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A systematic analysis of EU publications on the Circular Economy

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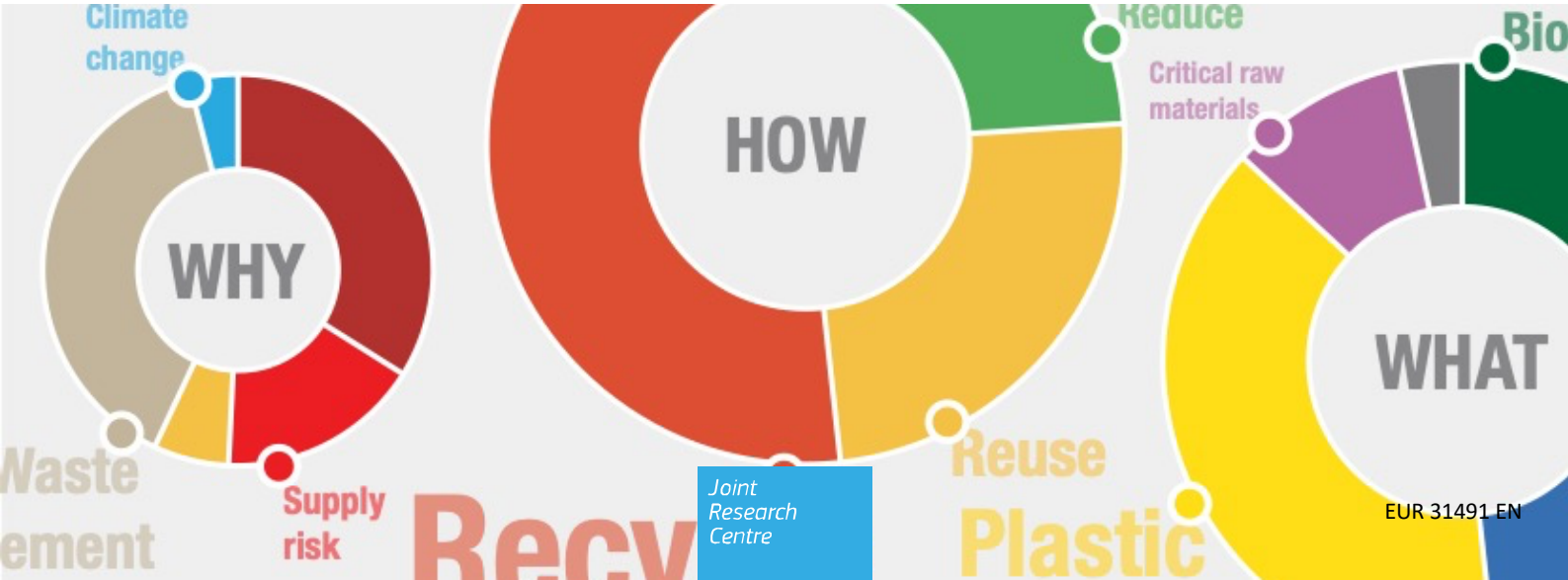

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Contents

Abstract

This report proposes a systematic analysis of all EU publications on the circular economy available in the database of the Publications Office of the European Union until December 31, 2022. Main results indicate that: Publications started to appear soon before the release of the first Circular Economy Action Plan (2015) and grew in number towards the second Circular Economy Action Plan (2020); Most publications originate from a few Directorate Generals of the European Commission, followed distantly by the European Environment Agency; Recycling is, by far, the circular economy strategy most frequently discussed, while reducing and reusing are mentioned significantly less despite their higher potential and priority position in the EU waste hierarchy; A major focus is placed on plastic in comparison to all other material categories including biomass, non-metallic minerals, metals and alloys, critical materials, and fossil fuels; “ecological issues and waste management” and “economic growth and innovation” are frequently mentioned as rationales behind the need for circularity actions, while the discussion on “resource concerns and supply risk”, “employment and job creation” and “climate change and emissions” is limited. These results are briefly discussed in the report, to inform future research in support of potential policy options to enhance the circular economy in the EU.

Acknowledgements

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Executive summary

Against the background of the global environmental and climate crisis, the emergence of circular economy policy in the European Union (EU) is a remarkable phenomenon. Aiming to better understand it, this report proposes an analysis of EU publications on the subject, retrieved with a systematic search of documents from the database of the Publications Office of the European Union until December 31, 2022.

The analysis is carried out with a corpus linguistics method, which allows to examine, categorize, and understand large amounts of written content by counting underlying numbers of document features and keywords rigorously selected according to existing theories.

Results are provided in terms of: 1) when the circular economy crystallized as a policy program; 2) who has been catalysing this development within EU institutions, agencies and bodies; 3) how the policy development has shaped and moulded scientific theories into actionable strategies; 4) what materials and industry sectors have so far received more attention from policymaking; 5) why the policy program is regarded as important according to the official EU stance.

When?

EU Publications on circular economy started to appear soon before the release of the first Circular Economy Action Plan (2015) and grew in number towards the second Circular Economy Action Plan (2020). However, the numbers seem to have levelled off in recent years.

Who?

Most publications originate from specific actors. The European Commission plays a primary role in terms of number of publications, followed distantly by the European Environment Agency. Within the European Commission, main authors are found in the Directorate General for Environment (DG ENV), Directorate General Joint Research Centre (DG JRC) and the Directorate General for Research and Innovation (DG RTD).

How?

Recycling is, by far, the circular economy strategy most frequently mentioned in the publications. Despite their higher potential and prioritization in the EU waste hierarchy, reducing and reusing are mentioned significantly less. In addition, while a prominent focus is placed on resources, materials and products, and a moderate focus is placed at a higher level on industry sectors, the same cannot be said for organizations' business models, industrial clusters, and value chains, which seem to be considered only to a limited extent within the ongoing discussion.

What?

Plastic is the material category discussed the most. Despite their importance, other material categories, including biomass, non-metallic minerals, metals and alloys, critical materials, and fossil fuels, are mentioned significantly less in the publications. Regarding the sectorial focus, there is balance across aerospace & defence, agri-food & forestry, construction & demolition, digital & electronics, energy & renewables, mining & heavy industry, transport & automotive, textile & apparel.

Why?

"Ecological issues and waste management" and "economic growth and innovation" are mentioned rather frequently in the publications, indicating that they are possibly regarded as the main drivers behind circular economy policies. "Resource concerns and supply risk" are discussed significantly less, but still moderately in view of their crucial importance. The discussion on "employment and job creation" is very limited, suggesting that societal factors might remain a minor driver in the circular economy agenda. Conversely, the discussion on the nexus between circular economy and "climate change and emissions", despite being still in its infancy, has intensified drastically in the documents published during the von der Leyen commission compared to those released under the Juncker mandate.

These results are briefly discussed in the report, with the intention of informing future and more focused research, geared toward specific policy options.

