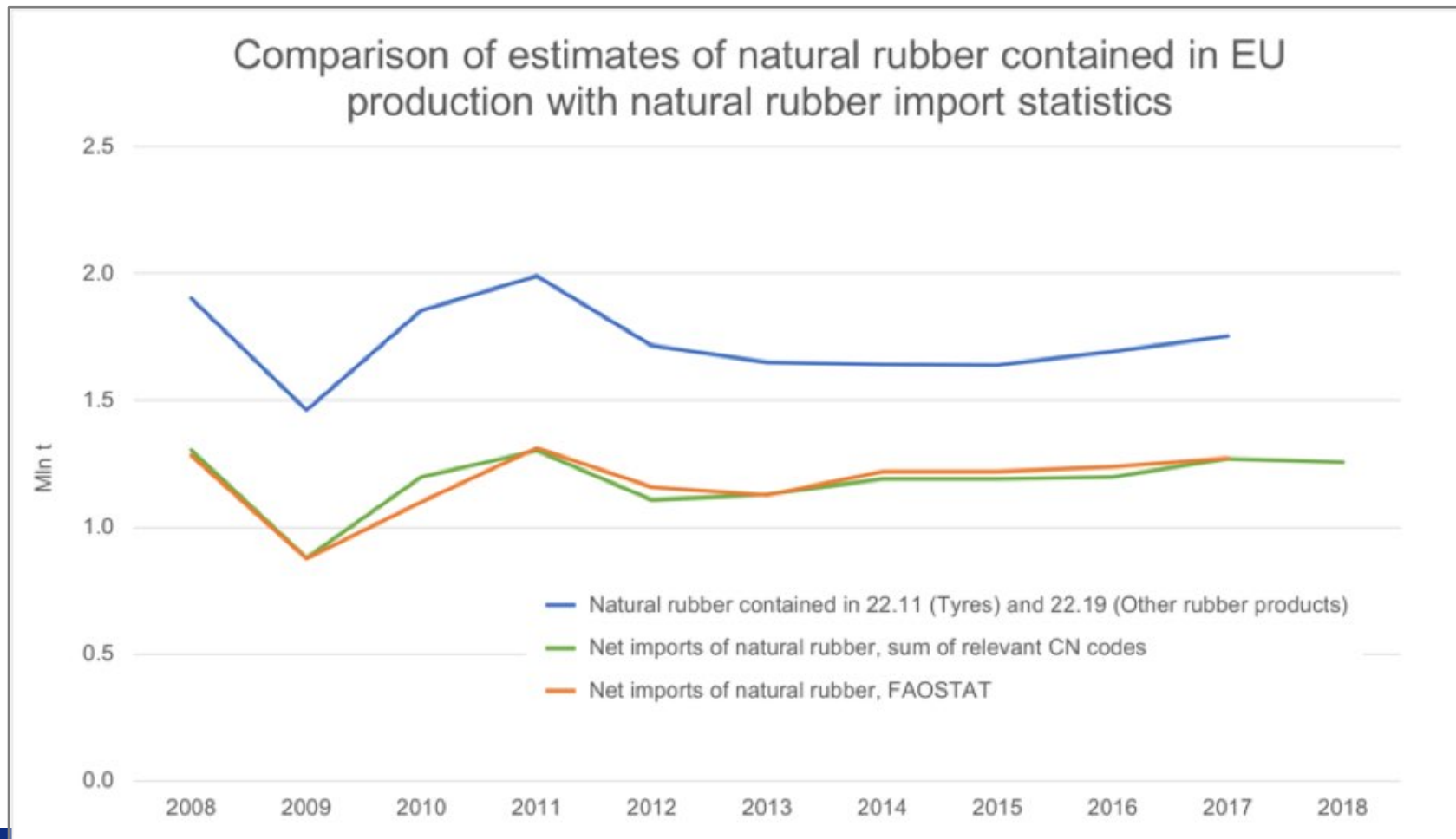
in 1,000 tonnes	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A) Staple Fiber													
· Cotton	540	365	326	257	237	223	340	313	346	348	276	268	308
· Other Natural	342	288	279	249	206	201	176	218	208	214	234	247	263
· Manmade	2'154	2'117	2'074	1'867	1'684	1'750	1'695	1'692	1'615	1'601	1'542	1'516	1'516
TOTAL Staple Fibers	3'035	2'769	2'679	2'372	2'127	2'175	2'211	2'222	2'169	2'163	2'052	2'031	2'086
B) Yarn													
· Filament Yarn	1'182	1'150	1'077	901	706	804	801	719	696	680	664	653	657
· Cotton Yarn	760	709	558	415	302	310	272	233	217	198	178	171	173

Source: The Fiber Year 2019

ca. 30% bio-based; total:
2.9 mln t ...

