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1 Introduction

1.1 Background

The Journal of Economic Perspectives used to have a special section titled “Anomalies” with the purpose of documenting research producing empirical results violating theoretical assumptions within the specific economic paradigm (Cárdenas 2016). The presence of theoretical anomalies in any domain of science is a driving force for constantly updating the existing paradigms of the time. Researchers can thus be motivated to explore research domains besides their own for inspiration, and to gauge theoretical approaches that could explain anomalies, and complement their research field.

This scientific symbiosis is not unknown in the domain of Environmental and Resource Economics (ERE). Theoretical approaches from ERE have in the past benefited researchers in other research domains, such as in Health Economics and in Policy Research (Hanley et al. 2003; Rogge, Reichardt 2016). It has also been the case that ERE researchers have benefited from theoretic approaches in other domains, such as from Behavioural Economics (Croson, Treich 2014; Shogren, Taylor 2008).

In the context of environmental problems, Shogren and Taylor (2008) argue that relying on the conventional model of homo economicus for policy-making is unrealistic based on people's behavioural biases, and calls for a redesign of policy instruments and their supporting economic models. Cárdenas (2016), paying special attention to common-pool resources, further critiques this conventional model of human behaviour by expanding on the abundance of model anomalies related to economic behavior based on the homo economicus model.

Their critique is valid, and justifies their research into bridging ERE models with approaches from behavioural economics. However, also in the pursuit of enhancing the existing ERE literature, this research explores a divergent approach to this. Instead of

questioning the validity of the assumption of rational, calculative, self-oriented and opportunistic agents in the market, this research is motivated by the lack of it when modelling the economic role of governments and their actors. The validity of the assumption of governments as "benevolent social planners" can also be explored to try and explain observed theoretical anomalies and assumption violations of conventional economic models. Political Economy (PE) and its theoretical models on voting markets, elections, forms of government, etc. might offer insights into this.

This research is thus motivated in laying the foundations for potential complementarity between theoretical approaches in the ERE research domain and the (PE) research domain. However, the first step in this direction is mapping the current state of scientific research in both research domains, identifying where they are overlapping, and what are the trends driving their research topics.

1.2 Research Focus

With the motivation to potentially enhance the ERE literature with theoretical approaches from the PE research domain, the research focus of this study centres on the landscape of ERE and PE research topics in top mainstream economic journals.

From this perspective, this research study approaches the issue by attempting to answer the following research question:

What are the trends in top economic journals of ERE and PE research topics, and where do they overlap?

The following specific objectives are defined, in order to progressively add to answering the research question as they are implemented:

1. Identify published research mapping ERE.
2. Construct ontologies of ERE and PE, delineating a conceptual core of each research domain.
3. Map ERE and PE research topics in articles published between 2007 and 2017 in selection of top economic journals.
4. Develop a framework for mapping topics of specific research domains within large corpora of scientific writing.

By identifying research trends in ERE and PE, and identifying potential areas where they overlap, this research hopes to add value to the ERE research community by providing a map of potential avenues for future research into specific opportunities of bridging the ERE literature with theoretical approaches from PE. The map produced by this research study may also lay the foundation for identifying and defining the research question for a future full systematic literature review on a specific topic in ERE.

Furthermore, by developing a method for mapping research domains from large bodies of scientific literature, this research study can be further expanded to encompass scientific literature from beyond a small set of top economic journals. Additionally, the ERE research domain can also be mapped to multiple other research domains besides PE, in order to explore more areas with potential for enhancing the existing ERE literature.

2 Literature Review

2.1 Introduction

This research study is guided by the following set of specific objectives that build upon each other to answer the posed research question of identifying recent trends and overlaps of ERE and PE research topics in top economic journals. This research is grounded on the ERE theoretical domain, which is thus the main research object of this study. The literature review focuses only on existing literature synthesis of ERE scientific literature, with the objective to identify if similar research has been done in the past, and if so, benchmark the most successful methods to do so. This provides a picture of the known thematic landscape of the recent research being conducted in the ERE research domain. This current landscape of ERE is the starting point of this research. The research domain of PE is approached in this research as a comparison variable to ERE, which is the reason for applying to both research domains the same methods of mapping their respective scientific literature. However, an initial literary review on existing studies mapping the scientific literature on PE is not necessary.

1. Identify published research mapping ERE.
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The literature review attempts to achieve objective 1, i.e. identifying existing studies mapping the ERE literature. Furthermore, special attention is given to research synthesis methods, and qualitative analysis software, which are further discussed in Chapter 3 Methods.

2.2 Literature Mapping the ERE Research Domain

2.2.1 Search Strategy

This research study implemented a search of journal articles with the goal of identifying existing scientific literature published in the last five years which mapped the theoretical space of ERE. The main strategy implemented was the use of Web of Science to search

for articles using a combination of keywords and a time range for only filtering results from the last five years. Several stochastic attempts with keywords associated to “literature review” proved too ambiguous, so the following systematic use of keywords was used to search the literature.

The first approach was the use of the term "environmental and resource economics" in combination with a set of keywords to narrow down the search to literary synthesis. This set was composed of the terms “review”, “mapping”, and “scoping”, and each was individually iterated with "environmental and resource economics" in the search parameters. Neither combination produced results.

A second approach was carried using the term "environmental economics" in combination with the same set of keywords “review”, “mapping”, and “scoping”, individually iterated. Again, results were filtered for articles published in the last five years. The combination of "environmental economics" plus “review” produced the highest number of results, returning 25 articles, two of which remained blocked behind a paywall. The combination of "environmental economics" plus “mapping” produced 3 results, two of which had appeared in the previous search with the keyword “review”, while the remaining study was not a literary synthesis of environmental economics, but a mapping of global value and distribution of coral reef tourism (Spalding et al. 2017). The combination of "environmental economics" plus “scoping” produced only 1 article, which did not scope ERE literature, but was a commentary on a Blue Ribbon Panel report commissioned by the Global Partnership for Oceans (Abbott et al. 2014).

The remaining 23 articles did not map ERE as research domain, but reviewed the literature on one or some topics associated to the environment. The articles relevant to ERE reviewed the existing literature on the following topics: carbon emissions trading, modelling EU environment policy, circular economy, and global climate justice.

The review of the selected scientific literature reviewing a topic associated to ERE was divided into two themes. The first group consisted on studies that mapped a specific topic associated to ERE; the second group consisted on studies that reviewed topics associated to ERE, but which also crossed research domain boundaries into other non-environmental economic fields.

2.2.2 Recent Studies Mapping ERE Topics

The most relevant study with regards to mapping recent existing literature on ERE was conducted by Yu, Xu (2017, p. 1321). They conduct a scientometric review on literature between 1991 and 2015 on carbon emissions trading (CET), based on 2,786 documents retrieved from Web of Science, using the CiteSpace method. CiteSpace is a software written in Java and designed for analysing and visualising co-citation networks. The authors produce scientometric results of the top subject categories, journals, countries, research institutes, and topics related to CET.

The author's use of qualitative analysis software gives the study the advantage of synthesising a vast amount of scientific literature on a single topic, and producing summative statistics of the results. For example, they detect that CET is not just a topic approached by environmental or economic subject categories. In fact, they identify that research "on CET spread across more than 100 subject categories". (Yu, Xu 2017, p. 1317). Among the top ten subject categories carrying out research on CET, four of them are non-environmental nor economic in nature. These are Energy Fuels, Public Administration, Electrical/Electronic Engineering, and Chemical Engineering. Classifying scientific publications into hundreds of subject categories and fields is a necessity for credible scientometrics (Glänzel, Schubert 2003). However, classifying science into discrete structures should not be considered synonymous with mapping (Klavans, Boyack 2009). This is relevant to this research, as one of the challenges when mapping a research domain is clearly identifying the breadth of its subject area, as the research domain prevalence of topics at the frontier tend to become blurred with thematic overlap from other research domains.

Another relevant result for this research study, is Yu and Xu's detection of the most prevalent subtopic clusters on CET research. Through the use of TD-IDF (term frequency-inverse document frequency), a document-term weighing technique commonly used in information retrieval and data mining, they label each cluster with their most representative keywords. The top ten CET subtopics they identify are "Input-output model", "Environmental kuznets curve", "Carbon market", "Tradable ghg permit", "Abatement capital", "Atmosphere", "Border adjustment", "Distributional effect", "Marketable permit" and "Carbon emission right". With the use of a technique called burst detection, which measures abrupt changes in the use of references, keywords, authors, and institutions in a co-citation network, they conclude that the "'Carbon market' and 'Input-output model' are the new emerging research trend in CET research area and

the research about ‘Cap-and-trade’ and ‘China’ has become the new research topics[sic] in recent years”. (Yu, Xu 2017, p. 1321)

These types of results are valuable for the publishing community of scientific literature. However, they are devised for the efficient retrieval of information, rather than establishing a valid system of coordinates for mapping scientific knowledge (Suominen, Toivanen 2016). Scientometric studies use pre-existing categories of science through human-assigned metadata, such as subject categories and keywords. These keywords and categories represent the scientific consensus around established terms and subjects. Attempting to map the current landscape of a scientific fields and identify its trends through the use of pre-established keywords would appear to be contradictory, and disregards the actual body of knowledge contained inside the full text of scientific research documents.

In the context of this research, another relevant study is Köhler et al. (2016), who implement a scoping study providing an overview of modelling activities in the context of EU environment policy. They identify opportunities for improving the modelling of environmental policies, structured around three thematic priorities: natural capital; resource efficient, low carbon economy; and human health and wellbeing. These thematic priorities are considered within the context of sustainable urban planning and design; and global challenges.

A positive aspect of the Köhler et al. study is its ability to clearly identify gaps in the modelling research, associate the challenges to these gaps, and propose solutions to address them. Specifically, they identify modelling gaps in sustainable production and consumption, material flows and resource efficiency, urban environmental policy modelling, resilience, and adaptation. They identify as general challenges that there is often research bias in the data and models, as these tend to focus on the present socio-economic system, ignoring behavioural change. For this, they propose the use of agent-based modelling as a useful mechanism for modelling behavioural change.

The study’s ability to rapidly identify the gaps, challenges, and possible solutions in a field of research stems from the methodological benefits inherent to a scoping study, defined as a map of the scientific literature on a particular topic or research area, providing the opportunity to identify: “key concepts; gaps in the research; and types and sources of evidence to inform practice, policymaking, and research” (Daudt et al. 2013, p. 7). Its main advantage is its ability to rapidly map the key concepts underpinning a research

area, and can be implemented as a standalone project in its own right, “especially where an area is complex or has not been reviewed comprehensively before” (Arksey, O'Malley 2005, p. 26). A scoping study, or scoping review as it is also commonly referred to, is often implemented by researchers ahead of a systematic review in order to ‘scope’ the existing literature (Petticrew, Roberts 2006). Other researchers use scoping reviews for identifying theoretical approaches that may suggest new research directions (Anderson et al. 2008, p. 4).