1 Introduction

The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible (European Parliament, 2020). With the publication of the first Circular Economy Action Plan in 2015, followed by a second Circular Economy Action Plan in 2020, circularity thinking was embedded into EU policy (European Commission, 2015, 2020a). The emergence of circular economy policy is a remarkable phenomenon (Calisto Friant et al., 2021; Kovacic et al., 2019). Recently, Kovacic et al. (2019) provided important insights regarding its theoretical roots and historical antecedents, connecting those with current developments and questions that deserve attention going forward. Seminal ideas on the subject emerged in the 1960s as a response to raising awareness upon environmental issues and the incompatibility of perpetual economic growth with the physical limits of our planet (Carson, 1962; Fuller, 1969; Meadows et al., 1972). This debate on the need of a more sustainable development has been embraced and led by the United Nations, struggling however to find concrete and scalable approaches to reconcile trade-offs between economic, societal, and environmental priorities (Brundtland, 1987; Elkington, 1998). A key element in this sense, is the notion of circularity, with the idea of closing resource loops, using waste as a resource to optimize environmental and economic performance at once (Odum, 1973; Stahel, 1994). These crystallized until 2013, when the Ellen MacArthur foundation effectively disseminated them across industry as a systems solution framework called "the circular economy" (Ellen MacArthur Foundation, 2013). This was defined as:

"an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models".

EU policymaking picked up this concept in 2014 with an official communication "towards the circular economy – a zero waste programme for Europe" (European Commission, 2014). On these grounds, the first Circular Economy Action Plans was released in 2015, with the aim to foster a dialogue on the subject across EU institutions and Directorate Generals (DGs) of the Commission beyond waste management, connecting to the policy debate on supply risk and climate change amongst other things (Kovacic et al., 2019). In 2016 the "Ecodesign Working Plan" stressed the importance of the innovation dimension to address waste management and other sustainability issues in a more holistic way (European Commission, 2016). In parallel, the discussion on the need of indicators to measure the progress of circular economy policy resulted in the "Raw Materials Scoreboard" and eventually in the 2018 "Monitoring Framework" (European Commission, 2018). The second Circular Economy Action Plan released in 2020 set the ambitious vision to lead the way on the global stage in fostering economic prosperity and resilience, while tackling global challenges like biodiversity loss, waste, and pollution (European Commission, 2020a). As multiple policy DGs work together on programs and projects to make this happen, with a common denominator in achieving "win-win" solutions to environmental and economic problems, different views on what should be prioritized, and how, are also present (Kovacic et al., 2019). Considering that the transition to a circular economy is part of the broader EU Green Deal, it becomes essential to better understand, disentangle and communicate the multifaceted nature of these views. With the von der Leyen Commission ending in 2024, it is thus worthwhile to take stock of what has been the specific focus of circular economy so far in the EU. This is valuable for policy makers to have a systematic account of this focus, in view of potential actions to steer and recalibrate it, when needed. Accordingly, the present report provides a thorough analysis of the entire body of EU publications on the subject, retrieved with a systematic search of documents from the EU publications office database until December 31, 2022. The analysis we present here is based on an analysis of these publications, using a corpus linguistics method. The ultimate objective of this study is to understand which circular economy aspects have been properly addressed so far and which ones could merit more attention. In turn, this is relevant to inform both policymaking and scientific efforts on the circular economy going forward.

The remainder of this report is structured as follows. The next section explains method used for the analysis. Follows a section presenting the results in a descriptive way. Finally, in the last section, the results are briefly discussed to conclude.

2 Method

We conducted a comprehensive analysis of all available EU publications on the circular economy. We adopted a corpus linguistics method. This is a scientific method to systematically investigate the language content (i.e., words and sentences) within a large collection of authentic text (Stefanowitsch, 2020).

The method has already been used in similar contexts. For example, some authors used it to examine the focus of EU policies on eco-innovation within the Horizon 2020 Programme (Colombo et al., 2019) while others analysed EU legislation on the circular economy enacted during the Juncker Commission (Calisto Friant et al., 2021).

The method is based on five steps: choosing the object of the research, stating the research questions, defining measurable search constructs, collecting, and processing the data, evaluating the data (Stefanowitsch, 2020). The activities performed within each step are further detailed in the following paragraphs.

2.1 Step 1 – Choosing the object of the research

This step entails defining the subject that is going to be investigated, and consequently creating a corpus for the analysis.

The investigated subject is the circular economy policy program in the EU. The analysed corpus is the body of EU publications on the subject. To create this corpus, a systematic search in the Publications Office of the European Union was performed, to retrieve all publications produced until 31/12/2022, containing "circular economy" at least once in the full text of the document. EU publications comprise various documents including but not limited to policy and science for policy reports, technical reports, policy briefs and official communications authored from all EU institutions, agencies, and bodies. EU laws were excluded from the search. The search resulted in a first sample of 2436 documents. To ensure that the corpus would contain only documents focusing primarily on the circular economy (rather than only mentioning it) the sample was reduced by removing duplicates and including only the documents containing the word "circular" in the title, or abstract or author keywords. This resulted in a final corpus of 498 documents, published between 25/02/2014 and 13/12/2022, which was used for the analysis in the following steps.

2.2 Step 2 – Stating the research questions

This step entails narrowing down the scope of the corpus analysis through the definition of specific research questions.

The aim is to gain a broad, comprehensive overview upon the content and features of the documents inside the corpus. Different research questions were thus defined across five macro-areas:

- When – were the documents published?
- Who – authored the documents?
- How – is circularity considered in the documents?
- What – materials and sectors do the documents focus on?
- Why – is circularity important according to the documents?

2.3 Step 3 – Defining measurable search constructs

This step entails defining measurable search constructs to operationalize the research question.

The first (When) and second (Who) research questions were operationalized by counting the number of documents in the corpus respectively by year of publication, and by corporate author (i.e., different EU institutions and DGs of the European Commission), which is common practice in systematic literature review

studies (Torraco, 2005). The third (How), fourth (What) and fifth (Why) research questions were operationalized by counting the number of keywords across all the documents within the entire corpus. This approach is central to content analysis in corpus linguistics studies (Stefanowitsch, 2020). However, to ensure its methodological rigor and validity of results, it is essential to avoid selecting keywords subjectively, but rather deriving them from solid theoretical foundations (Calisto Friant et al., 2021; Colombo et al., 2019). How this was done in the context of this study is detailed below and summarized in Table 1.