- Products containing natural rubber can be found in NACE division C22 (Rubber and plastic products).
- Product codes do not differentiate between synthetic and natural rubber but experts can solidly estimate the shares of natural rubber in different products:
 - Car tyres contain about 15-30% natural rubber
 - Tyres for heavy vehicles (trucks, buses etc.) contain about 30-40% natural rubber
 - 25% of natural rubber is used in non-tyre products
- With this information, the use of natural rubber in products manufactured in the EU is calculated and cross-checked with other sources.
- First, EU production in PRODCOM needed to be converted to kg because production of tyres is recorded in pieces.

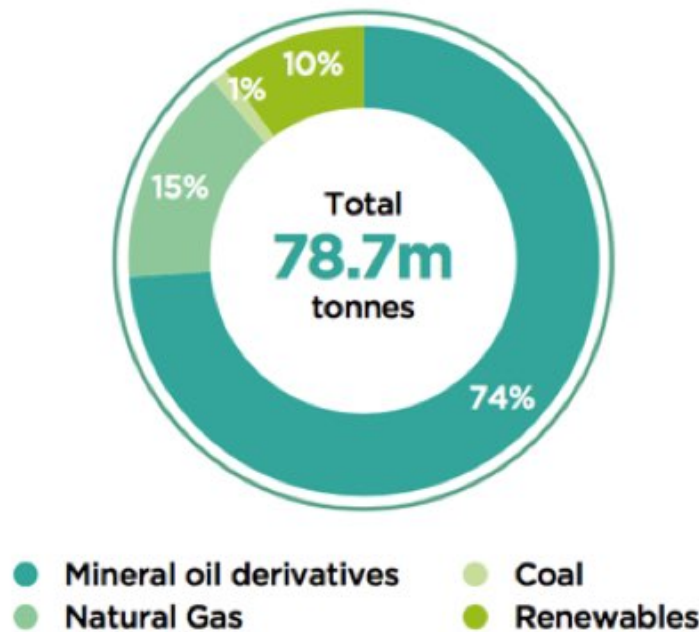
- Result: the estimated use of natural rubber in the EU fits well to import statistics, but seems a bit overestimated:



- Result: the estimated use of natural rubber in the EU fits well to import statistics, but seems a bit overestimated:

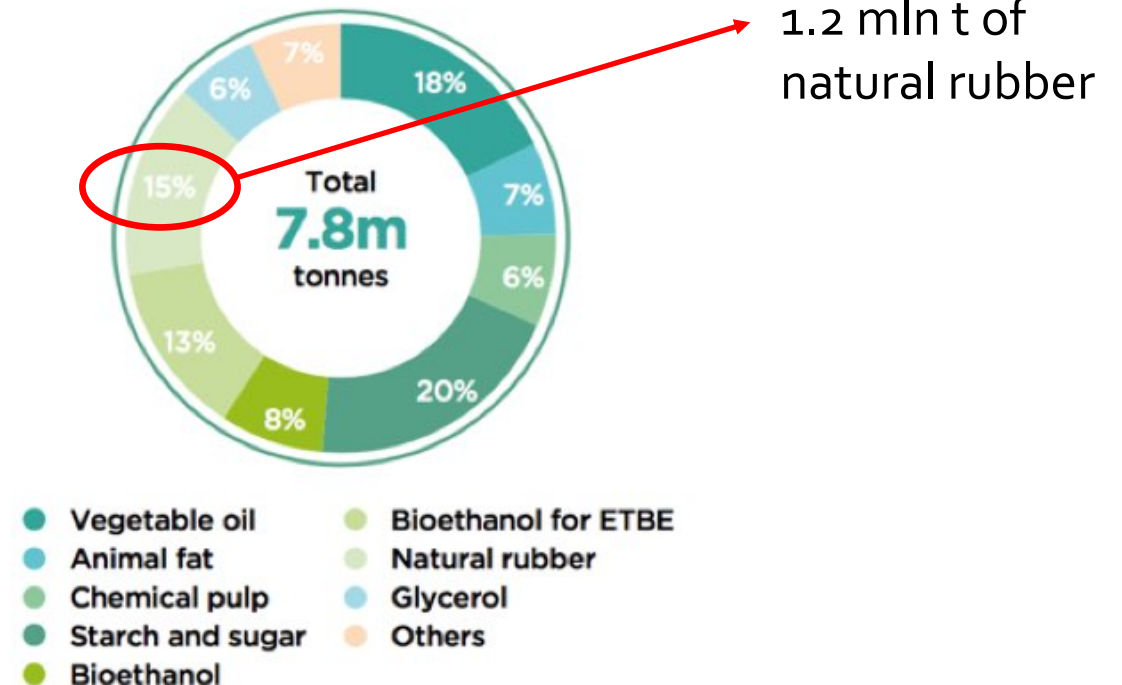
Organic raw materials use

Shares in total organic raw materials – material (feedstock) use only.
EU chemical industry, 2015.



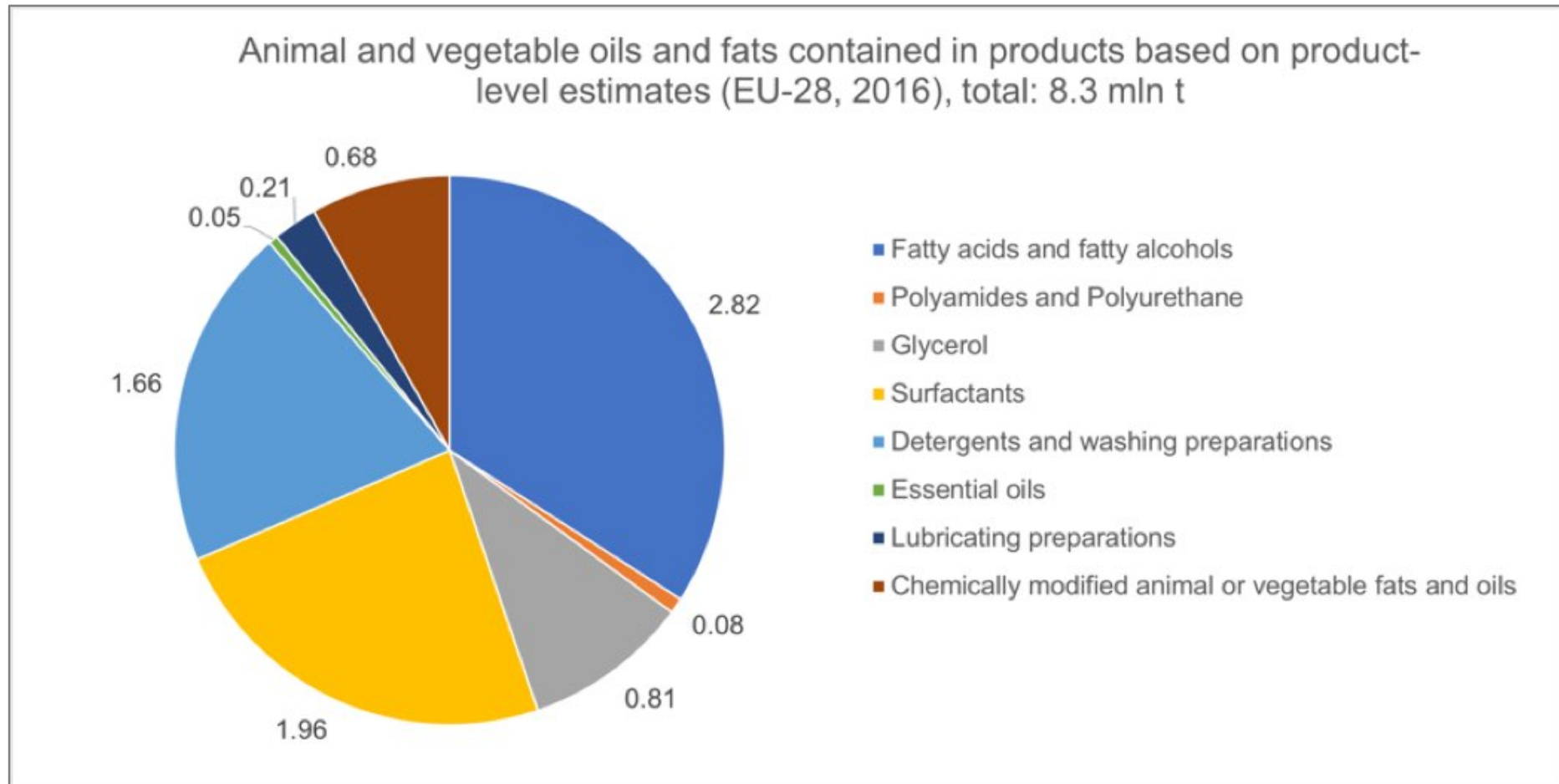
Renewable shares: detailed breakdown

Renewables shares in total renewables.
EU chemical industry, 2015.