A scoping review is intended to be broad in nature as its focus is to summarise the breadth of the scientific literature (Levac et al. 2010, p. 3). However, this can can create limitations, such as generating a significant quantity of data, leading to difficult trade-offs between breadth of coverage and depth of analysis. Furthermore, it can lead a scoping review to be unable to synthesis the data (Arksey, O'Malley 2005, p. 25). In spite of these limitations, a scoping review offers a potential methodological approach to mapping a research domain, provided the quantity of data limitation, and capacity to synthesise that data, can be mitigated.

2.2.3 Other ERE-Related Literature Review

Several other ERE-related studies, although not intended for mapping a research area, offered relevant insights into cases when different research domains heavily overlapped on specific research areas and topics. In some of the cases, theoretical approaches from one research domain were shuttled across the research domain boundary and used to complement theory on the other side.

Clear cases of situations where two or more research domains can overlap are particularly common in novel research concepts where environmental, economic, and social sciences intersect. An example of this is the concept of Circular Economy (CE). An extensive literature review conducted by Ghisellini et al. (2016, p. 11) intended to define the origins, basic principles, advantages, disadvantages, modelling, and implementation of CE at different global levels. The team explains how CE is primarily rooted in environmental economics and industrial ecology, and how the latter borrowed from ecological economics theoretical approaches specifically for the context of CE, while the former continues to borrow strongly from areas vested in technological innovation.

Another ERE-related research area where different research domains are overlapping is Climate Justice. Pottier et al. (2017) conduct a review to "propose a critical survey of the intellectual landscape of global climate justice". They define Climate Justice as a growing field where ethics, economics, and law intersect to produce a new and specific research domain. This definition falls short of several other fields that from their own review appear to overlap heavily on climate justice, such as climatology and politics, in the context of GHG emissions, and international and intergenerational equity respectively.

This pattern is observed repeatedly in the scientific literature on topics related to environmental issues. As these issues continue to gain prominence in both the general public and the scientific community, new and more novel research areas continue to spring forth in order to answer questions never before posed. However, components to these answers may currently exist in different areas of scientific knowledge.

2.3 Conclusions

Studies mapping the ERE research domain were scarce, and studies attempting to map an ERE-related subject tended to focus on a specific area or topic, but not on the entire research domain. Attempts at mapping a broad topic related to ERE, such as carbon emissions trading, used qualitative analytical software for conducting a scientometric study of the literature on the topic. Using qualitative analytical software benefits the mapping study as it enhances the studies capacity to capture more data at the same time as improving the synthesis of results. However, scientometric studies rely on pre-existing categories of science established through human-assigned metadata, such as subject categories and keywords. These studies produce efficient usage statistics of scientific literature, but are not good at mapping scientific knowledge nor good predictors of research trends.

A more relevant attempt for answering this study's research question was identified in a scoping review used for identifying gaps and opportunities in modelling of EU environmental policy. Scoping reviews, not being as rigid as a full systematic review, allows for a rapid, broad, and potentially systematic approach to mapping a research domain. Initially developed as a methodology for scoping results from studies in the health sciences, scoping reviews have been "used across a broad spectrum of academic disciplines and fields of study, including agricultural research, environmental studies and

process engineering. They have found particular utility in relation to public services, including education, housing and health care" (Anderson et al. 2008, p. 2).

3 Methods

3.1 Introduction

The methods section builds on the results of the literature review, describing the selected research strategy and methods used to answer the research question of identifying recent trends and overlaps of ERE and PE research topics in top economic journals. These methods target objective 2, and set the foundations for achieving objectives 3 and 4, from the set of specific objectives:

1. Identify published research mapping ERE.
2. Construct ontologies of ERE and PE, delineating a conceptual core of each research domain.
3. Map ERE and PE research topics in articles published between 2007 and 2017 in selection of top economic journals.
4. Develop a framework for mapping topics of specific research domains within large corpora of scientific writing.

This section details the overall research strategy implemented by this research study, then describes each step of the research synthesis framework carried out, and concludes by explaining the main challenges and limitations encountered.

3.2 Overall Research Strategy

The literature review identified some studies mapping specific ERE topics, but no studies mapping ERE as a broad research domain. This reinforces the need for a mapping exercise of the current ERE landscape in top economic journals, and in the specific context of this research study, how this landscape compares to the PE landscape.

Additionally, the literature review also identified some approaches for conducting synthesis of specific research topics, paying special attention to synthesis methods for qualitative research. In the pursuit of conducting a mapping of scientific literature, a scoping review was selected as an adequate methodology for the task (Levac et al. 2010; Brien et al. 2010; Miake-Lye et al. 2016; Anderson et al. 2008) Furthermore, a study conducted by Daudt et al. (2013, p. 2) identified that 75% of scoping reviews that fell under the same scoping review definition as this research, portray some form of comparison among research approaches, concluding that “this methodology may be best suitable to research that examines comparisons between interventions or approaches”.

This reinforces the methodological appropriateness of a scoping review, as this research also aims at detecting overlaps between the ERE and PE landscapes.

Specifically, this research study follows the framework developed by Arksey, O'Malley (2005) for conducting a scoping review. The framework consists of five stages plus a sixth optional one:

1. Identifying the research question
2. Identifying relevant studies
3. Study selection
4. Charting the data
5. Collating, summarising and reporting the results
6. Stakeholder consultation

Pointing out that scoping reviews had in the past been criticised for rarely providing methodological details on how results were obtained, Levac et al. (2010) identify that the framework prescribes for the collating and summarising of results: i) descriptive numerical summary of study content and metadata (sample size, year of publication, research methods, geographical location, etc.), and ii) a thematic analysis. However, they emphasise the lack of methodological details in the framework for how researchers can conduct the thematic analysis component of stage 5. They thus propose the use of "qualitative content analytical techniques and qualitative software to facilitate this process". Endorsing the proposal by Levac et al., Daudt et al. (2013, p. 6) go even further suggesting the addition of "a stage resembling qualitative data analytical techniques, or a thematic analysis". Considering the recommendations by Levac et al. and Daudt et al., this research applied a qualitative content analytical technique in stages 4 and 5 of Arksey and O'Malley's framework, using text mining software for statistical data analysis of the scientific literature.

Among the different approaches to qualitative content analysis (QCA), summative content analysis was selected as it prescribes descriptive quantitative analysis of manifest content, as well as latent content analysis (Hsieh, Shannon 2005). Latent content analysis is the process of interpreting content (Holsti 1969), which in the context of this research, focuses on discovering themes and underlying meanings within the text of research articles. To this effect, the summative content analysis was implemented via a statistical topic model, particularly a structural topic model (STM) (Roberts et al. 2017a). Like other statistical topic models, STM is a generative model of word counts, providing descriptive

quantitative analysis of manifest content and latent semantic analysis. However, STM's key innovation is that it allows researchers to incorporate metadata about each research article into the topic model (Roberts et al. 2017b). These key functionalities of providing a methodologically clear i) descriptive numerical analysis of both study content and metadata, and ii) latent thematic analysis, mitigate the criticism to scoping reviews' lack of methodological details for the collating and summarising of results, making thus STM an adequate model for stage 5 of Arksey and O'Malley's scoping review framework.

Finally, a summative content analysis approach heavily relies on creating and adhering to an analytical procedure or a coding scheme in order to increase trustworthiness and validity of a study, and is defined at the start of the study for quantifying and identifying contextual use of certain words and terms (Hsieh, Shannon 2005, p. 1286). Consequently, and taking into account the recommendation by Daudt et al. (2013) on adding to Arksey and O'Malley's framework a stage relating to the qualitative data analytical technique, this research includes an extra step for the creation of research domain ontologies. These ontologies play a crucial role in the coding scheme implemented by this research to successfully identify in the scientific literature domain-specific terms and themes composed of multiple words which cannot be captured through the conventional use of keywords. The other elements of the coding scheme are contained in the stage for charting the data.

Incorporating all the methods discussed into an overall research strategy, the scoping review framework implemented by this research is as follows:

Stage 1: Identifying the research question *(Stage 1 of Arksey and O'Malley Framework)*

Stage 2: Building the domain ontologies *(Part 1 of QCA coding scheme)*

Stage 3: Identifying relevant studies *(Stage 2 of Arksey and O'Malley Framework)*

Stage 4: Study selection *(Stage 3 of Arksey and O'Malley Framework)*

Stage 5: Charting the data *(Stage 4 of Arksey and O'Malley Framework + Part 2 of QCA coding scheme)*

Stage 6: Summative content analysis via Structural Topic Model *(Stage 5 of Arksey and O'Malley Framework)*

This research study did not include the sixth optional stage for stakeholder consultation in the Arksey and O'Malley framework, as stakeholder supervision was received across

all research stages. From another perspective, it could be said that the stakeholder consultation stage was implemented transversely across the framework.

The following subsections in this chapter specifically describe the implementation of the methods throughout each of the steps in the framework, as outlined in this overall research strategy.

3.3 Stage 1: Identifying the Research Question

The motivation behind this research lies in exploring the ERE landscape and identifying what approaches from other research domains may enhance the existing ERE literature. Interest is payed to PE, as it is theoretically close enough to ERE to share similar economic paradigms and assumptions, but far enough to potentially complement existing ERE theoretical models.

However, to prove if the potential of enhancing ERE literature with theoretical approaches from PE exists, the first step is to map both research domains and identify their themes, trends, and potential theoretical overlaps. Consequently, the research question was defined as:

What are the trends in top economic journals of ERE and PE research topics, and where do they overlap?

The research question calls for a scoping exercise, whose purpose is both to map a broad range of literature, as well as to envisage where gaps and innovative approaches may lie (Ehrich et al. 2002, p. 28). This research study focuses primarily on the mapping objective, but can be a useful step toward future research projects designed for a deeper analysis (Daudt et al. 2013, p. 6).

Research questions of scoping reviews are broad in nature as the focus is on summarizing the breadth of the scientific literature of interest. It is therefore recommended that researchers couple a broad research question with a clearly defined scope of research, setting explicit boundaries that keep the review synthesis manageable (Levac et al. 2010, p. 3).

By choosing to identify ERE and PE topic trends in top economic journals, the research question limits the breadth of coverage from the outset of the scoping review, with the intention of making the volume of articles selected for the research synthesis manageable,

while at the same time making its results relevant for the ERE research community. This decision is deliberate, as the time horizon for concluding this research had a limited duration.