The third question (How) was operationalized in two parts, focusing respectively on circularity strategies and units of analysis. For the first part, 11 circularity strategies (i.e., keywords) were identified based on academic literature, mirroring and complementing existing EU publications and policy frameworks (Delgado et al., 2009; European Commission, 2008; Kirchherr et al., 2017). For the second part, 8 circularity units of analysis (i.e., keywords) were identified and clustered into four levels, based on academic literature and EU policy documents as well (European Commission, 2020a; Ghisellini et al., 2016; Saidani et al., 2019; Tognato de Oliveira et al., 2021). The fourth question (What) was operationalized in two parts, focusing respectively on materials and sectors. For the first part, a comprehensive list of materials was defined and clustered in 6 categories (i.e., keywords), based primarily on EUROSTAT classification slightly adapted and integrated as necessary with several additional official sources from public bodies and industry associations (European Commission, 2020b; Eurostat, 2018; Plastics Europe, 2021; U.S. Geological Survey, 2022). For the second part, a comprehensive list of products categories was defined and clustered in 8 industry sectors based on EUROSTAT classification integrated as necessary with official EU sources (European Commission, 2021; Eurostat, 2008). The fifth question (Why) was operationalized by defining five rationales (i.e., keywords) behind circular economy as a policy program, in line with official EU documents (European Commission, 2020a).

Table 1. List of selected keywords used for the circular economy content analysis in the corpus.

HOW	**WHAT**	**WHY**
Circularity strategies • Regenerate • Reduce • Rethink • Redesign • Reuse • Repair • Refurbish • Remanufacture • Repurpose • Recycle • Recover **Circularity units of analysis** • Resource (nano level) • Material (nano level) • Component (nano level) • Product (nano level) • Organization (micro level) • Industrial cluster (meso level) • Value chain (meso level) • Industry sector (macro level)	**Material categories** • Biomass (e.g., wood, cotton, etc.) • Non-metallic mineral materials (e.g., cement, sand, etc.) • Metal and alloy materials (e.g., iron and steel, aluminium, etc.) • Plastic materials (e.g., polypropylene, polyethylene, etc.) • Critical materials (e.g., lithium, cobalt, etc.) • Fossil fuels (e.g., coal, natural gas, etc.) **Industry sectors** • Aerospace & defence sector (e.g., aircrafts, satellites, etc.) • Agri-food & forestry (e.g., crops, vegetables and fruits, meat and dairy, etc.) • Construction and demolition (e.g., buildings, roads, etc.) • Digital & electronics (e.g., computers, domestic appliances, etc.) • Energy & renewables (e.g., batteries, PV panels) • Mining & heavy industry (e.g., chemical products, metal products, etc.) • Transport & automotive (e.g., cars and road vehicles, trains, etc.) • Textile & apparel (e.g., clothes, carpets, etc.)	**Circular economy rationales** • Economic growth and innovation • Resource concerns and supply risk • Employment and job creation • Ecological concerns and waste management • Climate change and emissions

2.4 Step 4 – Collecting and processing the data

This step entails using the pre-defined measurable search constructs to collect raw data and turn it into processed data.

Data related to the first (When) and second (Who) questions was collected by listing all the documents in corpus in a spreadsheet, tagging them according to the year of publication and corporate author, and finally counting them based on this categorization. Data related to the third (How), fourth (What) and fifth (Why) research questions was collected using a dedicated software for corpus linguistics, including a tool for "keywords in context" analysis (Stefanowitsch, 2020). The analysis consists in counting the occurrence of a certain keyword in the corpus, taking into consideration also the terms appearing next to it within a predefined interval (i.e., 5 words to the left and 5 words to the right). This allows to make sure that the searched keyword corresponds to the intended meaning based on the occurrence context. All the text within all the documents in the corpus was first pre-processed and turned to lowercase. Then, it was loaded into the software and processed with the "keywords in context" tool. Within the tool, a search string was defined for each keyword, including Boolean operators (AND, NOT, OR). The definition of each search strings was iterative, enabling for modification after carefully screening on software outputs, to ensure validity of the results. A few examples of search strings are reported in Table 2.

Table 2. List of selected keywords used for the "keywords in context" analysis using a dedicated software for corpus linguistics.

Research question	**Keyword**	**Search string**
How – is circularity considered in the documents? Note A	Reuse (circularity strategy)	*(reus* OR re-us*) NOT (authorised OR document* OR energy OR policy OR wastewater OR water)*
What – materials and sectors do the documents focus on?	Rare earth elements (critical materials)	*(rare earth* OR rare-earth* OR ree OR rees OR hrees OR lrees OR lanthanum OR cerium OR praseodymium OR neodymium OR promethium OR samarium OR europium OR gadolinium OR terbium OR dysprosium OR holmium OR erbium OR thulium OR ytterbium OR lutetium) [OR la OR ce OR pr OR nd OR pm OR sm OR eu OR gd OR tb OR dy OR ho OR Er OR tm OR yb OR lu]* Note B
Why – is circularity important according to the documents? Note C	Resource concerns and supply risk (circular economy rationale)	*(competit* OR critical material* OR criticality OR crm* OR dependenc* OR deplet* OR import OR imports OR primary material* OR raw material* OR resourc* OR scarc* OR securit* OR shortag* OR srm* OR supply OR supplies OR virgin material*)*

Note A. For this research question, the "keywords in context" analysis was complemented by a "collocation" analysis (Stefanowitsch, 2020), allowing to identify and rank the top 10 words in the corpus that are statistically most likely to occur next to the keywords reduce, reuse and recycle.

Note B. Chemical symbols were also included in search, screening results manually to exclude from the keyword count irrelevant hits.

Note C. For this research question, search strings for each keyword were designed to contain the same number of items, defined with the support of a "synonym finder" software tool developed by the EU Commission, to ensure validity and comparability of results.

2.5 Step 5 – Evaluating the data

This step entails turning the processed data from the previous step into an output that is suitable for interpretation and reflection.

Processed data related to all the five research questions, ultimately consisting in document and keyword counts, was inserted into a spreadsheet to turn the relative numbers into percentages to be compared and visualized with a set of insightful graphs. Then, the graphs were interpreted and discussed by the authors to derive high-level conclusions.