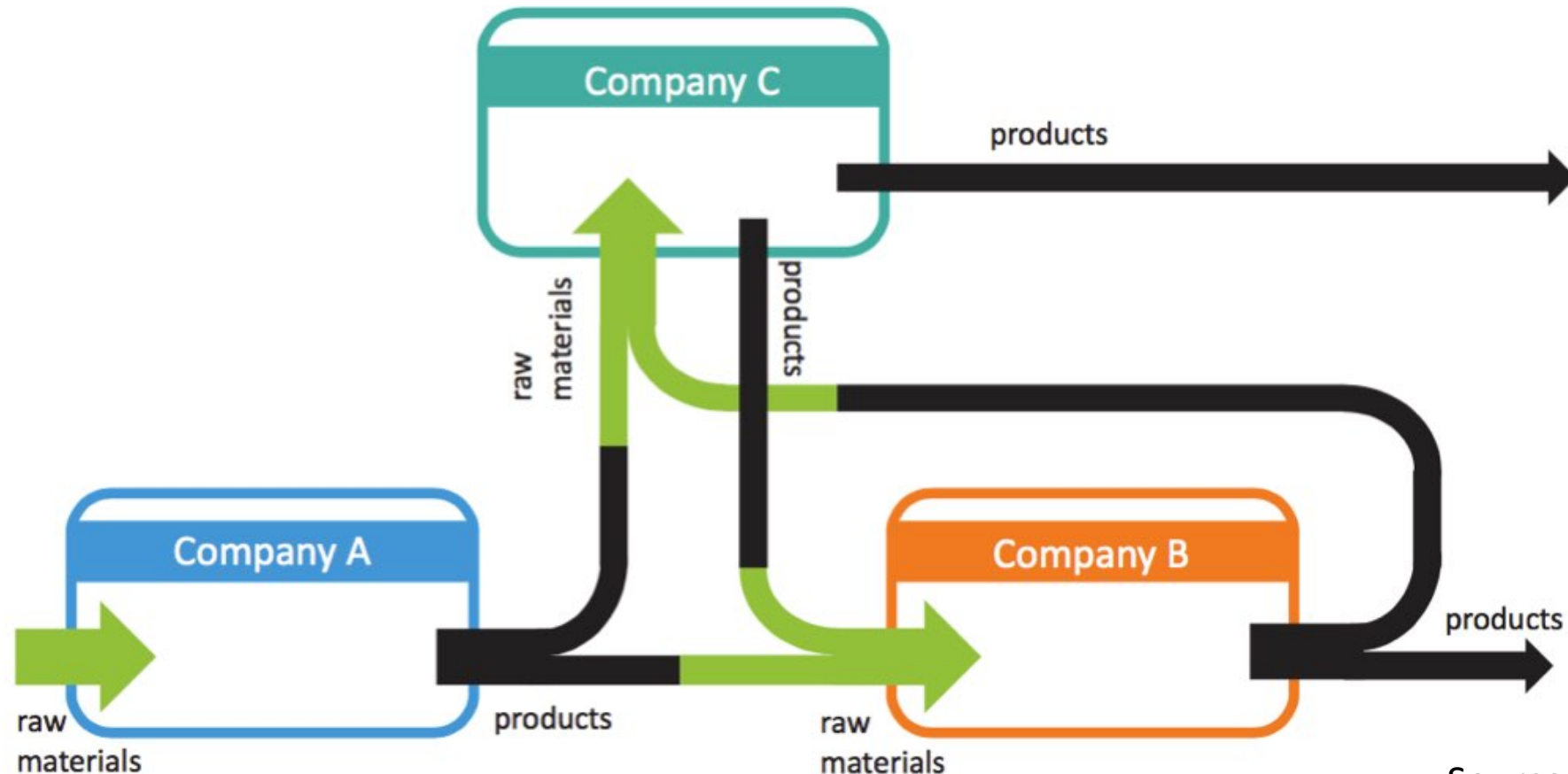


Source: CEFIC 2019

- Challenge: the chemical industry is highly intertwined – double-counting of production volumes in PRODCOM is difficult to avoid:



- Challenge: the chemical industry is highly intertwined – double-counting of production volumes in PRODCOM is difficult to avoid:

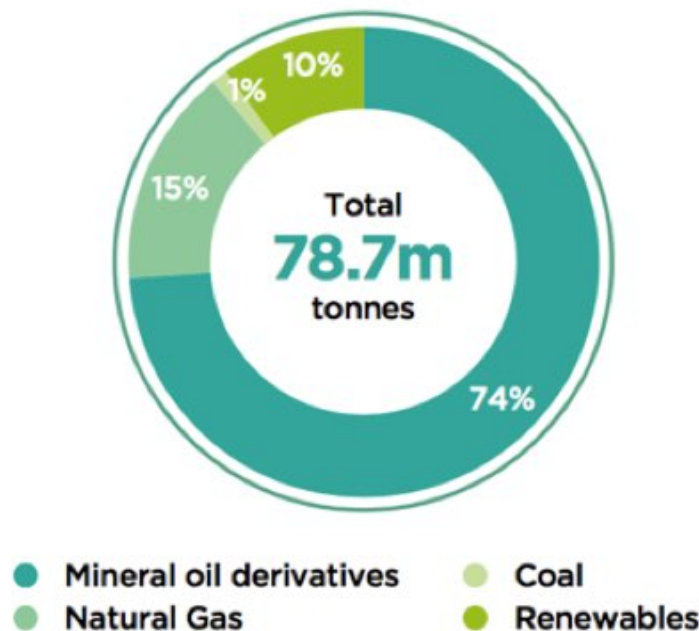


Source: Benzing 2016

- Challenge: the chemical industry is highly intertwined – double-counting of production volumes in PRODCOM is difficult to avoid:

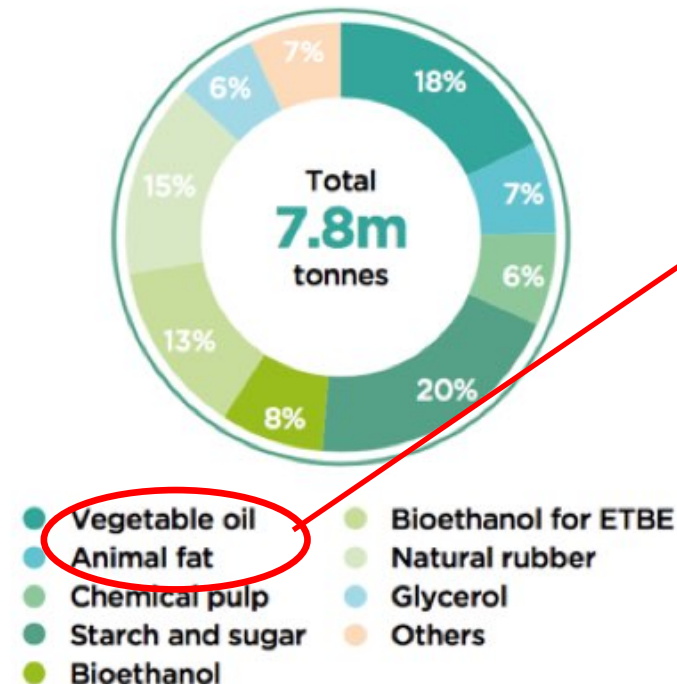
Organic raw materials use

Shares in total organic raw materials – material (feedstock) use only.
EU chemical industry, 2015.



Renewable shares: detailed breakdown

Renewables shares in total renewables.
EU chemical industry, 2015.



