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"Emperor's new Clothes?" Capturing Circular Economy topics in domains of science, politics, and lobbying

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Abstract

This paper analyses the concept of circular economy within different institutional domains. By using natural language processing tools, we study three intellectual fields: CE research ("science"), think tanks and interest groups ("lobby"), and government policy-makers ("policy"). With the help of the LDA topic modelling we identify shared and domain specific interests from a large text corpus. Analysis shows that institutional backgrounds do reflect word choices and thematic conceptualizations of circular economy, but there is also a strong common body in political and scientific discussion about circular economy.

Introduction

Circular economy (CE) has become a popular subject on the public agenda, not only in scientific but also in political discussions. Several governments and the European Commission have launched circular economy programmes as part of their future priorities. CE has in many instances been viewed as a promising way towards more sustainable production compatible with continuous economic growth (Murray et al. 2017; Ghisellini et al. 2016; Bocken et al. 2014; Hobson & Lynch 2016). It is seen as a new successful business model promoting more sustainable futures. Circular economy is even heralded as the next socio-technical regime which will solve the grave problems facing the whole of humanity, not to mention the potentially disruptive and politically controversial effects of such a change.

In this paper, we take our inspiration from selective attention to CE by those who professionally write about it. This will take us outside the field of science proper and include various science-inspired actors, such as think tanks, consultants, or industrial lobbies, as well as government agencies and policy-makers. These actors may share some common concepts and ideas of CE but differ in many others. By using natural language processing tools, we analyse the structure of CE discussion in three intellectual fields: CE research ("science"), think tanks and interest groups ("lobby"), and government policy-makers ("policy").

With the help of the LDA topic modelling (Blei et al. 2003) we identify domain specific languages from a large text corpus of scientific article abstracts and various CE reports, pamphlets, roadmaps and government plans. We will ask how these domains differ in their takes on CE and how the institutional backgrounds are reflected in word choices and thematic conceptualizations that characterize the domains. At the same time, we can show if there are any common body of concepts that unite the domains as well as concepts that dominate the CE discussion and others that fall into oblivion. While doing this, we will be able to speculate about the possible pattern of institutional domination in the field of CE discussion and the spread of ideas across domains. We assume that these "domains" are not identical in their use of language when they publicly engage in discussions on CE. This assumption is based on a general sociology of knowledge conception of social actors' views on subjects' close to them. Thus, it is hardly possible to realistically conceive a public discourse that will approach any topic with complete neutrality and detachment.

Language Domains

As indicated above, our primary focus will be on what we call institutionalized ideas. As we use the word "ideas" in the plural, it implies different sets of ideas which are either connected across institutional boundaries or exclusive to one discursive domain. In reality, we rarely observe purely exclusive domains. Even national intelligence services or highly specialized science communities, such as astronomy or high energy physics, share fragments of their core ideas with other domains, like literary fiction or movies. Often these domains overlap quite extensively so as to share not just a few core ideas but also complete vocabularies that constitute a common discursive universe for these domains. It follows that domains generate nuanced vocabularies that can share a common object which is then shaped by selective use of language. For example, engineers and economists may work together in constructing a power plant, but their emphasis - or concept - of the plant can be quite different. Similarly (closer to our theme), a think tank lobbyist may frame circular economy differently from a government official or a university professor. It is not inconceivable that these actors generate conflicting views on the same object in spite of their common root vocabulary.

Furthermore, one domain can become dominant even without explicit competition between domains. Architectural finesse often gets side lined in construction projects in favour of safety regulations, weather conditions, or cost-benefit analysis. However, it is perhaps more common that domains borrow language from neighbouring domains, producing overlap and circular movement of words and ideas from one domain to another and back. Sometimes, when new vocabularies are transferred from a weak domain to an already institutionalized domain, the incorporated ideas get recontextualized for the purpose of becoming regulated by the receiving domain (Chouliaraki 2000).