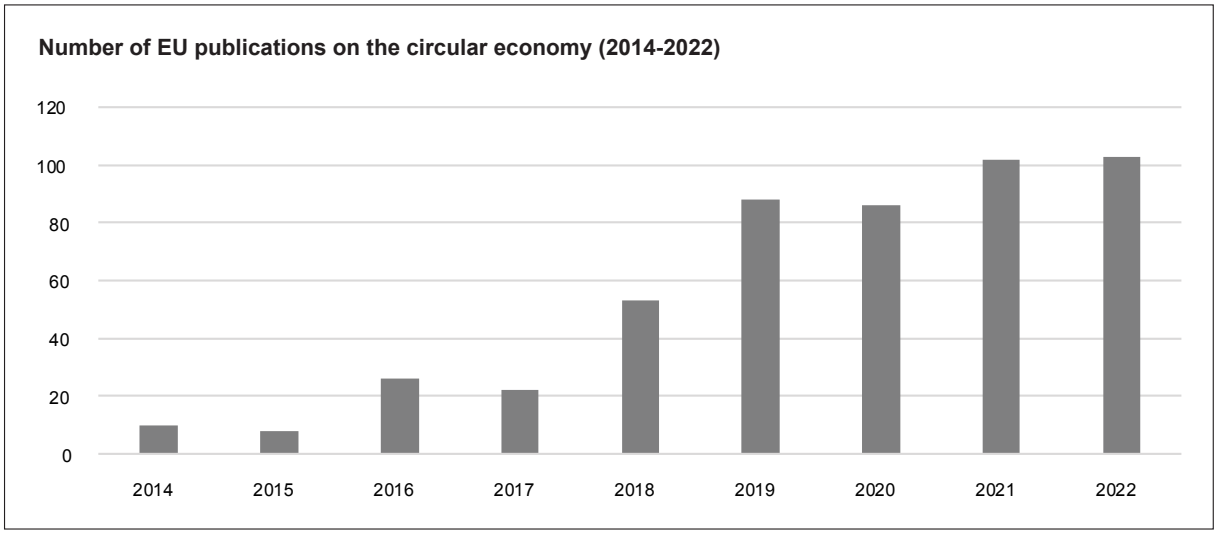
3 Results

This section presents the results related to the corpus linguistics analysis carried out upon the body of EU publications on the circular economy. It provides a comprehensive overview on their content, structured according to five research questions.

3.1 When were EU publications on the circular economy published?

Between 2014 and 2022, 498 EU publications on the circular economy have been produced. The first EU publication on the subject appeared in 2014. In that year, 10 publications on the subject were produced in total. In the next years, following the publication of the first circular economy action plan in 2015 (European Commission, 2015), the number of publications increased, up until 103 publications in 2022. The increase in the number of yearly publications visualized in Figure 1 suggests that the circular economy is gradually gaining traction as a policy programme in the EUs.

Figure 1. Number of EU publications on the circular economy produced yearly between 2014 and 2022.

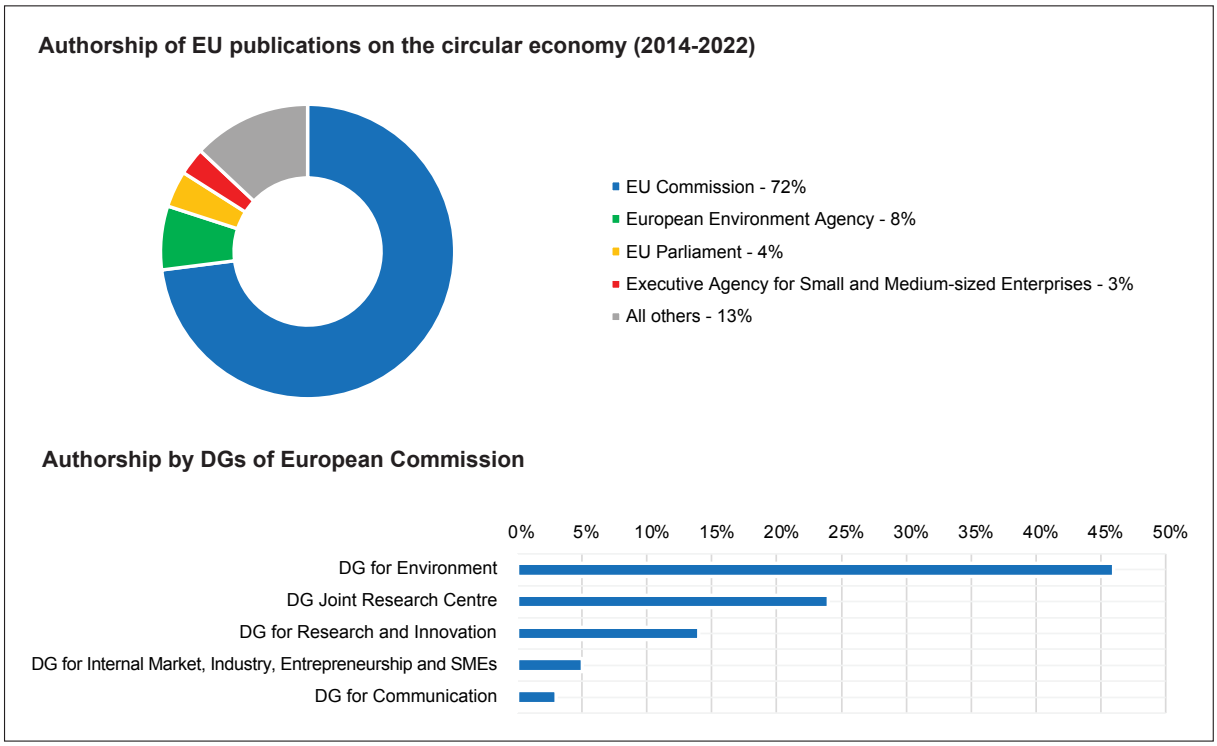


3.2 Who authored EU publications on the circular economy?

EU publications on the circular economy are authored by different EU institutions (e.g., European Commission, European Parliament) agencies (e.g., European Chemicals Agency), and bodies. The European Commission plays a primary role, authoring 365 publications, corresponding to 72% of the total number of 498 publications, as visualized in Figure 2. An important role is also played by the European Environment Agency, who authored 8% of the publications. A minor role is also played by the European Parliament and by the Executive agency for Small and Medium-sized Enterprises, who authored respectively 4% and 3% of the publications. The remaining 13% of the publications was authored by several other parties including, for example, the European Economic and Social Committee and the European Chemicals Agency.

Furthermore, within the European Commission, there is a different degree of involvement in the production of circular economy publications across Directorate Generals. Figure 2 shows that a primary role is played by the Directorate General for Environment, which authored so far 168 publications, corresponding to 46% of all the publications produced by the European Commission. An important role is also played by the Directorate General Joint Research Centre and by the Directorate General for Research and Innovation, which authored respectively 24% and 14% of the publications. Besides a minor role played by the Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and by the Directorate General for Communication, corresponding to 5% and 3%, all other Directorate Generals have been so far involved in a more punctual rather than a continuous way.

Figure 2. Authorship of EU publications on the circular economy produced yearly between 2014 and 2022.



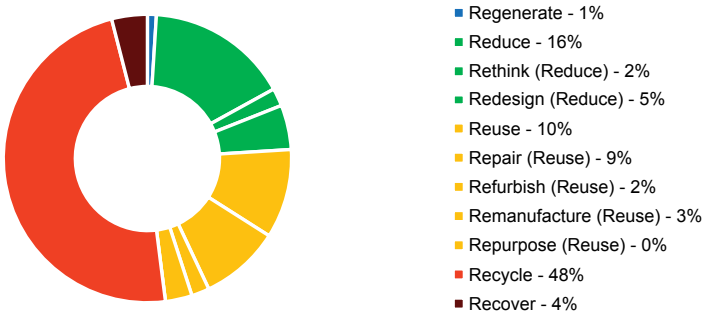
3.3 How do EU publications on the circular economy consider circularity?