1.4 mln t vegetable oil
0.5 mln t animal fat

Source: CEFIC 2019

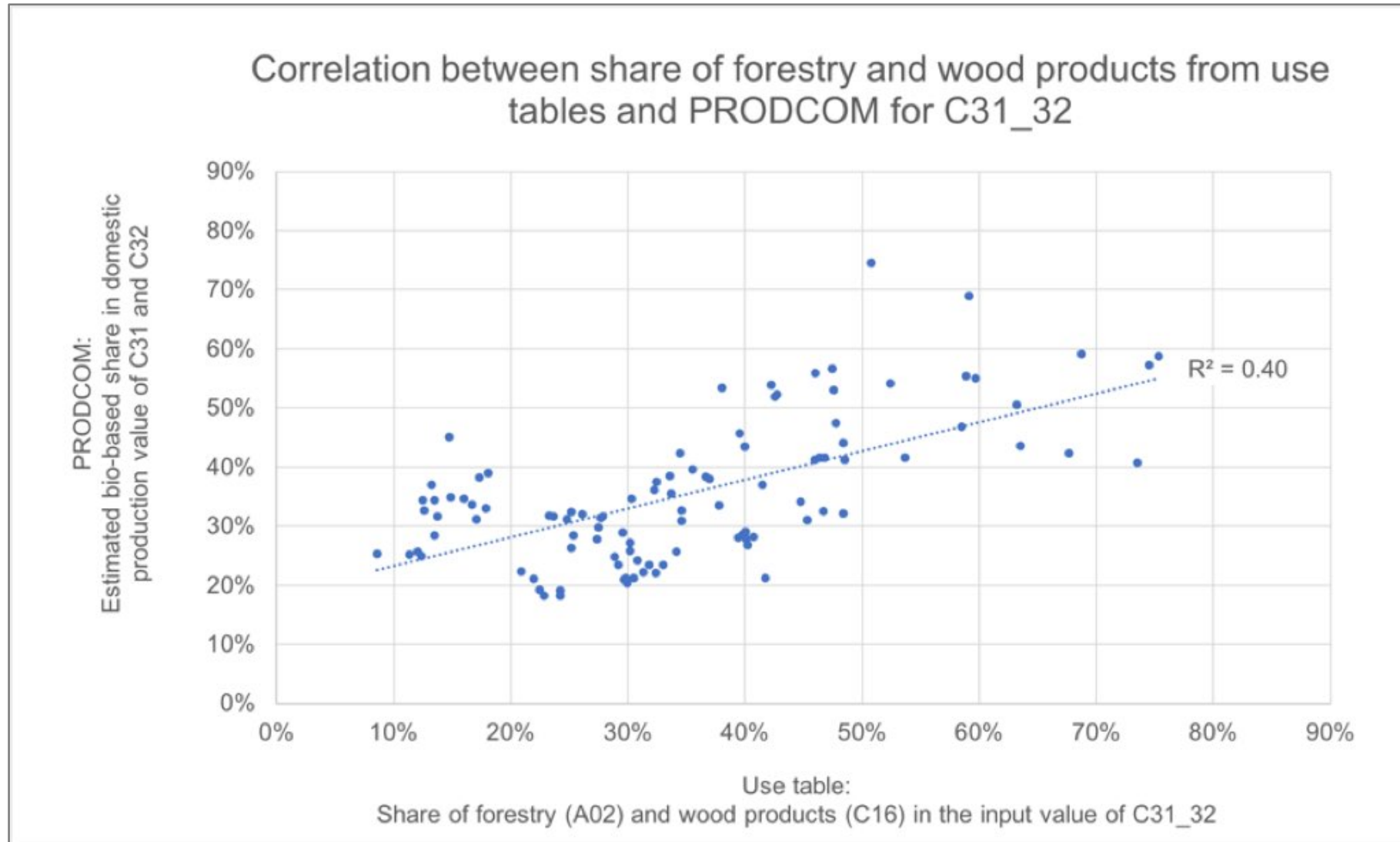
- Another way to cross-check the estimates with the **supply and use tables** (SUT).
- The **use tables** show products that are used by industrial sectors and the **supply tables** shows the supply of products by these sectors. SUT in Eurostat distinguish 64 products and 64 industries. SUT show the interlinkages of the economy only in monetary, not physical terms.
- In the 64x64 SUT, furniture is represented in the combined sector C31_32, where manufacture of furniture (C31) is combined with other manufacturing (C32).
- The following table shows a sample of the use table for **Poland for 2015**. In this example, it could be hypothesised that the share of forestry and wood products for the combined sector C31_32 (Furniture and other manufacturing) should correlate with the estimated bio-based share of this sector from PRODCOM.

	A01 Crop and animal production, hunting and related service activities	A02 Forestry and logging	...	C31_32 Manufacture of furniture; other manufacturing
A01 Products of agriculture, hunting and related services	3,823	15		3
A02 Products of forestry, logging and related services	13	795		90
A03 Fish and other fishing product	1	1		0
B Mining and quarrying	118	9		7
C10_12 Food, beverages and tobacco products	3,803	29		122
C13_15 Textiles, wearing apparel, leather and related products	2	8		601
C16 Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	56	41		1,715
C17 Paper and paper products	21	7		304
C19 Coke and refined petroleum products	478	18		74
C20 Chemicals and chemical products	2,104	34		509
C21 Basic pharmaceutical products and pharmaceutical preparations	7	0		1
C22 Rubber and plastic products	45	15		582
C23 Other non-metallic mineral products	89	7		180
C24 Basic metals	11	2		321
...