We have used the term "domain" quite freely above. To define the concept of domain more clearly, we need to grasp its empirical nature. Domains are not just manifestations of language use. We would not call a discussion about Brexit in a pub between old friends a domain simply because the discussion is lacked a regularity, institutional channels of expression, and criteria for accessing the channels. Also, this discussion would not have the power and legitimacy of, say, the European Commission report of common fiscal policy. Yet, the concept of domain is more general than institutional discourse understood as language produced by representatives of work-related institutions (Freed 2015). Professional language, such as litigation or economic forecast, belongs to a domain but so does a parliamentary debate or a television interview of an Olympic winner or an unemployed single mother. What we are saying is that a domain denotes institutionalized language use not restricted to professional or work contexts. It is true (as it is in our case) that domains are often characterized by professionalism or specialization of some kind.

In our case, we take three domains of circular economy under investigation, namely lobbying, policy-making and science. Science is highly professional with formal access criteria and advanced specialization. Lobbyists are a heterogeneous group of professionals who can access the profession from many different points and with varying credentials. Policy-making is also a heterogeneous domain but consisting mostly of highly trained specialist professionals. Although professionalism is a key element in all three domains, they differ in the actors' motivations and relations to political power. Scientists who study circular economy are often connected to businesses and policy-making through joint research projects or in their role as outside experts in policy hearings, but equally well scientists can work on their own and according to problem formulations unique to their domain. Lobbyists have often a role in mediating between policy-makers and scientists. Depending on the institutional connections, lobbyists can also assume the role of interest group representatives and become very selective in what they carry over into the policy-making process. Policy-makers

typically frame their ideas as expressions of the general good of the society (Rosanvallon 2011). In some cases, they include ideas generated in the science domain but often the general good corresponds to particular interests depending on how successfully the lobbyists manage to penetrate policy-making processes and "restrict preferences" of key actors (Person & Tabellini 2000, 21-27).

Research Design

Data

For identifying the topics in the discourses of circular economy in the contexts of policy and lobby domains, we identified reports, papers, policy briefs, etc. produced by different lobby and policy organizations through Google searches, visiting and going through the websites of individual lobbying and governmental organizations. We also read through review articles (Murray et al. 2017; Geissdoerfer et. al. 2017; Ghisellini et al. 2016; Tukker 2015) to find documents to be included in the analysis. We only selected documents written in English, because polylingual analysis was out of our resources at this point, though technically it is possible to carry out such topic modeling process. This produced a body of 39 documents mainly from Europe and from United States. The documents vary considerably in length, and the level of detail and information. We believe that this set of documents includes the most important ones, such as EU policy and documents produced by focal organizations in the field of circular economy, and captures essential part of the circular economy discussions in this context. The list of lobby and policy documents is provided in appendix 1.

For the science domain, we conducted a Scopus search for published academic journal articles on circular economy, searching for "circular economy" strings in title, abstract and keywords fields. In these fields the most prominent issues of a research are presented so other scholars and potential readers could find the document in question. This search produced a pool of 426 articles (Scopus database, date 20161209). This can be considered a relatively complete corpus for our aims for analysing the themes in circular economy discourses. The three domains are presented in the following figure 1.