EU publications mention different circularity strategies, including: regenerate, reduce, rethink (reduce), redesign (reduce), reuse, repair (reuse), refurbish (reuse), remanufacture(reuse), repurpose (reuse), recycle, recover. As visualized in Figure 3, recycling is by far the strategy mentioned most frequently (48% of the mentions to all circularity strategies). Mentions to reuse, also including repair, refurbish and remanufacture, are moderate (24%). Despite its relevance in circular economy theory, repurpose is mentioned only 381 times (0.4%, not displayed in the figure). Mentions to reduce, also including rethink (e.g., product service systems) and redesign (e.g., eco-design), are moderate as well (23%). Mentions to recover (i.e., incineration with energy recovery) and regenerate (e.g., ecosystems) are very limited (respectively 1% and 4%).

Besides the significantly superior number of mentions in comparison to other circularity strategies, recycling is also the only one discussed in quantitative terms. According to the results of the "collocation" analysis reported in Figure 3, it appears that the terms "rates" and targets" are amongst the top 10 words that are statistically most likely to occur next to "recycl*". The same cannot be said for reducing and reusing. Looking at the ranking of statistically significant collocations, it is also worth noting that "reus*" is mentioned much more frequently next to "recycling" and "water", rather than next to "centres" and "remanufacturing", possibly indicating that this circularity strategy is not yet associated to specific materials as well as clearly defined goals. In most cases, "reduc*" is frequently appearing next to generic terms such as "waste" or "impacts", as well as in conjunction with climate change related words (e.g., emissions, ghg) rather in a material efficiency context.

Figure 3. Circularity strategies mentioned in EU publications on the circular economy produced yearly between 2014 and 2022.

Circularity strategies mentioned in EU publications on the circular economy (2014-2022)



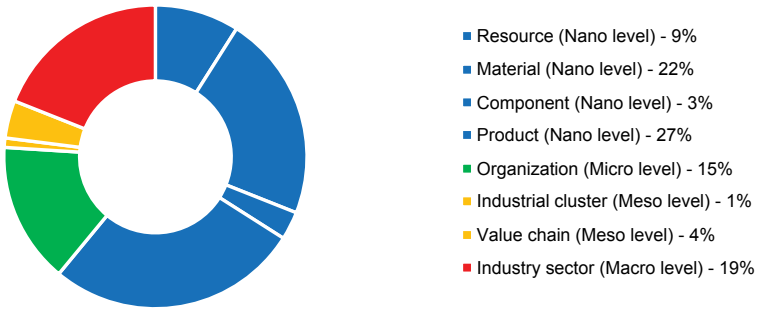
Statistically most significant words appearing next to recycling, reusing and reducing (collocation)

	Recycling	Reusing	Reducing
#1	waste (7414 collocations)	recyclng (2535ollocations)	waste (2371 collocations)
#2	material/s (6547 collocations)	water (1002 collocations)	emission/s (2242 collocations)
#3	plastic/s (5105 collocations)	repair (795 collocations)	impact/s (1368 collocations)
#4	rate/s (3092 collocations)	plastic/s (629 collocations)	cost/s (1107 collocations)
#5	content (3034 collocations)	preparation (493 collocations)	consumption (854 collocations)
#6	reuse (2676 collocations)	recovery (484 collocations)	ghg (648 collocations)
#7	recovery (1767 collocations)	litter (472 collocations)	gas (584 collocations)
#8	packaging (1495 collocations)	marine(468 collocations)	greenhouse (487 collocations)
#9	targets (1203 collocations)	remanufacturing (287 collocations)	litter (397 collocations)
#10	mechanical (1136 collocations)	centres (218 collocations)	dependence (192 collocations)

EU publications also discuss the circular economy in terms of different units and levels of analysis, including: resources (nano level), materials (nano level), components (nano level), products (nano level), organizations (micro level), industrial clusters (meso level), value chains (meso level), industry sectors (macro level). As visualized in Figure 3, resources, materials, components, and products are mentioned very frequently in the circularity discourse at the nano level (cumulatively 61% of the mentions to all units of analysis). Mentions to organizations are significantly less (15%), indicating a more limited focus on the micro level. At the meso level, mentions to industrial clusters and value chains, are minimal (5%). At the macro level, mentions to industrial sectors as units of analysis for the circularity discourse are moderate (19%).

Figure 4. Circularity units and levels of analysis mentioned in EU publications on the circular economy produced yearly between 2014 and 2022.

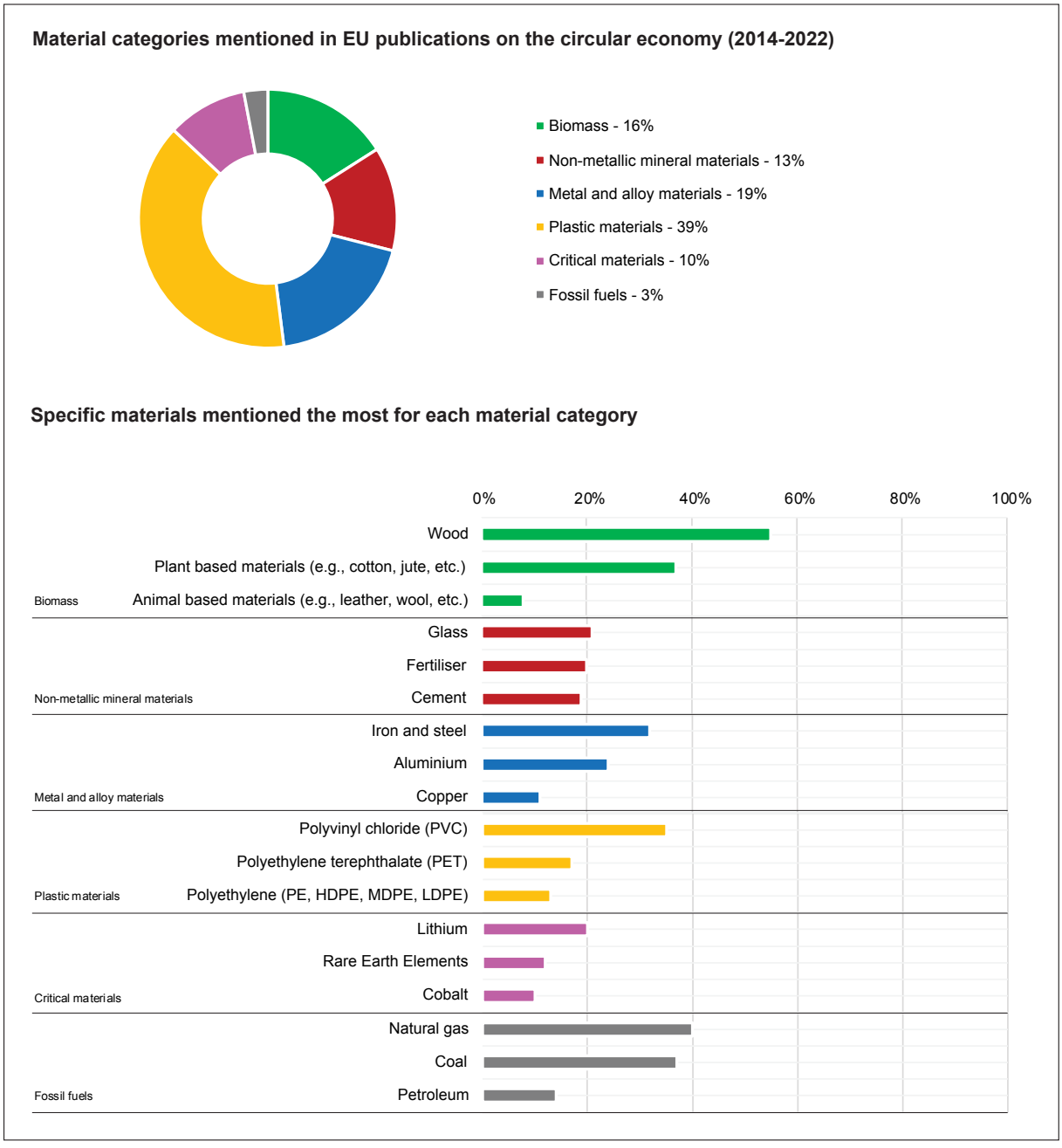
Circularity units (levels) of analysis mentioned in EU publications on the circular economy (2014-2022)