Similarly, by focusing on identifying recent trends in the ERE and PE literature, the research question also helped defining the temporal scope of this study. To that effect, this research set the novelty of ERE and PE research topics to the period between January 1st, 2007 and December 2nd, 2017. This timeframe allows this research to map the most novel ERE and PE topics being published in top economic journals, as well as identifying changes in topic trends during the last decade.

3.4 Stage 2: Building the Domain Ontologies

As explained in the overall research strategy section, this new stage was included in the scoping review framework implemented by this research to adhere to the summative content analysis requirement of defining a coding scheme. The coding scheme implemented by this research consists of two parts: i) building research domain ontologies for ERE and PE; and ii) data preparation and tokenising of articles. The first part is explained in this section; the second part is explained in the stage for charting the data.

The purpose of building domain ontologies in this research stems from the imperative to identify and extract from corpora of journal articles relevant, domain-specific, and often new, terms which consist of multiple words, but which have not been included by the academic community into pre-existing keywords and scientific categories (Suominen, Toivanen 2016, p. 2464). More importantly, domain ontologies permit researchers to clearly identify research domain content in the form of a thesaurus, listing domain-specific terms grouped by synonyms and related concepts. As research domains are arbitrary human-categorisations of scientific knowledge, ontologies provide researchers with a clear core of theoretical concepts for a research domain, and thematic interstices with other at its borders.

Although this stage is not an official stage in the Arksey and O'Malley framework for scoping reviews, they themselves point out "the importance of defining terminology at the outset" (Arksey, O'Malley 2005, p. 16), when describing in stage 3 of their framework specific difficulties they faced selecting studies for their research study. Levac et al. (2010, p. 6) also recommend researchers to determine which variables to extract that will help to answer the research question. This research therefore built domain ontologies for

ERE and PE to use as coding schemes intended to effectively extract the domain-specific terms that could help better identify current ERE and PE topics, trends, and overlaps.

3.4.1 Setting Domain Anchors

In order to build domain ontologies which were theoretically congruent with ERE and PE, this research chose one academically recognized textbook for each domain, following the recommendations from supervisory experts, and accounts that researchers report using summative content analysis in studies that analyse specific content in textbooks (Hsieh, Shannon 2005, p. 1284). The chosen textbooks were Perman (2003) "Natural Resource and Environmental Economics" for the ERE research domain, and Persson, Tabellini (2000) "Political Economics. Explaining Economic Policy" for the PE research domain. These textbooks are referred to as the "domain anchors" for the rest of this research study, precisely because they function as anchors to the specific location in the universal map of scientific knowledge defined as ERE an PE respectively.

The first step in building the domain ontologies was to split each domain anchor into subchapters in Microsoft Excel, and any subchapters with more than 32,767 characters (Excel 2016 cell limit) was further split into subsegments using subchapter topic headers as breaks. Each split was then treated as an individual document, and aggregated into their respective corpus. The result were two corpora: one for ERE and another for PE.

3.4.2 Extracting Multi-Word Expressions

The domain-specific terms were extracted from the domain anchor corpora using a statistical model for identifying and scoring multi-word expressions in text. Multi-word expressions (MWE) are defined by Farahmand (2017) as sequences of words that show some level of idiosyncrasy, i.e. a peculiar behaviour, often associated with idiomaticity. When applied to a domain anchor, the idiomaticity component of MWE extracted from it represents the peculiar characteristics of domain-specific terms idiosyncratic to that research domain. Farahmand (2017, p. 1) also summarises in three groups the most common types of idiosyncrasies associated to MWE:

i. Semantically idiosyncratic: The meaning of the MWE cannot be directly inferred from the meaning of its individual components, e.g. "flea market", "kangaroo court";

ii. Syntactically idiosyncratic: The syntax of the MWE cannot be inferred from the syntax of its components or it does not follow syntactic rules of the language, e.g. “at large”, “in short”;
iii. Statistically idiosyncratic: The components of a MWE tend to co-occur more often than chance, e.g. “drug dealer”, “finish line”.

As this research uses a statistical model for detecting and extracting MWE through word co-occurrences, only statistically idiosyncratic MWE are identified. However, this approach also identifies semantically and syntactically idiosyncratic MWE if they appear frequently in the selected journal articles.

The statistical model used in this research for extracting MWE was developed by Benoit et al. (2017) and can be found in the Quanteda package (Benoit et al. 2017) for the R Language and Environment for Statistical Computing (Team R. Core 2017). The exact model for identifying and scoring MWE from text can be called by using the textstat_collocations functions from the Quanteda package (Benoit et al. 2017).

The model was run three times for each domain: once for bigram MWE (two-word sequences), once for trigram MWE (three-word sequences), and once for four-gram MWE (four-word sequences). An initial threshold for extracting a MWE, based on the minimum frequency a MWE appeared in its respective domain anchor corpus, was set to 10. However, this produced only a third of results when compared to a minimum frequency threshold of 5. Based on this, the threshold for MWE minimum frequency was set to 5 for all model runs.

The model produced a ranked unsupervised list of MWE from the domain anchors, composed both of domain-specific MWE (e.g. “abatement cost”, “electoral cycle”), as well as general use MWE (e.g. “even though”, “simple numerical example”). The list was then manually curated by the researcher for only domain-specific MWE. This was not always a clear-cut objective decision, especially for cases of MWE associated to high-order general economic terms (e.g. “utility function”, “net present value”). Since all MWE came from vetted ERE and PE academic textbooks, all MWE containing high-order economic terms were kept in the ontology, although tagged under a category called “modelling” in the subsequent step of aggregating the list of MWE. This category can be easily filtered, and the terms removed from the ontology, in future research studies with a more stringent domain-specific criterion.

To the list of MWE, some unigrams (one-word terms) were added. These were terms with the highest frequency in each corpus, calculated using term frequency-inverse document frequency (TF-IDF). TF-IDF weighs each word proportionally to the number of times it appears in the document, and offsets it by the frequency of itself in the whole corpus. TF-IDF helps detecting frequent terms that tend to be exclusive to one or a few documents in the corpus. Once again, this list of frequent terms was manually curated to only include domain-specific terms.

3.4.3 Curation Guidelines of MWE List

The general guidelines applied during the curation of the MWE and unigram lists were:

- Preference of bigrams over trigrams;
- Preference of trigrams over four-grams;
- Preference of four-grams over unigrams;
- No wildcard characters for names.

As a preference scale:

name < 0 < unigrams < four-grams < trigrams < bigrams

The reason for having the least preference for unigrams is that if a unigram was used to match and extract domain-specific terms from a corpus of journal articles without the use of wildcard characters (e.g. glop patterns, used in this research study), the singular form of the term would not match its plural form (e.g. "fuel" vs. "fuels"). This accounted to the same concept being represented with two different terms when running the structural topic model, increasing thus the number of variables (dimensionality) of the model. Additionally, unigrams without the use of wildcard characters would not match key derivations, adjectivisations, nominalisations, etc., of relevant domain-specific concepts (e.g. "agriculture" vs "agricultural", "fishery" vs. "fishing", "harvest" vs. "harvested"). On the other hand, unigrams with wildcard characters risked capturing terms that were not domain-relevant or aggregable into the same thesaurus category (e.g. "flow" could match "flower ", "cash" could match "cashew").

In the end, the few unigrams that were included into the ontologies represented:

- Acronyms (e.g. "wtp", "cvm", "epa");

- Highly domain-specific terms identified among top 200 most TF-IDF frequent terms (e.g. "abatement", "pollution", "emissions", etc. for ERE; "voting", "policymaking", "lobbying", etc. for PE).

The least preferred MWE were four-grams (e.g. "aggregate marginal abatement cost", "social utility discount rate", "extensive form game theory"). Four-grams with or without wildcard characters tended to be too specific, limiting the probability of matching any actual term in the corpus of journal articles, while increasing dimensionality of the topic model when run. Furthermore, four-grams exhibited compounded word variability, i.e. some authors hyphenated two of the words in a four-gram (e.g. "special-interest politics model"), others used them as open compound words (e.g. "special interest politics model"), while others used them as closed compound words (e.g. "non-renewable natural resource" vs. "nonrenewable natural resource"). This variability on the occurrence of hyphens and whitespace characters between four words created a significant level of complexity in matching terms in the corpora; a complexity not experienced with trigrams.

Trigrams were valuable when two of the words made a compound word, either open or hyphenated, and the third word added a deeper and relevant level of domain specificity (e.g. "air pollution control" vs. "air pollution"; "air quality standards" vs. "air quality"; "public-good provision", vs. "public good"). However, a third word in a trigram often didn't add a significant or relevant level of domain-specificity, in which case its compounded bigram was preferred (e.g. "abatement cost" over "abatement cost curve" or "abatement cost function").

Finally, wildcard characters were not used with unigrams of researchers' names, to avoid aggregating a MWE that carried a researcher's name as part of the concept, with when the author was being cited (e.g. "downsian [model]" vs. "downs"; "marshallian [demand]" vs. "marshall").

3.4.4 Curation Guidelines for Thesaurus Keys

Ontologies which contained all possible permutations of derivations, adjectivisations, nominalisations, etc., of relevant domain-specific concepts would have contained several thousand terms each. By using wildcard characters that matched patterns shared by several permutations of a single concept, the ontologies could be reduced in size into a more manageable set of thesaurus keys. Each of these keys could match and extract

multiple domain-specific terms from corpora of journal articles. The following general guidelines were used to construct:

- Keys that matched a noun's singular with its plural, by adding the asterisk ("*") wildcard character (using glob pattern matching) to the word stem from where the plural stemmed out. These keys would match and extract their nouns in the corpus independently of if they appeared in singular or plural form in the corpus (e.g. "non-renewable resource" and "non-renewable resources" grouped to thesaurus key "non-renewable resource*").
- Keys that grouped conceptually equivalent MWE. These keys would identify and extract any variation of the concept that matched the key's pattern (e.g. "central banking", "independent central bank", and "central bank independence" grouped to thesaurus key "central bank*").
- Keys that matched same compound words with different compounding method; i.e. one had been hyphenated, while the other left as an open compound word (e.g. "common-pool" and "common pool" grouped to thesaurus key "common* pool").
- Keys that matched same terms, but where the possessive form of a noun in the MWE appeared with its apostrophe and another didn't. This matching was done by adding the question mark "(?)" wildcard character twice (e.g. "citizens juries" and "citizens' juries" grouped to thesaurus key "citizens?? Juries".