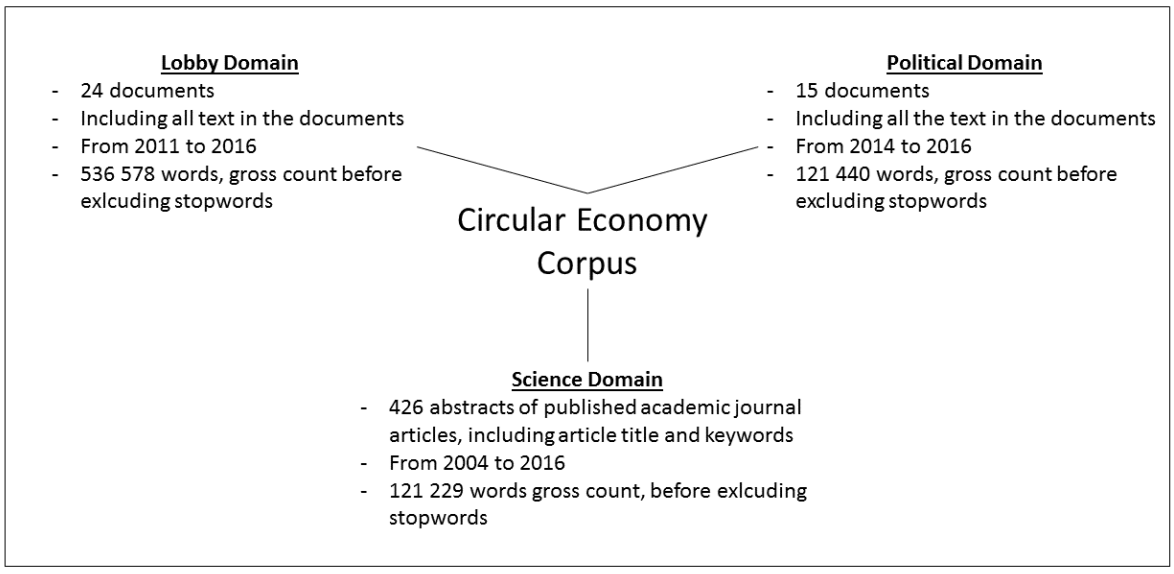

Figure 1. The structure of the Circular Economy Corpus.

For analysing data, we used a natural language processing called topic modeling, which we describe briefly in the following chapter.

Topic modeling as a method

Topic modeling is automated data mining tool for analysing large, unstructured bodies of textual and other types of data. Topic modeling algorithms go through a selected corpus (a pre-defined set of documents), grouping words into themes (topics) running through these documents (Blei et al. 2003 and Blei 2012). As a method topic modeling tools use different probabilistic algorithms (Blei 2012).

The central idea behind topic modeling is that instead of predefined codes and categories of meaning to understand the contents of the documents, the researcher begins to look for a predefined number of topics from the texts. In other words, a document is a collection of (latent) topics, and the algorithm identifies the number of topics and returns the probabilities of words in a topic. In addition, it creates the distribution of the topics across the documents in the corpus. Both distributions are based on frequencies and co-occurrence of words. The basic algorithm used for topic modeling is LDA - Latent Dirichlecht's Allocation, in which each document in the corpus "*is viewed as a bag-of-words produced according to a mixture of themes that the author …intended to discuss*" (Mohr and Bogdanov 2013, 547). Each topic is a theme constructed through the distribution of words in corpus, and the order of words is not considered to have a strong effect on the formation and allocation of topics (Blei 2012).

Words that are strongly associated with the document's dominant topics have a higher probability of being selected and put in the bag-of-words. It is important to remember that these topics are not connected to an explicit label, but instead with a set of word probabilities that, when ordered in a decreasing probability, form something that we humans would recognize as a theme. The advantages of topic modeling are that it overcomes problems of mere keyword search, because the search includes the whole dictionary of the corpus, and the words are weighted (probabilities) by topical importance, which makes the hidden patterns in the text more visible. On the other hand, the interpretation of the topics requires substantial understanding of the studied phenomena, as in this case understanding the concepts related to circular economy.

Steps for carrying out a topic modeling for Circular Economy corpus

To perform topic modeling for the selected documents they must be transform into a file form that both enables to answer the research questions and that is suitable for the analysis tool used. For the topic modeling, we used Mallet - MAchine Learning for LanguagE Toolkit (McCallum 2002).
As described earlier we divided the documents to domains of lobbying, politics and science. For topic modeling, we first transformed each individual document into text file and then combined all lobby and policy reports into single lobby and policy text files. The abstracts were downloaded into a text file directly. After this initial phase, we imported the text files in a single folder in Mallet, creating files for both calculating the topics and providing possibilities for deeper diagnosis of the topics. At this state, also regular and added stop words were excluded from the texts, and only the proper text was left for analysis. Next state was to train the latent topics out of the corpus.