3.4 What materials and sectors do EU publications on the circular economy focus on?

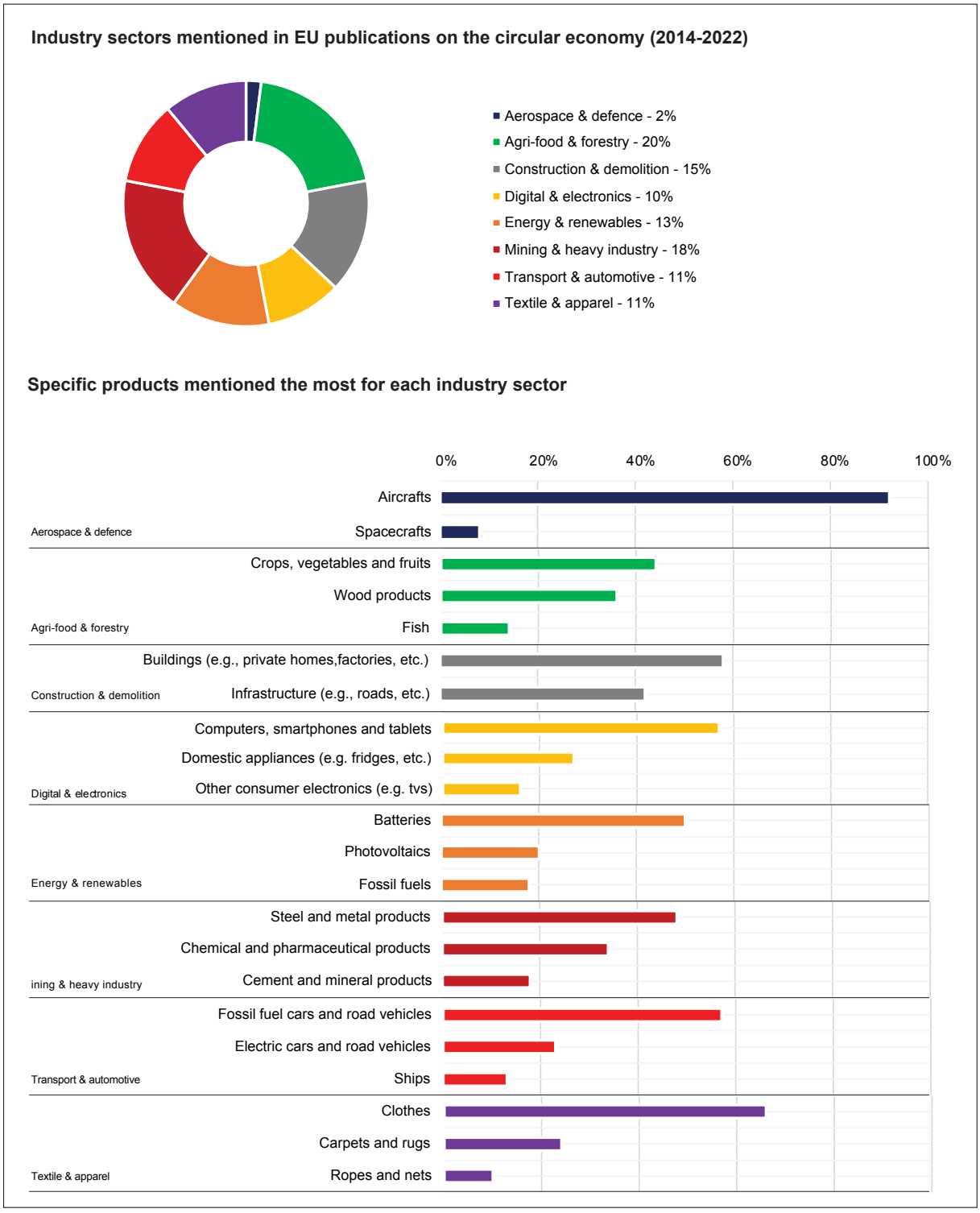
EU publications mention different materials categories to different extents. As visualized in figure 5, plastics are mentioned extensively and significantly more than other types of material (39% of all mentions to all material categories). The plastic materials mentioned the most are PVC, PET and PE. Mentions to biomass (16%), metals and alloys (19%) and non-metallic minerals (13%) and critical materials (10%) are less frequent but also more balanced. The most frequently discussed biomass-based material is wood. Glass, fertilizer and cement are by far the most mentioned amongst non-metallic mineral materials, while steel, aluminium and copper dominate the discussion on metals and alloys. Regarding critical materials, a prominent focus is placed on lithium, rare earth elements and cobalt, while the other ones are mentioned very little. Mentions to fossil fuels are scarce (3%).

Figure 5. Materials mentioned in EU publications on the circular economy produced yearly between 2014 and 2022.