Some keys implemented more than one guideline, such as keys that grouped conceptually equivalent MWE, and grouped the singular with the plural of a noun in the MWE (e.g. "capital taxation", "capital taxes", and "capital tax" grouped to thesaurus key "capital tax*").

3.4.5 Curation of Other Minor Aspects

Once all the terms from the MWE and unigrams list were converted to thesaurus keys, only minor issues were left for mitigating. The most relevant were:

- British vs. American English: Perman's "Natural Resource and Environmental Economics", used for ERE's domain anchor, was written in British English. Conversely, Persson and Tabellini's "Political Economics. Explaining Economic Policy", used for PE's domain anchor, was written in American English. This impeded some thesaurus keys from converging into the same concept. The most

notable example were word endings “our” vs. “or” (e.g. “labour” vs. “labor”, “behaviour” vs. “behavior”). This situation was mitigated by adding the asterisk wildcard character in the corresponding thesaurus key after the “o” (e.g. “labo*”, “behavio*”). This allowed the thesaurus keys to match both versions in the corpus of journal articles.

- Intuition false positives: Terms that intuitively belonged to the ERE or PE domain, but were not the direct object of theoretical discussion. Example:
    - “Street lighting”: At first glance, the term gave the impression of being relevant to topics in the ERE domain, such as "public good" or "energy". However, when auditing the term, the researcher detected that the term appeared 20 times, all within the context of an example on the topic of "preference revelation and the free rider problem". As the term was not a direct object of the theoretical discussion, it was discarded from ERE's ontology, to avoid creating artificial thematic correlations with “preferences” or “free rider problem”.
- Congruence false positives: Terms that were relevant to a domain or topic, but irrelevant to another, making them thematically incompatible. Examples.
    - “First term”, “second term”, third term”, “last term”, “two terms”, “two periods”: These terms were highly relevant in the PE domain anchor, relating to incumbents’ terms in office, inter alia. However, these terms were used in the ERE domain anchor for referring to terms in economic equations and time horizons in economic models. The terms were discarded from both domain ontologies, to avoid creating thematic incongruence when merging the ontologies for running the structural topic model. As in the previous example, an artificial thematic correlation would have been created between “elections” and “economic modelling”.
- Completing word dyads: Terms belonging to domain-specific dyads, but which one of the parts was missing. The missing parts were added to the ontologies. Example:
    - “extrasomatic energy”: The term was detected in the ERE domain anchor, but its complement “endosomatic energy” was not detected in either. It was thus added, as well as with the former’s most common synonym “exosomatic energy”.

3.4.6 Merging Domain Ontologies

So far, the process of building the domain ontologies consisted of:

i. Selecting academically validated domain anchors from which to extract terms that reflect each research domains' conceptual core.
ii. Splitting domain anchors by chapters, subchapters, subsegments, etc., into smaller documents, and aggregating them into domain corpora.
iii. Extracting MWE and most frequent TF-IDF words from each domain corpora.
iv. Manually curating list of MWE and frequent words.
v. Convert each ontology's terms into thesaurus keys, for later use matching and extracting from the corpus of journal articles the terms identified as each research domain's conceptual core.

For any research study mapping an individual research domain, this would be the end of the methodology for building domain ontologies to use as a coding scheme for scoping a body of scientific literature. As this research study is looking for topic trends and overlaps in ERE and PE, there was an extra step of merging the two ontologies into two broad conceptual networks connected by shared core terms. The list of thesauri keys from the merged ontologies can be found in Appendix 1.

3.5 Stage 3: Identifying Relevant Studies

According to Arksey, O'Malley (2005, p. 26), the scoping review method is guided by the imperative of identifying all relevant literature, published or not, regardless of study design. In practice, the volume of literature to review may be overwhelming for the research team depending on the topic or field being researched. Some restrictions are thus suggested, such as searching across a limited number of key databases, limiting searches to a specific range of time, or restricting journal articles by language (Petticrew, Roberts 2006).

Another approach implemented by some researchers is to consult stakeholders, colleagues, and members of the scoping research team, who may provide methodological and context expertise for limiting the breadth and comprehensiveness of the study (Brien et al. 2010, p. 4; Levac et al. 2010, p. 5). Through these consultation exercises, list of relevant sources and websites to search can be compiled (Brien et al. 2010, p. 4).

This research consulted with supervisory experts from the team overviewing the study, to delineate relevant boundaries to the scoping exercise. The initial strategy was to use

convenience sampling of journals, selecting the top 10 economic journals, based on the SCImage Journal Rank (SJR) values (Sturm, Haucap 2017). The advantages of this strategy for limiting the study's scope was that it provided state-of-the-art research in the most reputed economic journals, which guaranteed the scientific quality of the articles to be selected. The disadvantage of this strategy was that more specialized journals, although with lower ranking, could provide more domain-specific research topics. This was especially true for ERE, which had no specialized journals among the top 10 economic journals. PE did have a specialized journal among the top 10 economic journals (Journal of Political Economy).

The top 10 economic journals initially selected for the study were:

- American Economic Journal: Applied Economics
- American Economic Journal: Macroeconomics
- American Economic Review
- Econometrica
- Journal Of Economic Literature
- Journal Of Finance
- Journal Of Financial Economics
- Journal Of Political Economy
- Quarterly Journal Of Economics
- Review Of Economic Studies

However, as will be further explained in the Study Selection section, article selection was limited using their JEL codes. The reason for this strategy was to select articles tagged with JEL codes associated to either ERE or PE topics, and reduce thematic noise from other research domains with little relevance to answering this study's research question.

Among the top 10 economic journals, articles from journals associated to the American Economic Association were easily searched and downloaded using JEL codes directly from their websites, by typing the three-digit code (e.g. Q51) into the search bar. These were:

- American Economic Journal: Applied Economics
- American Economic Journal: Macroeconomics
- American Economic Review
- Journal Of Economic Literature

Conversely, articles from some of the other journals could not be effectively searched using JEL codes directly from their websites, such as:

- Econometrica
- Journal Of Financial Economics
- Journal Of Political Economy

For this reason, the journal selection strategy was modified to only include the journals from the American Economic Association (AEA), plus the Journal Of Political Economy (JPE) because of its domain-specificity to PE. However, the method for selecting articles from JPE had to be modified from the one used to select articles from the AEA journals. This will be further elaborated in the next section. Additionally, only 4 articles from the Journal of Economic Perspectives were identified using the methodology used for the other journals from AEA, so it was removed from the journal selection to avoid journal covariate class imbalance.

The final journal selection, and their corresponding SJR ranks were:

JOURNAL	SJR RANK
American Economic Journal: Applied Economics	1
American Economic Journal: Macroeconomics	2
American Economic Review	3
Journal Of Economic Literature	5
Journal Of Political Economy	8
American Economic Journal: Economic Policy	12
American Economic Journal: Microeconomics	28

Table 3.1 – List of Journals for Article Selection

The advantage of this final strategy for journal selection was that, except for JPE, the subsequent article selection strategy using JEL codes had a high methodological rigour. The disadvantage was that the articles selected for the research study could potentially carry selection bias from the editorial board of the AEA. This strategy was implemented nonetheless, as it guaranteed quality of the scientific literature, methodological congruence, and time efficiency.

3.6 Stage 4: Study Selection

As Gough (2007) notes, the inclusion criteria in a review with an emergent iterative method, such as in a scoping review, may not become fully clear until later stages of the review. On the subject of searching electronic databases, he also adds that “the majority of papers may not be on the topic or meet the other inclusion criteria for the review” (Gough 2007, p. 219). This became evident to this research when manually reviewing the articles from the selected journals. The initial strategy was to include all articles in the

structural topic model, but the volume of non-ERE and non-PE topics was not trivial. Too many articles from topics with little to no relevance to ERE or PE would have added noise instead of valuable insights to the mapping of these research domains. Running the structural topic model including all articles from the selected journals was computational possible, but counterproductive to the domain-specificity of the literature synthesis.

To safeguard domain-specificity of the sample, a more stringent inclusion criterion was necessary. In a study by Brien et al. (2010, p. 3), researchers mapped keywords to database thesauri search terms, which were then searched as text word terms in databases. Suominen, Toivanen (2016) go even further, identifying meaningful connections between knowledge classifications of science (ISI-WoS) and unsupervised statistical learning results by overlaying one over the other. Building on these approaches, inclusion criteria that refined the ERE and PE domain-specificity of the corpus of journal articles was designed.

The first inclusion criterion implemented by this research used the ontologies from the previous stage as coding schemes to match JEL codes associated to ERE and PE. All JEL codes were tabulated with their subject descriptions, guidelines, and keywords, and compared to thesaurus keys and categories in the merged ERE-PE ontology. From this process, the following JEL codes were chosen for article selection:

JEL Code	Subject Description	Guideline	Keywords
D23	Organizational Behavior; Transaction Costs; Property Rights	Covers studies about issues related to firm behavior a la Williamson and Coase and other studies about organizational behavior.	Cost, Institutional Choice, Internal Organization, Organization, Organizational Behavior, Property, Property Rights, Transaction Costs, Transactions
D62	Externalities	Covers mostly theoretical studies about issues related to externalities and welfare analysis.	Consumption Externality, Externality, Internalizing Externalities, Negative Externality, Pigouvian Tax, Positive Externality, Production Externality, Spillover Effect
D72	Political Processes: Rent-Seeking, Lobbying, Elections, Legislatures, and Voting Behavior	Covers studies about issues related to public choice, including economic models of political process, such as rent seeking, election, legislatures or voting behavior. These topics originated in public choice a la Buchanan-Tullock. Studies about the premises that underlie political process such as liberty and rights are also classified here.	Agenda Setting, Apportionment, Arrow Impossibility Theorem, Ballot, Bicameral, Bipartisan, By Election, Campaign, Caucus, Coalitions, Condorcet Voting, Congress, Constitution, Democracy, Democratization, Dictatorship, Election, Electorate, Feudalism, Gerrymandering, Government, Impeachment, Impossibility Theorem, Interest Group, Legislature, Liberty, Lobbying, Majority Rule, Monarchy, National Government, PAC, Parliament, Party System, Politic, Political, Political Business Cycle, Political Campaign, Political Process, Politician, Politico Economic, Presidential, Regional Government, Rent Capture, Rent Seeking, Representation, Representatives, Rights, Separation of Powers, Suffrage, Two Party, Veto, Voting