At this point the words in the corpus are transformed into tokens. Put it simply, a token presents a single word or group of words and tokenization means splitting the text in the documents into tokens representing individual words and phrases that can be analysed. For example, a phrase "The concept of Circular Economy has appeared" can be tokenized as ["The", "Circular", "Economy", "has" "appeared"], or ["The", "Circular Economy", "has", "appeared"]. In the latter case, Circular

Economy is handled as a single token, whereas in the first one both Circular and Economy are tokens. This tokenization of words is language and context specific. In our analysis, we did not change the built-in tokenization process of Mallet, in which both Circular and Economy would have been individual tokens.

Topic modeling is an iterative and qualitative research process in the sense that researcher need to try different number of topics that in his or her knowledge fits best to the corpus in question and for the research questions. This requires a thorough understanding of the corpus and the subject area in question. Therefore, we tried out several rounds between 4 to 12 topics, and ended up using six topics. Of these six topics five had enough weight in one or all of the three domains. The excluded topic had a very weak weight and coherency, which means that the words of the topic do not co-occur often. This in turn diminishes topic's analytical power. If choosing too few topics, the algorithm may end attaching too many words in a single topic, which may make them too broad, whereas using too many topics produces highly similar ones. (Greene et al. 2014)

A minor, yet an important reason for going through several rounds of modeling topics, is the need for refine the stop words to be excluded from the corpus. Stop words are words that are excluded from the corpus before processing it. They normally refer to the most common words in a language, and short function words, such as the, is, at, which, etc. A particular corpus, such as the abstracts, or reports in our data, may need additional stop words, such as abbreviations, journal names, web addresses. These stop words could mess up the analysis by producing topics formed by names or web addresses. In the following chapter, we describe the choices for the topics and our interpretation in more detail.

Analysis

The topics created by our analysis are listed in Table 1. One topic was dropped from further inspection due to its weak loading and heterogeneity. The remaining five topics can be given a reasonably intelligible interpretation. If we look at the standard LDA metric, we can see that there is a pattern that pairs topics and our three language domains (Topics 2, 3 and 4). The lobby domain was divided between two topics, although the second topic was very weak (Topic 5). Topic 1 loads on every domain and can therefore be considered a common background topic that can be found in most of documents in our corpus. We also found one domain-overlapping topic (4). It is not a strong topic but we will include it in our analysis. In what follows, we will pay attention to the distribution and exclusivity of words within topics. Top words can be seen as a general framework for the topic to which less frequent and fringe words are connected as additional thematic information.

To understand better distribution of words between and within topics, we used the diagnostics tools available in Mallet. The metrics used in our analysis are shown in table one. The comparison between *token count of a topic and the sum of token counts for all topics* tells the proportion of the corpus (all documents) assigned to the topic (*theme*) in question. *Document entropy* calculates the probability of documents in given a topic. A topic with low entropy will be concentrated in a few documents, while a topic with higher entropy is spread evenly over many documents. *Coherence* measures whether words in a topic tend to co-occur together. Large negative values indicate that words do not co-occur often; values closer to zero indicate opposite.

Table 1
The top 20 words of and key metrics for each topic.

	Topic 1 CE Background	Topic 2 Industrial Engineering and management	Topic 3 Innovation policies	Topic 4 New Business	Topic 5 Globalisation
	waste	environmental	waste	recycling	global
	materials	waste	recycling	companies	world
	products	recycling	government	opportunities	assets
	economic	management	environmental	model	policymakers
	resource	development	support	business	labour
	material	analysis	eco-innovation	figure	reverse
	energy	Sustainable	public	development	net
	product	cycle	products	report	components
	business	life	efficiency	sector	price
	potential	Industrial	measures	food	intelligent
	resources	Production	innovation	foundation	time
	production	sustainability	development	efficiency	toolkit
	industry	efficiency	re-use	billion	economies
	system	study	policy	company	externalities
	design	assessment	energy	service	unemployment
	policy	model	raw	opportunity	land
	food	results	procurement	chains	today
	systems	economic	action	businesses	fertiliser
	water	carbon	sustainable	costs	circularity
	consumption	steel	local	models	resilience
Dirichlet parameter*	21.75	0.78	0.53	1.52	0.14
Domain Lobby	0.5419	0.0010	0.0156	0.2757	0.1346
Domain Politics	0.4641	0.0008	0.4273	0.1078	0.0000
Domain Science	0.4764	0.5235	0.0000	0.0001	0.0000
Token share of corpus**	52 %	9 %	7 %	20 %	9 %
Document entropy	0.806	0.055	0.408	0.278	0.000
Topic coherence	0.000	-39.220	0.000	0.000	0.000
Topic exclusivity	0.637	0.576	0.549	0.633	0.841