Concerning industry sectors, the focus across EU publications on circular economy is rather balanced, as visualized in Figure 6. Within the agri-food & forestry sector (20% of all mentions to all sectors), the product categories mentioned the most are, in order of frequency, crops vegetables and fruits, wood products and fish products. In the construction & demolition sector (15%), buildings (e.g., private homes, hotels, factories etc.) and infrastructure (e.g., roads, bridges, railways, etc.) are the main product categories. Mentions to the digital & electronics sector (10%) include extensive references to computers, smartphones and tables, followed by domestic appliances (e.g., fridges, washing machines) and other consumer electronic products (e.g., televisions, photo cameras, etc.). Within the energy & renewables sector (13%), the discussion is largely dominated by batteries. Mentions to the mining & heavy industry sector amount to 18%, including mainly references to steel and metal products, chemical and pharmaceutical products and, to a lesser extent, cement and mineral products. Mentions to the transport & automotive sector amount to 11%, with a discussion dominated by internal combustion engine road vehicles, followed by the electric ones. Mentions to the textile sector amount to 11%. Finally, mentions to the aerospace & defence represent only 2% of all mentions, with a focus on civil aircrafts.

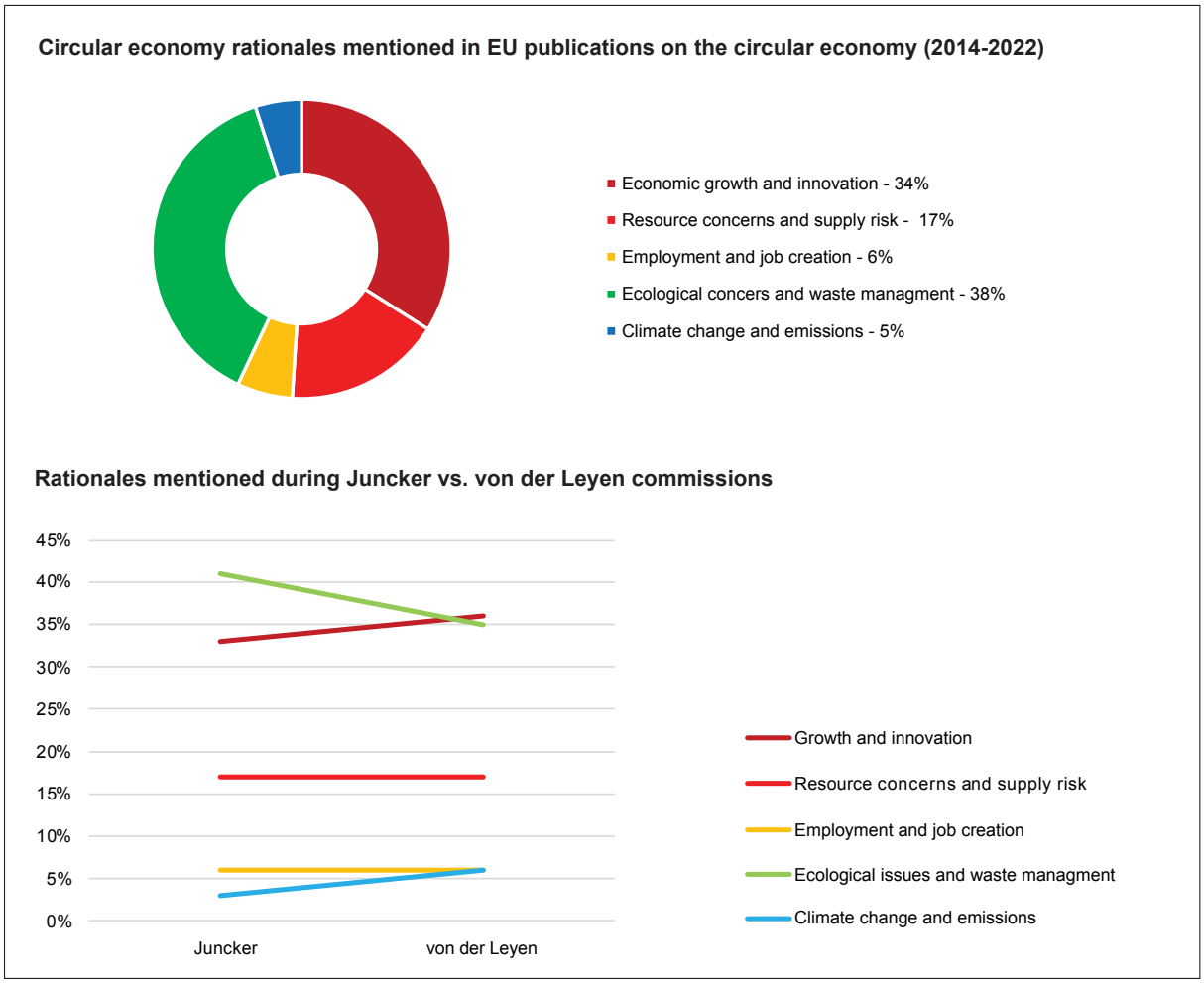
Figure 6. Industry sectors and product categories mentioned in EU publications on the circular economy produced yearly between 2014 and 2022.



3.5 Why do EU publications on the circular economy consider circularity important?

EU publications on the circular economy mention different rationales behind the policy programme to different extents. As visualized in figure 7, they contain many keywords related to "economic growth and innovation" (e.g., growth, prosperity, entrepreneur*) and to "ecological concerns and waste management" (waste, landfill* environmental impact*). The number of keywords falling in these two categories is relatively similar. This is in line with the EU stance and academic literature stating that circular economy is mainly about optimizing economic and environmental performance simultaneously. Furthermore, the corpus linguistics analysis applied within the subset of documents published respectively during the Jucker and von der Leyen Commission, indicates that while in earlier years the number of keywords related to "ecological concerns and waste management" was slightly superior, more recently they were outnumbered by keywords related to "economic growth and innovation". The number of keywords related to "resource concerns and supply risk" (e.g., deplet*, raw material*, scarc*, etc.) is more limited yet still significant, while remaining unchanged over the years. On the other hand, the number of keywords related to "employment and job creation" (e.g., job, employ*, regional development*) and to "climate change and emissions" (e.g., climate chang*, ghg, fossil fuel*) is very limited. While the first remained unchanged over the years, the latter has doubled.

Figure 7. Circular economy rationales mentioned in EU publications on the circular economy produced between 2014 and 2022, as well as during the Juncker and von der Leyen commissions.



4 Discussion

The present study is a systematic analysis of publications on the circular economy produced by EU institutions and bodies. The main insights from the analysis may be relevant to inform future and more focused research geared toward specific policy options, intended to recalibrate the focus of circular economy policy, when needed.

EU Publications on the circular economy started to appear soon before the release of the first Circular Economy Action Plan (2015) and grew in number towards the second Circular Economy Action Plan (2020). However, the annual numbers seem to have levelled off in recent years. It is unclear whether this indicates that policy research on circular economy has reached a certain steady-state or whether publication output growth was limited by the global events that followed the second Circular Economy Action Plan, including the COVID-19 pandemic, Russia's invasion of Ukraine and cost-of-living crisis. At the same time, it should be noted that the research output is not directly linked to the production of legislation, so a plateauing publication level does not necessarily indicate less policy creation activity.