JEL Code	Subject Description	Guideline	Keywords
D73	Bureaucracy; Administrative Processes in Public Organizations; Corruption	Covers studies about issues related to bureaucracy, corruption, and administrative processes in public organizations. Studies about administrative processes, involving collective or political decision making in public organization are classified here.	Bureau Politics, Bureaucracy, Corruption, Hierarchy, Public Organization, Technocrat
F51	International Conflicts; Negotiations; Sanctions	Covers economic studies about issues related to international conflicts, negotiations and sanctions.	Conflict, Conflict Cooperation, Conflict Resolution, International Conflict, International Negotiation, International Sanctions, Negotiation, Peace Keeping, Reconstruction, Sanctions, Terrorism, War
F55	International Institutional Arrangements	Covers studies about issues related to international institutional arrangements, including noneconomic aspects of economic integration.	Border, Cooperation, European Union, International Norms, Member States, Political Economy
F64	Environment	Covers topics related to the impact of globalization on the environment.	Environment, Foreign Direct Investment, Globalization, Multinational Corporations, Pollution
H11	Structure, Scope, and Performance of Government	Covers studies about issues related to the roles of government as an institution.	e-Government, Executive, Government, Government Performance, Judiciary, Parliament, Role of Government, Scope of Government, Size of Government, Structure of Government, Wagner's Law
H23	Externalities; Redistributive Effects; Environmental Taxes and Subsidies	Covers studies about issues related to externalities due to taxes and subsidies, the redistributive effects of taxes and subsidies, and environmental taxes. Studies about intergenerational effects of taxes and subsidies are classified here as redistributive effects.	Ecotax, Environmental Subsidy, Environmental Tax, Externality, Income Transfer, Internalizing Externalities, Lump Sum Transfer, Negative Income Tax, Pigouvian Tax, Pollution Tax, Redistributive Effects, Tax Equity, Tax Externalities, Tax Shifting
H41	Public Goods	Covers studies about issues related to public goods and services, including privately provided public goods and services.	Free Rider, Joint Products, Local Public Service, Privately Provided Public Good, Public Services, Pure Public Goods, Voucher
H71	State and Local Taxation, Subsidies, and Revenue	Covers studies about issues related to taxation, subsidies, and revenue at the state and local level, including state lotteries and sales taxes.	Local Government Revenue, Local Government Subsidies, Local Government Taxation, Local Tax, Property Tax, Sales Tax, State Government Subsidies, State Lottery, State Revenue, State Tax, Taxation
H72	State and Local Budget and Expenditures	Covers studies about general issues related to the budget and expenditures of state and local governments.	Appropriation, Budget Constraint, Expenditure, Local Government Budget, Local Government Deficit, Local Government Expenditures, Local Public Service, Public Expenditure, State Budget, State Budget Deficit, State Expenditure, Surplus
H76	State and Local Government: Other Expenditure Categories	Covers studies about issues related to state and local infrastructures, procurement, public safety, penal systems and other expenditures not related to health, education or welfare.	Environment, Infrastructure, Local Government Expenditure, Penal System, Prison, Public Safety, State Expenditure, State Infrastructure, State Procurement, Transportation
H77	Intergovernmental Relations; Federalism; Secession	Covers studies about issues related to intergovernmental relations, including federalism, secession, and intergovernmental grants.	Block Grant, Centralization, Decentralization, Federal State, Federalism, Fiscal Federalism, Grants In Aid, Intergovernmental Grants, Intergovernmental Relations, Multi-level Governance, Secession
K32	Environmental, Energy, Health, and Safety Law	Covers the intersections of environmental, health and safety laws and economics or economies.	Air Quality Law, Alcohol Laws, Anti-Dumping, Consumer Protection, Emissions Law, Energy Law, Environmental Law, Health and Safety Law, Medical Law, Natural Resources Law, Occupational Safety Law, Pollution Law, Product Safety, Tobacco Laws, Waste Management Law

JEL Code	Subject Description	Guideline	Keywords
O13	Agriculture; Natural Resources; Energy; Environment; Other Primary Products	Covers studies about development issues related to agriculture, natural resources, other primary products, energy, and the environment.	Agrarian, Agricultural Policy, Agriculture, Agrienvironment, Agrifood, Deforestation, Desertification, Drought, Energy, Environment, Environmental Policy, Erosion, Farm Input Markets, Farmers, Farmland, Farms, Food, Food Production, Hazardous Waste, Hydrocarbons, Land, Land Markets, Mechanization, Mining, Natural Resources, Primary Products, Rainfall, Resource Base, Resource Booms, Resource Policy, Resource Poor, Resource Rich, Sharecropping, Waste Management
P48	Political Economy; Legal Institutions; Property Rights; Natural Resources; Energy; Environment; Regional Studies	Covers studies about issues related to political economy, legal institutions and property rights in economic systems other than capitalist, socialist, and transitional economic systems. This includes roles of government and/or power relationships in resource allocation.	Economic Institutions, Energy, Environment, Government, Legal Institutions, Natural Resources, Political Economy, Primary Products, Property Rights, Public Economics, Regional Studies, Rural Economics, Urban Studies
Q15	Land Ownership and Tenure; Land Reform; Land Use; Irrigation; Agriculture and Environment	Covers studies about issues related to agricultural land, including ownership and tenure (for example, issues related to share cropping), irrigation and agricultural land valuation.	Acreage, Agricultural Land, Agriculture and Environment, Agrienvironment, Bureau of Land Management, Climate, Crop Choice, Cropland, Dams, Drought, Erosion, Extensive Farming, Fallow, Farm Emissions, Farm Real Estate, Farmland, Flooding, Irrigation, Land Ownership, Land Reclamation, Land Reform, Land Tenure, Land Use, Land Valuation, Landholdings, Rainfall, Ranchland, Resettlement, Sharecropping, Smallholders, Soils, Tenancy, Tenant, Tillage
Q20	General	Covers studies about general issues related to renewable resources and conservation, including survey articles, textbooks, and data.	Conservation, Conservation Data, Natural Resources, Renewable Resources, Resource Data
Q21	Demand and Supply; Prices	Covers mostly theoretical studies about issues related to the market for renewable resources in general, such as demand, supply, and price analysis. Also includes issues pertaining to the commons.	Common Pool Resources, Commons, Conservation, Depletion, Resource Demand, Resource Prices, Resource Supply, Willingness to Pay
Q22	Fishery; Aquaculture	Covers studies about issues related to fishery and aquaculture.	Aquaculture, Aquaculture Conservation, Fisheries, Fishing, Inland Fisheries, Maritime, Overfishing, Seafood, Seafood Farming
Q23	Forestry	Covers studies about issues related to forestry.	Afforestation, Agroforestry, Deforestation, Forest Conservation, Forestry, Hunting, Logging, Lumber Industry, Planting, Rainforest, Reforestation, Rubber Industry, Timber Market, Trees, Wood, Woodland
Q24	Land	Covers studies about issues related to land as a renewable resource and its conservation.	Acreage, Desertification, Erosion, Land, Land Conservation, Land Development, Land Markets, Land Ownership, Land Reclamation, Land Use, Land Value, Landholdings, Reclamation, Soil Degradation, S
Q25	Water	Covers studies about issues related to water as a renewable resource and its conservation.	Chemical Pollution, Dams, Drought, Dumping, Flood Control, Groundwater, Oceans, Rainfall, Reef, Rivers, Sewage, Wastewater, Water, Water Conservation, Water Pollution, Water Safety, Water Security, Water Supply
Q26	Recreational Aspects of Natural Resources	Covers studies about issues related to the recreational uses of natural resources, for example fishing or parks.	Conservatory, Cost Benefit, Hunting, National Parks, Nature Preserve, Parks, Protected Area, Public Parks, Public Use, Recreation, Recreational Fishing, Trails, Water Sports, Wildlife Preserve, Willingness to Pay
Q27	Issues in International Trade	Covers studies about issues related to the international trade aspects of renewable resources, including fishing rights.	Commodity Trade, Fishing Rights, International Trade, Renewable Resource Trade, Resource Protection, Trade Policy
Q28	Government Policy	Covers studies about government policies related to renewable resources and their conservation, including international policies.	Conservation Policy, Environmental Policy, International Environmental Policy, International Resource Policy, Renewable Resource Policy
Q29	Other	Not Specified	None Specified

JEL Code	Subject Description	Guideline	Keywords
Q30	General	Covers studies about general issues related to nonrenewable resources and their conservation, including survey articles, textbooks, and data.	Conservation, Conservation Data, Exhaustible Resources, Natural Resources, Nonrenewable Resources, Resource Data
Q31	Demand and Supply; Prices	Covers mostly theoretical studies of issues related to the market for nonrenewable resources, including demand, supply, and price analysis.	Depletion, Exhaustible Resource Markets, Fossil Fuel Prices, Oil Prices, Resource Demand, Resource Prices, Resource Supply
Q32	Exhaustible Resources and Economic Development	Covers studies about issues related to nonrenewable resources and economic development.	Least Developed Countries, Resources and Development, Resources and Growth
Q33	Resource Booms	Covers studies about issues related to resource booms and their effects, including Dutch disease.	Dutch Disease, Resource Booms, Resource Curse, Resource Discovery
Q34	Natural Resources and Domestic and International Conflicts	Covers studies about domestic and international conflicts related to natural resources.	Conflict Minerals, Conflict Resource, Natural Resource Conflict, Natural Resource Security, Oil Conflict, Resources and War.
Q35	Hydrocarbon Resources	Covers studies related to the market for and conservation of hydrocarbon resources including oil, gas, and coal.	Coal, Fossil Fuels, Gas, Hydrocarbons, Hydrocarbons Conservation, Natural Gas, Oil, Petroleum, Shale
Q37	Issues in International Trade	Covers studies about issues related to the international trade aspects of nonrenewable resources.	Conflict Resources, Fair Trade, International Trade, Oil Country, Oil Exports, Oil Imports, Oil Trade, Rare Earth Minerals Trade, Resource Supply Chain
Q38	Government Policy	Covers studies about government policy related to nonrenewable resources and their conservation, including OPEC policy.	Conservation Policy, Natural Gas, Oil Policy, OPEC, OPEC Policy, Protectionist Policy, Resource Trade Policy
Q39	Other	Not Specified	None Specified
Q40	General	Covers studies about issues related to energy in general, including survey articles, textbooks, and data.	Energy, Energy Data, Energy Markets, Energy Resources, Energy Sources
Q41	Demand and Supply; Prices	Covers studies about issues related to the market for energy in general, including demand, supply, and prices.	Energy Conservation, Energy Consumption, Energy Demand, Energy Efficiency, Energy Markets, Energy Pricing, Energy Supply, Energy Use
Q42	Alternative Energy Sources	Covers studies about issues related to alternative energy sources, for example non-hydrocarbon fuels or wind.	Alternative Energy Source, Bioenergy, Energy Sources, Energy Substitution, Ethanol, Gasification, Hydropower, Non-Hydrocarbon, Nuclear Energy, Renewable Energy, Solar Energy, Wind Energy
Q43	Energy and the Macroeconomy	Covers studies about issues related to the relationships between energy and the macroeconomy, such as the relationship between energy usage and GDP or growth.	Aggregate Energy Consumption, Aggregate Energy Prices, Energy and Growth, Energy Shocks, Oil Shocks
Q47	Energy Forecasting	Covers studies about issues related to forecasting of energy markets, including prices and production.	Energy Demand Forecast, Energy Forecasting, Energy Futures, Energy Price Forecasting, Energy Supply Forecast, Energy Sustainability Forecast, Oil Price Forecast, Production Prediction
Q48	Government Policy	Covers studies about issues related to government policy on energy.	Clean Energy Policy, Energy Certificates, Energy Conservation, Energy Policy, Energy Reform, Energy Regulation, Energy Use Policy, Green Certificates
Q49	Other	Not Specified	None Specified
Q50	General	Covers studies about general issues related to environmental economics and/or ecological economics, including survey articles, textbooks, and data.	Ecological, Environment, Environmental Accounts, Environmental Data, Environmental Economics, Green Economics
Q51	Valuation of Environmental Effects	Covers studies about issues related to valuation of environmental effects. Includes studies on recreational effects and health effects, as well as valuation methods, such as contingent valuation.	Contingent Valuation, Cost Benefit, Eco Efficiency, Environmental Health and Safety, Environmental Valuation, Health Effects, Hedonic, Recreational Effects, Revealed Preference, Stated Preference