***** Dirichlet parameter or topic weight is proportional to the overall proportion of the corpus assigned to a given topic.
******N=392,346 tokens

The larger number of *effective number of words* indicates a more specific topic tied to fewer documents in the corpus. *Rank one documents* counts the frequency at which a given topic is the single most frequent topic in a document. Some topics are more specific i.e. occur in relatively few documents, but it will produce a weighty count of tokens, while a "background" topic will occur in most documents and have a high overall number of tokens, but do not produce many tokens in any single document. *Exclusivity* measures the extent to which the top words for a topic do not appear as top words in other topics, i.e. to extent these words are exclusive to a topic. High exclusivity

indicates vaguer, more general topics. We also looked some of similar diagnostics within individual topics to understand better in what way they are structured at word level. Coherence illustrates the co-occurrence of the words in a topic and exclusivity shows whether an individual word is specific for topic or not.

Topic 1: The common ground for CE Discourses in the Domains

The topic one can fairly be called common ground for CE because it is a topic all domains share with almost equal loads (see the domain loadings in the column for topic 1). It is also the single most frequent topic in any given domain or document in the corpus, covering 52 per cent of topic tokens. What is it then that all three domains share when they talk about circular economy? It seems that this topic is cantered on matter, that is, "materials", "products", "resources", and "waste". These words are shortly followed by generic words "economy" and "system" and a more substantial "energy". In combination these words point at basic industrial processes that are hard to avoid in the circular economy discourse. Or, in other words, circular economy discourse appears to be focused on industrial production regardless of the domain in which the discourse takes place. This topic is least coherent of all topics (coherence -39.2244) implying the words do co-occur in the corpus less than the other topics - most general words have overlap in other topics. The entropy of the topic is very high (0.8055), which verifies that it is spread evenly across the corpus.

Although circular economy is often defined as a systemic change towards more sustainable economic model the core words in the topic one shifts the emphasis on existing issues. However, the second block of words in the common ground topic ("business", "potential", "production", "industry") contains ideas about business potentials and opportunities. "Design", "policy" and "consumption" also arises to the list suggesting general discussion about systemic changes CE might need in order to become mainstream. Words "food" and "water" indicate that CE includes, yet to a smaller degree, aspects of primary production and basic human needs besides industrial production. According to this, we propose that three discussions are dominating all CE: First, a production dominated talk about materials, waste and resources; second, a more business oriented talk about new business opportunities (in industry); and third, a discussion on systemic changes towards CE.

Topic 2: Industrial Engineering and Management

For the science domain, topic 2 (here called industrial engineering and sustainability management) receives clearly the highest load (0.5235). It has no visible loads in any of the other domains. It clearly focuses on environment and recycling of waste in the context of sustainability. "Waste" and "recycling" are frequently-used words in the whole corpus and tend to co-occur often. However, words "analysis" and "study" betray the academic source of the topic's documents. These words do not show up in other topic vocabularies. The following blocks of words indicate that the topic's take on circular economy comes from an industrial process and production perspective. The words related to business, economy or policy, except "economic" are not present in this theme. "Economic" is the most non-exclusive (exclusivity load 0.256) word of the topic, meaning it is a rather common word in the whole corpus unlike "analysis" (exclusivity load 0.800) which is the most specific word appearing in this topic. The engineering and learning or understanding related words generally have a relatively high exclusivity: "assessment" 0.78, "results" 0.75, "study" and "life" 0.70, "cycle" 0.69, and "management" 0.65.