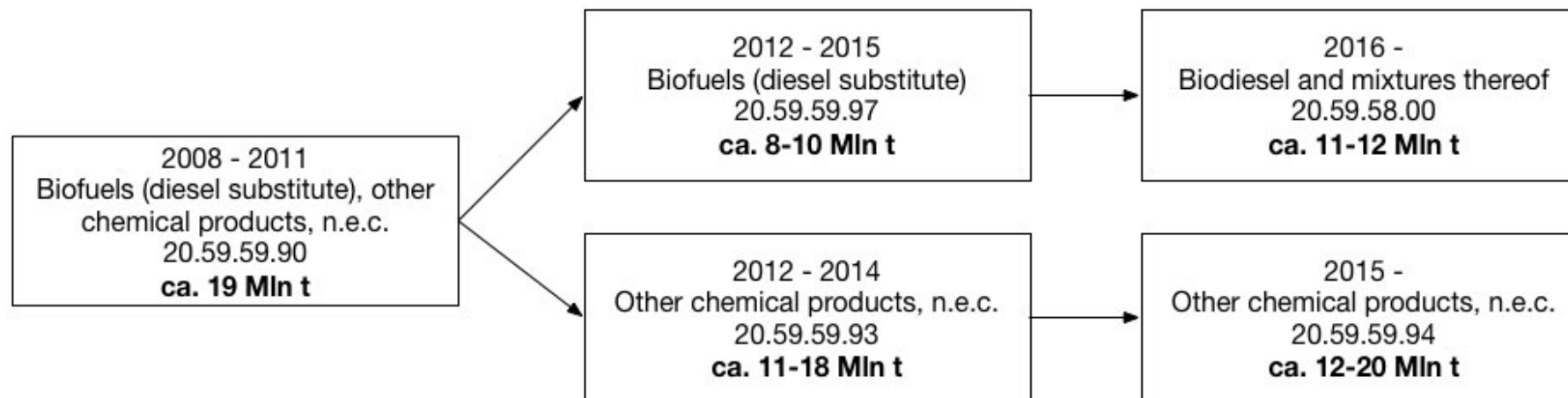
	A01 Crop and animal production, hunting and related service activities	A02 Forestry and logging	...	C31_32 Manufacture of furniture; other manufacturing
A01 Products of agriculture, hunting and related services	3,823	15		3
A02 Products of forestry, logging and related services	13	795		90
A03 Fish and other fishing product	1	1		0
B Mining and quarrying	118	9		7
C10_12 Food, beverages and tobacco products	3,803	29		122
C13_15 Textiles, wearing apparel, leather and related products	2	8		601
C16 Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	56	41		1,715
C17 Paper and paper products	21	7		304
C19 Coke and refined petroleum products	478	18		74
C20 Chemicals and chemical products	2,104	34		509
C21 Basic pharmaceutical products and pharmaceutical preparations	7	0		1
C22 Rubber and plastic products	45	15		582
C23 Other non-metallic mineral products	89	7		180
C24 Basic metals	11	2		321
...

Products used in industrial sectors

	A01 Crop and animal production, hunting and related service activities	A02 Forestry and logging	...	C31_32 Manufacture of furniture; other manufacturing
A01 Products of agriculture, hunting and related services	3,823	15		3
A02 Products of forestry, logging and related services	13	795		90
A03 Fish and other fishing product	1	1		0
B Mining and quarrying	118	9	40% share of input value	7
C10_12 Food, beverages and tobacco products	3,803	29		122
C13_15 Textiles, wearing apparel, leather and related products	2	8		601
C16 Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	56	41		1,715
C17 Paper and paper products	21	7		304
C19 Coke and refined petroleum products	478	18		74
C20 Chemicals and chemical products	2,104	34		509
C21 Basic pharmaceutical products and pharmaceutical preparations	7	0		1
C22 Rubber and plastic products	45	15		582
C23 Other non-metallic mineral products	89	7		180
C24 Basic metals	11	2		321
...