JEL Code	Subject Description	Guideline	Keywords
Q52	Pollution Control Adoption and Costs; Distributional Effects; Employment Effects	Covers studies about environmental effects on firm behavior, including pollution control costs and environmental technology adaptation.	Abatement Cost, Cost Benefit, Distributional Effects, Employment Effects, Environmental Compliance, Environmental Protection Cost, Environmental Tax, Environmental Technology Adaption, Firm Behavior, Green Production, Industrial Ecology, Pollutant, Polluter, Pollution, Pollution Control, Pollution Haven
Q53	Air Pollution; Water Pollution; Noise; Hazardous Waste; Solid Waste; Recycling	Covers studies about issues related to environmental degradation, its impacts and its solution.	Air Pollution, Chemical Pollution, Clean Air, Clean Water, Dumping, Environmental Degradation, Garbage Collection, Hazardous Waste, Landfill, Nitrogen Oxide, Noise Pollution, Pollutant, Polluter, Polluting, Pollution, Recycling, Sewerage, Solid Waste, Waste Management, Water Pollution
Q54	Climate; Natural Disasters and Their Management; Global Warming	Covers studies about issues related to climate and natural disasters, including desertification and drought.	Carbon, Carbon Capture, Climate, Climate Change, Desertification, Disaster Management, Drought, Emissions, Flood, Global Warming, Greenhouse Gas, Natural Disaster, Rainfall, Storm, Tornado, Weather
Q55	Technological Innovation	Covers studies about issues related to technological innovation that is used to control environmental degradation.	Clean Technology, Environmental R&D, Green Technology, Recycling Technology, Technological Innovation
Q56	Environment and Development; Environment and Trade; Sustainability; Environmental Accounts and Accounting; Environmental Equity; Population Growth	Covers studies about issues related to the environment and development, the environment and trade, environmental accountability, environmental equity, and environmental sustainability.	Environment and Development, Environment and Growth, Environment and Trade, Environmental Accounting, Environmental Accounts, Environmental Equity, Environmental Kuznets Curve, Environmental Reporting, Environmental Security, Green Growth, Pollution Haven, Population Growth, Sustainability, Sustainability Forecast
Q57	Ecological Economics: Ecosystem Services; Biodiversity Conservation; Bioeconomics; Industrial Ecology	Covers studies about issues related to topics in ecological economics including ecosystem services and biodiversity.	Biodiversity Conservation, Bioeconomics, Eco Efficiency, Ecological Economics, Ecology, Ecosystem, Ecosystem Management, Ecosystem Services, Endangered Species, Habitat Protection, Industrial Ecology, Sanctuary, Wildlife
Q58	Government Policy	Covers studies about issues related to both national and international government policy pertaining to the environment, including environmental taxes and tradable permits.	Climate Policy, Command and Control, Ecotax, Emission Control, Environmental Planning, Environmental Protection, Environmental Regulation, Environmental Subsidies, Environmental Tax, EPA, Green Certificates, International Environmental Policy, Pollution Control, Pollution Tax, Tradable Permits, Waste Policy
Q59	Other	Not Specified	None Specified

Table 3.2 – List of JEL codes used for article selection

As mentioned before, the JPE online platform could not be searched following the same JEL codes methodology as with the AEA journals. Since JPE was a PE domain-specific journal, the online search methodology was modified to make sure this domain-specific journal was included in the corpus of journal articles. The sui generis methodology applied for JPE consisted on searching its online database using keywords from the subject descriptions and keywords of the selected JEL codes. The following table contains the keywords used for searching articles in the JPE online database:

Subcat. JEL Code	JEL Subcategory Description	Keywords Used for Searching JPE
D2	Production and Organizations	"Production and Organizations"
D6	Welfare Economics	"Welfare Economics"
D7	Analysis of Collective Decision-Making	"Collective Decision-Making"
F5	International Relations, National Security, and International Political Economy	"International Relations"
H1	Structure and Scope of Government	"Structure of Government"
H2	Taxation, Subsidies, and Revenue	"Environmental Taxes"
H4	Publicly Provided Goods	"Public Goods"
H7	State and Local Government; Intergovernmental Relations	"Intergovernmental Relations"
K3	Other Substantive Areas of Law	"Environmental Law"
O1	Economic Development	"Economic Development + Natural Resources"
P4	Other Economic Systems	"Other Economic Systems"
Q1	Agriculture	"Agriculture" + "Land Use"
Q1	Agriculture	"Agriculture" + "Irrigation"
Q2	Renewable Resources and Conservation	"Renewable"
Q2	Renewable Resources and Conservation	"Conservation" + "Fish"
Q2	Renewable Resources and Conservation	"Conservation" + "Forest"
Q2	Renewable Resources and Conservation	"Conservation" + "Land"
Q3	Nonrenewable Resources and Conservation	"Nonrenewable"
Q3	Nonrenewable Resources and Conservation	"Exhaustible Resources"
Q3	Nonrenewable Resources and Conservation	"Hydrocarbon"
Q4	Energy	"Energy" + "Coal"
Q4	Energy	"Renewable Energy"
Q5	Environmental Economics	"Environmental Economics"
Q5	Environmental Economics	"Climate Change"

Table 3.3 – Keywords Used for Searching JPE Online Database

The second inclusion criterion implemented was defining a time horizon. Articles published between January 1st, 2007 and December 2nd, 2017 were selected to form the corpus with which the structural topic model was run.

After downloading as pdf files every article that meet the inclusion criteria, the total sample of articles amounted to 401 publications, with the following journal and yearly distribution:

Journal	# of Articles
AEJ: Applied Economics	50
AEJ: Economic Policy	67
AEJ: Macroeconomics	15
AEJ: Microeconomics	33
American Economic Review	142
Journal Of Economic Literature	21
Journal Of Political Economy	73
TOTAL	**401**

Table 3.4 – Article Distribution Across Journals

Publication Year	# of Articles
2007	19
2008	18
2009	41
2010	58
2011	43
2012	57
2013	29
2014	12
2015	72
2016	43
2017	9
TOTAL	401

Table 3.5 – Article Distribution Across Publication Year

3.7 Stage 5: Charting the Data

Arksey, O'Malley (2005) describe charting the data as identifying and tabulating key items of information obtained from the studies being reviewed. They define "charting" through (Ritchie, Spencer) as a method for synthesising and analysing qualitative information by sifting, tabulating and organising the data according to key aspects and themes. Arksey and O'Malley's approach to charting is similar to a narrative review. This means taking a broader view and recording contextual information of the studies being reviewed (e.g. author(s), year of publication, study location, aims of the study, etc.). In this research, these types of contextual variables are referred to as metadata covariates, as they primarily provide information about the research data, but can have and influencing role in how the research is implemented and its outcomes. These metadata covariates do not include variables that are related to a study's actual research content (e.g. methodologies, outcome measures, study results, etc.) and which Arksey and O'Malley do include in their charting exercise.

However, this is the stage of the Arksey and O'Malley framework that Levac et al. (2010) feel needs additional guidance to reduce the challenges faced by researchers implementing a scoping review, when charting and summarising complex concepts in a meaningful way. It is at this stage that qualitative content analysis can provide additional direction and structure to the charting process, with cascading effects to the following collating, summarising, and reporting stage.

Qualitative Content Analysis, and specifically for this research, summative content analysis, provides a more systematic approach to charting the data, through the design and implementation of a coding scheme. Hsieh, Shannon (2005, 1285:1286) formulate

that the success of a qualitative content analysis depends greatly on the coding process, and refer to it as follows:

> *"The basic coding process in content analysis is to organize large quantities of text into much fewer content categories (Weber 1990). Categories are patterns or themes that are directly expressed in the text or are derived from them through analysis. Then, relationships among categories are identified. In the coding process, researchers using content analysis create or develop a coding scheme to guide coders to make decisions in the analysis of content. A coding scheme is a translation device that organizes data into categories (Poole, Folger 1981). A coding scheme includes the process and rules of data analysis that are systematic, logical, and scientific."*

From this perspective, the coding process of a summative content analysis can be embodied by a statistical topic model, particularly a STM. The STM can reduce the dimensionality and complexity of textual data into fewer thematic categories, through the statistical analysis of explicit and latent content, as well as from the influence of metadata covariates. The STM can then identify the thematic relationships between the coded categories, i.e. the correlations between topics, enabling researchers to analyse and leverage the results.

In this sense, charting the data for an STM captures the advantages of the approach by Arksey and O'Malley, as well as from the coding process of summative content analysis. This research study implemented thus two complementary charting methods. The first one was akin to Arksey and O'Malley's method in the framework for scoping reviews, used to capture metadata covariates from the selected studies. The second charting method was akin to summative content analysis, used for developing a systematic process of creating and pre-processing the corpus of journal articles to reduce the complexity of the textual data.