Topic clearly discusses issues that relate to analysing and managing sustainability issues in the context of industrial production through waste and recycling. Even concrete materials such as carbon and steel come up in the topic. Thus, it can be said, that at least up until 2016, the science or

research domain in circular economy seems to focus on subject areas closely related to industrial engineering and natural sciences.

Topic 3: Innovation Policies

The policymakers' CE discourse is rather marginal as the topic vocabulary of the policy domain (topic 3) represents only 7 per cent of the tokens in our complete corpus (compared to 52 % of the generic topic 1). In other words, what policymakers emphasize is not that much shared by other domains. The document entropy measure (0.06) points towards very limited distribution of words beyond policy documents. Words, such as "waste" and "recycling" are generic, but "eco-innovation", "innovation" (eco-innovation exclusivity 0.98, innovation 0.60), "government" (0.74), "support" (0.76), and "public" (0.60) are exclusive words to this topic, hence to the policy domain. Judging by the exclusivity of topic words, the most distinct element in this topic relates to government-led innovation policies.

"Waste" is by far the most dominant word in this topic, yet it repeats the structure of our background topic and appears in other domains as well just like "recycling" (it appears among the top words also in science and lobby texts). The likely interpretation of these dominant words can be reached through "innovation". A high-loading word here is also "environmental" (exclusivity 0.28) which this domain shares with the science domain. Yet, the policy domain differs from the science domain by putting no emphasis on industrial processes. Instead, the road to environmentally sound policies is much more abstract, involving innovations that can be supported by government action. The rest of the words are quite infrequent compared to this core of innovation policy.

Topics 4 and 5: Lobbing for New Business

The lobbyist domain was split into two topics. Topic 3 is a relatively large topic (21 % of tokens) with some document overlap with other domains (document entropy 0.28) although less than what we saw in the policy domain (0.41). Besides the high-ranking word "recycling" and the quite common "business", there are only a few words that are used also by other domains. The topic is dominated by the words "company" and "companies" even our lobby corpus includes texts also from non-business interest groups (see appendix). This domain is very much oriented towards new business models and opportunities opened up by CE (or, more specifically, recycling). Hence, the word "opportunity" has a very high exclusivity metric (0.88).

The topic five is very marginal and highly exclusive in our corpus (1 % of tokens; document entropy 0.0003). It seems that in some rare occasions lobbyists use political and economic vocabulary instead of their primary focus on approaching CE as a business opportunity. In topic 5 we find indications of rhetorical appeal to policy-makers to reverse some of the negative effects of globalized trade – or at least attempts to connect globalization and policy-makers in their discussion on CE. It is interesting to note that resilience belongs to this topic. Turbulent global economies need to secure continuity and fight unemployment, which rests on the shoulders of governments. This topic is the only one that brings in individuals as actors in CE. In this topic, we see words "policymakers" and "labour", which both point to individuals despite labour being a collective noun and policymakers a plural form. Topic 4 also carries some weight in the policy domain, which indicates more interaction between these two domains, compared to the non-existent weight of the science specific topic 2 (industrial engineering) in them.

Conclusions

In this paper, we have compared different language domains that all focus on circular economy using topic modeling as an analyses tool. By using natural language processing, we analyse CE discussion in three different fields: CE research ("science"), think tanks and interest groups ("lobby"), and government policy-makers ("policy"). The paper in hand shows that institutional backgrounds do reflect word choices and thematic conceptualizations on circular economy, but there is also a strong common body in political and scientific discussion about circular economy.

According to analyses, the domains share a common background vocabulary which, in our data, comprised roughly half of the units of analysis (the so-called tokens). As shown above, the concept of circular economy is generally described as technological and economic development to ensure more sustainable production and consumption of resources in the future. The general background topic touches these areas, although on a very general level. This topic seems to be a kind of an "introduction" to all things that are important and should be mentioned when discussing circular economy before the authors in their respective domains can focus on more domain specific issues.