Most publications originate from specific actors. The European Commission plays a primary role in terms of number of publications, followed distantly by the European Environment Agency. The numbers, however, might not only be influenced by the role of the institutions, but also by the amount of their staff. For example, while the European Commission counts roughly 32 000 employees, the staff of the European Environment Agency only amounts to 200 people. Furthermore, within the European Commission, the main authors are found in DG ENV, DG JRC and DG RTD. Although various reasons may be at play, this seems to suggest that circular economy is still widely viewed as a predominantly environmental policy or research subject. For circular economy to become embedded in the core of the EU's future socio-economic model and Union agenda, one may expect to see more publications related to other Commission competences, such as climate, the single market and employment.

An important observation is that recycling is, by far, the circular economy strategy most frequently mentioned in the publications. Despite their higher position, and therefore priority in the waste hierarchy, reducing and reusing are mentioned significantly less. Furthermore, recycling is the only strategy discussed in relation to quantitative targets. This is in line with the "Monitoring Framework" developed by the Commission where there are no indicators so far that reflect ideas about repair, reuse, sharing, product durability, and standardisation of designs which may help substitute parts rather than the whole product (European Commission, 2018; Kovacic et al., 2019). This may have various explanations. They include the prior existence of a recycling industry and proven technology for many waste streams, the possibility to easily adapt existing business models by merely swapping primary raw materials for secondary raw materials, as well as substantial opportunities for economies of scale and standardization. As for reduction, it may be argued that economic drivers in many cases already help reduction, as in the case of minimizing packaging or lowering the weight of vehicles with an internal combustion engine to reduce emissions. Reducing also has a clear economic benefit in many cases and can equally well be integrated in the existing business models. More problematic is to ensure reduction of material usage where the material internal cost is too low and where only externalities justify reduction. Reduction linked to increased durability and longevity of products also results in higher manufacturing costs and lower sales volumes for manufacturers, which mean less income in traditional business models. In the case of reuse, major challenges exist due to the diversity of products on the market and the costs of re-use in the current business environment, in particular labour costs. Increasing the penetration of reuse-based business models may hence be much more challenging than fostering recycling and reduction.

In addition, while a prominent focus is placed on resources, materials and products, and a moderate focus is placed at a higher level on industry sectors, the same cannot be said for organizations' business models, industrial clusters, and value chains, which seem to be considered only to a limited extent within the ongoing discussion. The Circular Economy Action Plan of 2020 already called for new business models and revised approaches to existing value chains. Moreover, the European Commission has taken initiatives for action, such as establishing the Battery Alliance and the Circular Plastics Alliance. Finally, first steps are being taken to foster new business models, e.g., through re-use and refill targets in the new proposal for a Regulation on Packaging and Packaging Waste (European Commission, 2022b). However, these actions don't seem to be reflected into many of the publications, which in turn have the goal to inform future policy actions and trajectories.

Concerning the focus across different material categories, plastics are the main subject of discussion. Despite their importance, other material categories, including biomass, non-metallic minerals, metals and alloys, critical materials, and fossil fuels, are mentioned significantly less in the publications. At the same time, recent

geopolitical events resulting in import restrictions from Russia and high energy prices have highlighted the dependence of Europe on raw material and energy imports. These high energy prices in turn have exposed the link between fossil fuel consumption and raw material production, e.g., for fertilisers or steel. From this, the circular economy emerges not only as a tool to address environmental issues, but also strategic autonomy and climate change. In view of the envisaged green transition, which will see the demand for certain raw materials increase rapidly, it should be expected that the focus of research on circular economy will broaden across material categories.

Regarding the sectorial focus, there is balance across aerospace & defence, agri-food & forestry, construction & demolition, digital & electronics, energy & renewables, mining & heavy industry, transport & automotive, textile & apparel. This seems to be a balanced representation of economic sectors, in line with the expected material demand and climate impact.

Finally, the analysis indicates that “ecological issues and waste management” and “economic growth and innovation”, might be regarded as the main drivers behind circular economy policies. Indeed, this in line with statements found in the Circular Economy Action Plan, in industry and in scientific literature as well (Ellen MacArthur Foundation, 2013; European Commission, 2020a; Stahel, 1994). However, considering that the goal of the Circular Economy Action plans is to go beyond the narrow focus on waste and recycling, more attention to other drivers might be needed going forward to avoid a mismatch between the rhetoric and the practice (European Commission, 2015, 2020a; Kovacic et al., 2019). Despite the crucial importance, “resource concerns and supply risk” seem, seem to still be regarded as a lesser important driver behind circularity in policymaking, for the time being. However, this is likely to change soon, considering aggravating resource depletion in conjunction with the above-mentioned complex geopolitical landscape and disruptions caused by the invasion of Ukraine and the COVID-19 crisis (European Commission, 2022c; Gislev & Grohol, 2018; Nygaard, 2022). The discussion on “employment and job creation” has so far been very limited, and there are no signs of increase, possibly indicating that societal factors are to remain a minor driver behind the circular economy agenda. Conversely, from the Juncker to the von der Leyen Commission, the discussion on the nexus between circular economy and “climate change and emissions” has intensified. Indeed, the circular economy can be a powerful force for climate mitigation, considering the lower carbon footprint of recycled materials compared virgin ones, and the emission cuts that can be achieved by repairing and sharing products to reduce production and consumption (Enkvist & Klevnäs, 2018). Thus, the European Commission is initiating important activities that will eventually lead to policies in this direction (ICF et al., 2022).

5 Conclusion

The analysis of EU publications with the corpus linguistics method presented in this study has revealed an increasing interest in the Circular Economy by EU institutions, especially since the publication of the first Circular Economy Action Plan. At the same time, it appears that not all building blocks of the circular economy are equally well covered. The focus in the current set of publications is heavily skewed towards recycling, focusing on the material and product level and with a specific interest for plastics. Moreover, an analysis of the main publishing actors seems to suggest that the circular economy is still widely viewed as an environmental policy or research subject. Its potential for economic growth, strategic autonomy and especially climate mitigation might be well unexplored and underexploited.

With circular economy being a relatively new concept, it may be understandable that the lowest-hanging fruits, such as recycling of raw materials, have been picked first, but for the EU economy to become net-zero and achieve open strategic autonomy, it is important to foster the penetration of the circular economy at a higher level in the wider policy agenda. Going forward, this may include increasing the focus on those aspects of the circular economy related to the demand-side, such as promoting reduce, reuse and repair strategies, and thinking more widely in terms of value chains or business models. Although this will be a complex transition that will require dialogue and new collaborations between the socio-economic actors, it might become urgent to accelerate the decarbonization of EU industry sectors and achieve the objectives of the Green Deal (European Commission, 2019, 2022a).

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