3.7.1 Charting Metadata Covariates

Once all the articles that matched the inclusion criteria had been selected and downloaded, article metadata was charted into a Microsoft Excel spreadsheet. Each row corresponded to an article, while each column to a metadata covariate. The covariates tabulated were:

- Journal Name: Name of the journal from where the article belonged.
- JEL Codes: Articles ranged from being tagged with only one JEL code to tagged with up to 8 different JEL codes. Most articles downloaded from the JPE online platform lacked references to JEL codes, and were assigned only one subcategory code (1 letter + 1 number) as listed in Table 3.3. As JEL code tagging was not homogenous across all articles, this covariate was not included for analysis in the STM.
- Research Domain: Any article tagged with a JEL code from the general category "Q - Agricultural and Natural Resource Economics; Environmental and Ecological Economics" was assigned to ERE. If an article had no JEL code from the the Q category, it was assigned by default to PE.
- Article Name: Name of the article as it appeared printed on the article.
- Year: Year of publication.
- Lead Author: First named author of the publication.
- Author2 through Author6: Some articles had only the lead author, while the article with the maximum number of authors had six.
- Reference: Coding for referencing the articles in the STM.
    - Articles with only a lead author: [Lead Author, Year]
    - Articles with two authors: [Lead Author & Author2, Year]
    - Articles with more than three authors: [Lead Author et al., Year]
- Abstract: The article's abstract as it appeared printed on the article.
- File Name: File name of the article when stored after downloading. Colons, question marks, and other illegal naming characters in Windows were replaced with a period.

The Excel spreadsheet was converted to comma-separated value (csv) format and loaded into the R programming environment as a data frame to hold the metadata covariates for the STM.

3.7.2 Corpus Pre-processing

The coding scheme implemented for pre-processing the corpus of selected articles was based on the standard approach to data cleaning and preparation in text mining. This standard approach consists on first putting the documents together into a single corpus, followed by parsing the corpus into word tokens, removing stopwords, removing words with less than three characters, stemming words to lemmas, and finally removing words with lowest frequency in the corpus. In this research, an extra stage was added after

removing stopwords, which involved overlaying the ontologies onto the corpus to preserve the domain-specific terms captured in stage 2 of this study's framework. The specific steps taken for pre-processing the corpus are the following:

1. Building the Corpus:

The pdf files of the selected articles were read into R using the readtext package (Benoit, Obeng 2017). Text that did not pertain to the articles (e.g. journal names, publishing institutions, citing instructions, etc.) was removed. The reason for doing so was that these pieces of text appeared in every article, sometimes in every page of an article, becoming very frequent words that would have been picked up by the latent semantic analysis, creating distortions in the topic analysis.

The cleaned articles were aggregated into a data frame, their metadata covariates assigned to each one, and then converted into a corpus object using the Quanteda package (Benoit et al. 2017). Finally, all characters were converted to lower case, to allow same words to match irrespective of having first or all letters capitalised.

2. Tokenising

Mimno (2012, p. 4) identifies the word as the fundamental unit of text, which he defines as a sequence of letter characters. He also highlights the importance of distinguishing two uses of the concept 'word': "a word type is a distinct sequence of characters, equivalent to a dictionary headword or lemma; while a word token is a specific instance of a word type in a document. For example, the string "dog cat dog" contains three tokens, but only two types (dog and cat)." The process of tokenising is thus simply identifying each word type in the corpus, and counting the occurrence frequency of word tokens per each word type. Through this process, the corpus is converted from unstructured text, to a structured document-term matrix composed of rows depicting documents, columns depicting word types (i.e. terms), and values corresponding to the frequency of each word type appearing in each document.

The tokenisation process in this research consisted of taking the unstructured text from the corpus, removing punctuation characters, numbers, symbols and hyphens, and converting it to a document-word type tokens object. The tokens object is simply a list with all the journal articles, each with its list of word tokens.

3. Overlaying Ontologies on Corpus

At this stage, tokens are only one-word tokens, and although they provide some thematical information, they still lack the research areas' domain-specificity. A key ERE concept such as "non-renewable natural resource" would have been tokenised into "non", "renewable", "natural", and "resources". It is here where the value of identifying multi-word expressions and constructing domain ontologies becomes clear: the sum of the individual information value of the tokens "non", "renewable", "natural", and "resources", is not the same, with regards to research domain specificity, as the information value of "non-renewable natural resource".

To preserve research domain specificity, the ontologies were converted in R into dictionary objects, and then applied to the tokenised set of one-word tokens using quanteda's tokens_compund function. This function identified where a MWE (or a permutation matched via the thesaurus keys with wildcard characters) was split into several one-word tokens during tokenising, and compounds them together again into a single word multi-word token. Through this process, the domain-specific and information-rich terms contained in the ontologies get preserved and passed into the STM for a more relevant research domain literature synthesis.

4. Removing Stopwords

Stopwords are small sets of very common words in a language. Because of the power-law characteristic of natural languages, this small set of common word types tend to have the highest frequency in a corpus. This leads to a large proportion of tokens in a corpus being composed of very common word types, while the domain-specific distinct word types, which occur proportionally less frequently, end up making a significantly smaller part of the tokens in the corpus. On stopwords, Mimno (2012, p. 4) explains: "Common words generally provide little information, especially if word order is dropped, but can overwhelm more important semantic words in analyses. Removing them can reduce the size of the data that must be analyzed by up to half while improving semantic coherence. Infrequent words, while often having the most specific meanings, can be difficult to perform meaningful inferences on due to small sample sizes."

For removing stopwords in this research, the "english" and "SMART" sets included in the Quanteda package were used. Through multiple iterations between stage 4 and stage 5, a third set of corpus-specific stopwords was added, as new results produced prominent word types that provided little information towards answering the research question (e.g.

names of months, “yearly, “percent”, etc.), or word types from file encoding errors (e.g. "ðvþ", "ðyi", "ðaþ", etc.). An important issue to point out is that many articles were formatted with paragraph hyphenation and saved in pdf format. In these cases, words at the end of a line that had been hyphenated were tokenised as two different tokens. The first half of the word tended to be stemmed into its lemma (subsequently explained in the stemming step), while the second half of the word (e.g. “lution”, “cian”, “ciary”, etc.), usually a suffix, was stored as an independent word type. These word types were also added to the third set of stopwords. The three sets of stopwords amounted to 965 word types, and the list of them can be found in Appendix 3.

A recommendation for future research is to download articles in a different format, whether pdf without paragraph hyphenation, or even better, html as it includes information on document structure. However, this is not a choice always available to researchers, but a matter of format availability.

5. Removing Tokens with Less Than 3 Letters

As many economic articles may contain mathematical functions depicting variables and indices, many one and two-letter words were present in the tokens object as word-types. As these contain no relevant thematic value, all tokens with less than 3 letters were removed. The benefit of this approach is that it reduces the number of tokens in the model (dimensionality reduction) and removes semantic noise. A downside to this approach is that two-letter acronyms that might be domain relevant get removed from the coding scheme. However, the frequency of two-word acronyms is assumed to be trivial by this research, and the probability an author uses a two-word acronym instead of the full two words is expected to be trivial.

6. Stemming

Stemming is the process of reducing word derivations, adjectivisations, nominalisations, inflections, etc., to their word stem or root form. It is an optional step researches may choose to use in text mining, as it has benefits as well as disadvantages. The two main benefits of stemming are that it i) reduces the number of word types in the model (dimensionality reduction), and ii) increases the thematic weight of a concept which appears in the corpus with different inflectional forms or by aggregating derivationally relate words. A disadvantage is that stemming algorithms may increase the aggregation of homonym, i.e. words having the same spelling but different meanings (e.g. “pound” is a measure of weight, unit of currency, etc.). Aggregation of homonym exists without

stemming, but new homonyms can be created by different words being stemmed to a same stem (Porter 2001).

In this research, the tokens object was stemmed using quanteda's token_wordstem function, based on Martin Porter's stemming algorithm. As can be seen in the following example of the thesaurus key "pollut*", the stemming algorithm stemmed all variations of the word "pollution" (e.g. "pollution", "pollutant", "polluted", etc.) to "pollut". The stemmer did not stem any variation of the word "pollution" when it was the first word of a MWE (i.e. "pollution_", "pollutant_", "pollutants_", and "polluting_"), but did stem the MWE as a whole (i.e. "pollution_sourc" and "polluting_sourc"). The reason for this is that, since the MWE had been compounded into whole tokens, the stemming algorithm perceived them as single words, and the stemming algorithm stems from right to left:

[1] "pollut"	"pollution_reduct"	"pollution_concentr"	"pollutant_model"
[5] "pollution_extern"	"pollution_abatement_cost"	"polluting_firm"	"pollution_damage_funct"
[9] "pollution_level"	"pollution_damag"	"pollution_control"	"pollution_abat"
[13] "pollution_polici"	"pollution_problem"	"pollution_sourc"	"polluting_model"
[17] "pollutant_reduct"	"pollutant_emiss"	"pollution_target"	"pollution_emiss"
[21] "polluting_sourc"	"pollution_control_technolog"	"pollution_tax"	"pollution_control_cost"
[25] "pollution_control_polici"	"pollutant_level"	"pollution_cost"	"pollutants_level"
[29] "pollutant_damag"			

Table 3.6 – Stemming of Thesaurus Key "pollut*" in Corpus

7. Trimming

The final step of pre-processing the corpus was to remove infrequent tokens which carry no information value to the model. Tokens with a very low occurrence frequency in the corpus imply that either i) the terms or concepts they represent are not domain-specific, or ii) very few researchers are using them, thus not relevant for answering this study's research question of identifying ERE and PE topic trends in top economic journals.

After the previous six steps of corpus pre-processing, the coding scheme had been reduced to 65,184 different word types; a still highly computationally expensive schema. The tokens object was thus weighed using term frequency-inverse document frequency (TF-IDF), in order to discern the level of information provided by each term depending on how common or rare the term was across all articles.

The tokens object was then trimmed using as threshold a minimum TF-IDF weight of 0.001 and occurrence in at least 5 of the 401 articles in the corpus. In text mining standards this would be considered as a significantly low threshold, and the reasoning behind it was to allow the schema to remain thematically large while computationally efficient. A threshold this low removed i) common words that appeared in all or most articles (similar

to stopwords), and ii) terms that appeared in less than 1.25% of the sample of articles, hardly providing signals of a trending topic in either research domain.

Once trimmed, the final tokens object contained 4,956 word types. It was then converted into a document-term matrix (DFM), providing a coding scheme based on both i) an ontology built from academically verified domain anchors, and ii) the most relevant terms from a corpus constructed using ERE and PE domain-specific JEL codes.