This is not to say that the domains are similar in their nature, but have unique features that reflect the institutional origins of the documents in a domain. In the scientific domain, which is mainly dominated by technical and engineering sciences, industrial ecosystems perspective, industrial engineering and management related questions were the most apparent themes. The institutional background largely explains why the wide bodies of research on sustainable consumption or sustainable lifestyles are absent in this domain. Lobbyists find their most favoured subject in new business opportunities created by circular economy. Somewhat surprising is that the CE discourse in the lobbying domain is so strongly business oriented although our data is not exclusively from organizations that promote business interests. In the policy domain circular economy seems to be a niche specialty that mainly caters for government innovation policies, which is traditionally keen on supporting industries and businesses towards rejuvenation and national growth. Again, there is an institutional affinity between the topic and the domain, namely the governments' limited ability to influence new economic development by public funding. This is typically channel through a country's innovation system that involves government induced cooperation between higher education institutions and business enterprises as well as various subsidies and tax relief programmes. Citizens and the social impact of circular economy are present in the topics only vaguely through the concern over adverse effects of globalization.

The most relevant limitations of this work derive from the methodologies employed for our topic modeling. Size of the corpus is moderate compared to many used in topic modeling. The documents come from variable sources and are of different length and depth of information, from abstracts to full reports over 100 pages. Our corpus contains a bit less than 800.000 words, 426 abstracts, and 39 policy and lobby documents, when for example some researches do topic modeling with article corpus including 8.000 newspaper articles (DiMaggio et al. 2013). Topic modeling is, in general, considered to operate better with larger corpora. On the other hand, it can be thought that we have started to construct a library, focusing on Circular Economy in domains of lobbying, politics and science.

We acknowledge that our corpus is not a full account of Circular Economy discourses, because we were able to use only documents published in English, and had to left out other languages such as French and German. Including these languages could have add substantially to the corpus. Circular Economy may be a hot topic, but then again there is very likely documents that analyse issues related into circular economy, but do not use phrase "Circular Economy", but for example "closing the loop", "material efficiency". Such research could be found from sustainable consumption and

sustainable lifestyles, not to mention sustainable business model literature. This limits the scope and richness of the corpus and the scope of topics that might be present in discussions in various places and regional/local discourses. On the other hand, a lot of the lobbying and politics documents use English as secondary language, if not the primary one. At least in the European and North-American context, not to mention scientific writing of which internationally is mainly written in English. Because of this fact, the three domains of the Circular Economy corpus are strong enough to give a tentative, yet solid image of the discourses present.

When analysing wordings between the three domains of this study, it seems the discourses have only little in common in addition to the general CE discourse. If circular economy is something towards which societies want to thrive, active discussions and cooperation across domain boundaries could be useful. Inclusion of multiple perspectives generally produces better outcomes when dealing with complex issues like transformation towards circular economy. That applies also to the scientific domain. For example, knowledge accrued in sustainable consumption or sustainable life-styles studies is nowhere present in the discourse of the science domain. It could be useful for diverse research approaches to sustainability to discuss and share actively their research questions and findings, thus better cumulate knowledge of what might work and in what ways to enhance positive and alleviate negative impacts of the change.

In the beginning of the paper we were raising the question is the CE discussion a way of reframing old things with new concepts, emperor's new clothes. Our analyses show that domains do have common background but also variations in their focus. One can speculate that for lobbyist the concept of circular economy might be a way to promote their sustainable will without compromising economic growth. Furthermore, this is also the tendency in other domains. Moreover, the protagonists for CE promote the existing concepts of industrial ecology and eco-efficiency for production part of CE. In similar fashion, product service systems, repair, recycling refurbishing and collaborative consumption are promoted as the way to circularity and for changing the unsustainable consumption patterns. Despite this, there seem to be only little empirical and systematic research or debate on consumers and citizens, and their understanding of CE.

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Appendix 1

Lobbying documents, organized from oldest to most recent

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