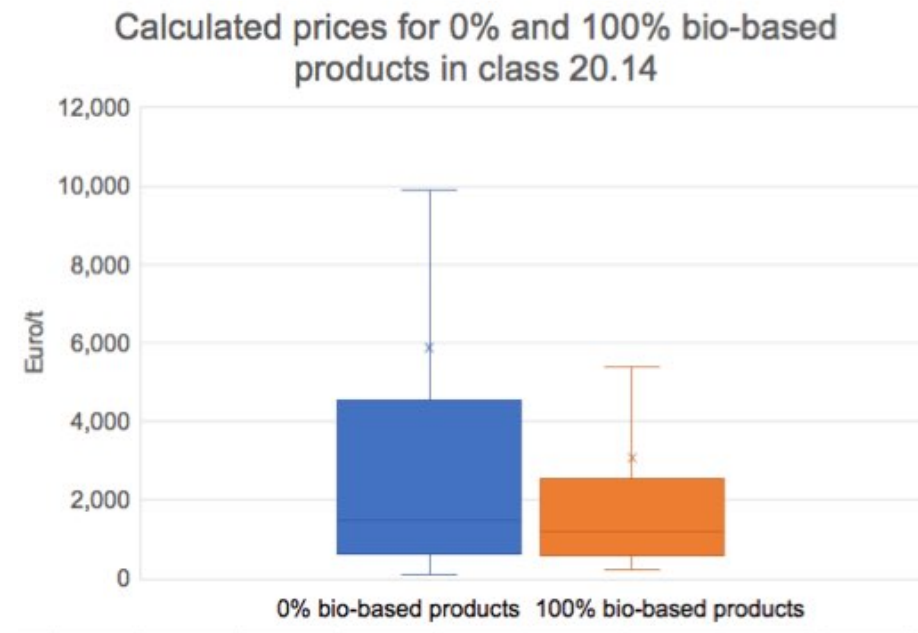
- The main advantages of the outlined approach is that it requires relatively little effort in data collection and it is transparent and easy to implement. Eurostat data is, in principle, completely available for all Member States and over time.
- However, several shortcomings and challenges have also been identified.
- Frequent changes of the PRODCOM list over time can make it difficult to track the same products over time:



- The approach highly depends on expert information for each bio-based sector.
- The description of a PRODCOM code is sometimes not sufficient to understand what products are really included in it; example: 20.14.51.39 Other organo-sulphur compounds. As a solution, one can look up the corresponding CN codes as well as the CN and HS explanatory notes:

20.14.51.39	{	29.30.50.00	Captafol "ISO" and methamidophos "ISO"
		29.30.90.13	Cysteine and cystine
		29.30.90.16	Derivatives of cysteine or of cystine
		29.30.90.20	Thiodiglycol "INN" "2,2'-thiodiethanol"
		29.30.90.30	DL-2-hydroxy-4-"methylthio"butyric acid
		29.30.90.40	2,2'-Thiodiethyl bis[3-"3,5-di-tert-butyl-4-hydroxyphenyl"propionate]
		29.30.90.50	Mixture of isomers [...]
		29.30.90.60	2-(N,N-Diethylamino)ethanethiol
		29.30.90.99	[Other] Organo-sulphur compounds

- While the problem of missing values in Eurostat is not specific to the bioeconomy sectors, it may be particularly severe for particular, new bio-based products that are only produced by a small number of companies.
- The assumption of a direct relationship between bio-based shares in production volume, production value and economic indicators is a simplification.
 - How serious is the problem?
 - How could it be overcome?



- Furthermore, the following methodological challenges remain:
 - How to come up with **Member State specific shares?**
 - Shares of partly bio-based products:

NACE division	Share of partly bio-based products
C13 Textiles	22% (10)
C14 Wearing apparel	90% (118)
C15 Leather and related products	69% (34)
C16 Wood and products of wood	0%
C17 Paper and paper products	15% (16)
C20 Chemicals and chemical products	22% (127)
C21 Pharmaceuticals	37% (19)
C22 Rubber and plastic products	80% (126)
C31 Furniture	44% (14)

- Furthermore, the following methodological challenges remain:
 - How to track estimated shares over **time**?
 - How to include **international trade**?
 - Problem of **double-counting**: the biomass contained in manufactured products cannot be added up for a cross-check with the available biomass because PRODCOM records raw materials, intermediates and end products → could be overcome with insights into the specific value chains.



Monitoring the Bioeconomy

Thank you.



This project has received funding from the
European Union's Horizon 2020 research and innovation
programme under grant agreement No. 773297