3.7.3 Estimate Number of Topics

The most challenging parameter to define when running a statistical topic model is choosing the right number of topics (K) in which to divide a corpus of documents. There are many statistical metrics for calculating an ideal number of topics in a specific corpus. However, Chang et al. (2009, p. 9) demonstrate that traditional statistical metrics do not adequately capture topic coherence:

> *"Traditional metrics are, indeed, negatively correlated with the measures of topic quality […] practitioners developing topic models should thus focus on evaluations that depend on real-world task performance rather than optimizing likelihood-based measures. "*

In practice, there is not a "right" number of topics for a given corpus (Grimmer, Stewart 2013). From an intuitive perspective, a researcher may find usefulness synthesising a corpus into 20 topics as well as into 100. Choosing the number of topics depends on the number of documents in the corpus, the average length of the documents, and the thematic granularity required by the researcher for the literature synthesis.

In this research, a traditional metrics approach and an intuitive approach were implemented. First, an unsupervised model calculating 4 metrics for optimum number of topics was run using the R package ldatuning (Murzintcev 2016). The metrics focus alternatively on maximising a likelihood function or minimising Kullback–Leibler divergence (relative entropy), among other (Arun et al. 2010; Cao et al. 2009; Griffiths, Steyvers 2004; Deveaud et al. 2014). As seen in Figure 3.1, the results showed potential optima at K = 16, 24, 30, 32, 42, and 51 for this corpus.

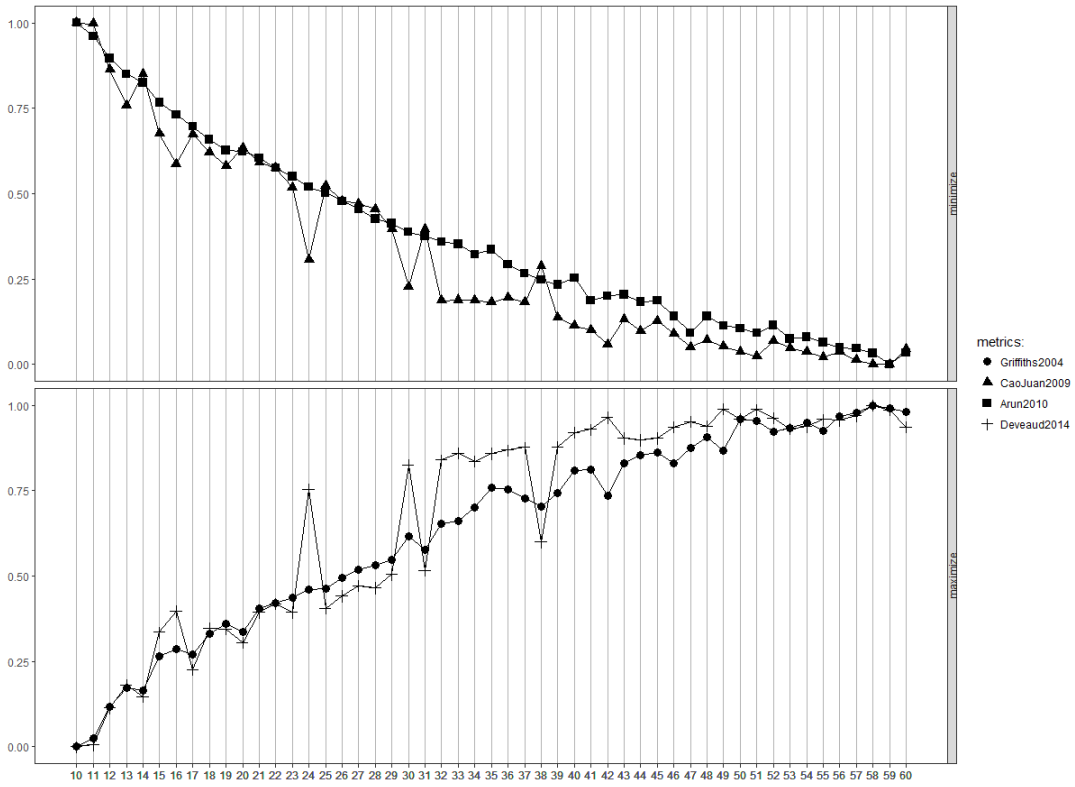


Figure 3.1 – Statistical Measures for Optimum Number of Topics
Model run duration: 18.25614 hours, using 3 cores, and "Gibbs" method for fitting LDA.

With these results, a supervised sensitivity analysis was carried out to detect which of the potential optimum produced topics that offered human readability and comprehension. The sensitivity analysis was carried out by running four different STM, for K = 16, 24, 32 and 42. A model run was not implemented for K = 30 as it was too close to both K = 24 and K = 32, and a model run was not implemented for K = 51 as topic models with more than 50 topics for a corpus of only 401 documents defeat the purpose of synthesising the literature. Results from the sensitivity analysis can be found in Appendix 4.

After reviewing the results from the four model runs, the model with K = 42 was selected for running the final model with which to answer the research question, as it provided coherent topics for human readability, and sufficient thematic granularity in most of the topics for an interpretable review synthesis of the selected corpus.

3.8 Stage 6: Collating, Summarising and Reporting the Results

This research, although following a scoping review framework, borrowed from qualitative content analysis the systematic approach to coding, synthesising and analysing textual data. The seven classic steps in qualitative content analysis are (Kaid 1989):

Step 1: Formulating the research question

Step 2: Selecting the sample

Step 3: Defining the categories to be applied

Step 4: Outlining the coding process and the coder training

Step 5: Implementing the coding process

Step 6: Determining trustworthiness

Step 7: Analysing the results of the coding process

So far, steps 3 and 4 have been implemented in this research for defining the coding scheme used for the literature synthesis. Step 3, defining the categories to be applied, was applied in Stage 2 of this research, building the domain ontologies. Step 4, outlining the coding process and the coder training, was applied in Stage 5, charting the data. For the last stage of the Arksey and O'Malley framework for scoping reviews, this research study now implements steps 5, 6 and 7 of a qualitative content analysis.

Among the different approaches to qualitative content analysis, this research chose summative content analysis as mechanism for synthesising and analysing the literature. The summative approach to content analysis is fundamentally different from most other qualitative content approaches. Instead of analysing the textual data as whole, "the text is often approached as single words or in relation to particular content. An analysis of the patterns leads to an interpretation of the contextual meaning of specific terms or content" (Hsieh, Shannon 2005, p. 1286). This is fundamentally the process implemented by statistical topic models: text is tokenised, patterns between tokens are analysed, and results are interpreted in relation to the contextual meaning of specific terms or topics. To this effect, this research chose a structural topic model (STM) for implementing and analysing the coding process of the summative content analysis.

The STM was fed the document-term matrix and metadata covariates from stage 5. The model was configured with the following parameters:

- Number of topics: 42
- Topic prevalence metadata covariates: *(refer to 3.7.1 Charting Metadata Covariates)*
    - Research Domain
    - Journal Name
    - Year of Publication
- max.em.its: 200
- init.type: "Spectral"

The STM was run and converged in 2.93227 minutes. The following measures were analysed to interpret the model results:

1. Topic-term distributions:

In statistical topic models, each topic contains every term in the corpus. However, the probability distribution of these terms occurring in each topic is what differentiates one topic from another. The first step in interpreting topics is to analyse the topic-term distribution, and identifying the terms that have the highest probability of belonging to a given topic. This research interpreted the topics produced by the STM, by looking at the seven terms (default parameter in STM) with highest probability of belonging to a topic, using four different word weighting measures (Roberts et al. 2017b):

- Highest Probability: Top terms with unweighted highest probability of belonging to a given topic.
- FREX: Weights term by their overall frequency and how exclusive they are to a topic. "It is calculated by taking the harmonic mean of rank by probability within the topic (frequency), and rank by distribution of topic given word p(z|w = v) (exclusivity)" (Roberts et al. 2017a, p. 20).
- Lift: Weights terms by dividing their frequency in other topics, giving thus a higher weight to words that appear less frequently in other topics.
- Score: Weights terms by dividing the log frequency of a term in a topic by the log frequency of the term in other topics.

2. Topic names:

Assigning topic names is an optional measure for interpreting topic model results. Topics can be referenced using the top n terms (e.g. 5) from one of the topic-term distribution measures above. This approach avoids interpretation bias from the researcher when

naming a topic. However, for ease of explaining the results, this research opted for naming topics as inferred from the top seven most probable terms, from all four topic-term distribution measures above.

3. Topic domain prevalence and overlaps:

The function estimateEffect in the R stm package (Roberts et al. 2017a) performs a regression where topic proportions are the outcome variables, documents are the units, and document metadata are covariates. This function is used to calculate a measure that estimates the mean difference in topic proportions for two different values of the research domain covariate, specifically, whether a topic leans more towards ERE, more towards PE, or if both domains overlap on that topic.

4. Topic proportions:

Having differentiated the topic prevalence between research domains, the next measure identifies expected topic proportions across the corpus. Mot statistical topic models assume that not all topics are proportionally distributed across a corpus. This measure calculates which topics are expected to occur more often in the corpus. Topics are separated into topics with ERE prevalence and topics with PE prevalence.

5. Topic coherence and term exclusivity:

This measure allows to identify semantic coherence of topics, and exclusivity of terms in a given topic. Semantic coherence, developed by Mimno et al. (2011), is a closely related concept to pointwise mutual information (Newman et al. 2010), also used in identifying multi-word expressions. In this context, semantic coherence is maximised when the terms with the highest probability in a given topic frequently co-occur together.

Term exclusivity identifies topics that have terms with high probability in it, but which have low probabilities in all other topics (Bischof, Airoldi 2012). That is, topics whose high-probability terms have low probability in other topics are considered exclusive.

Analysing topic coherence and term exclusivity helps to measure a statistical topic model's effectiveness in synthesising a corpus. "A topic that is both cohesive and exclusive is more likely to be semantically useful." (Roberts et al. 2014, p. 1070)

6. Most representative articles:

Just as topic-term distributions are probability distributions which include all terms in every topic, document-topic distributions are probability distribution which include all topics in every document. One or a few topics will have a large probability of occurring in a document, while the rest present significant smaller and diminishing probabilities of occurring in it. This measure identifies which journal articles from the corpus have a high probability of belonging to a given topic.

7. Most representative domain:

This measure calls the research domain that had been assigned in the charting metadata covariates section (3.7.1) to each of the most representative articles for each topic. This measure can help identify, for example, articles that might contain an ERE topic with a high probability of occurring in it, but which did not have a JEL code from the general category "Q - Agricultural and Natural Resource Economics; Environmental and Ecological Economics". Although this functionality is being applied only to identify the domain of the most representative articles for any given topic, it can be used to identify all articles not classified with JEL code for general category "Q" but which contain highly ERE-related topics.

8. Most representative authors:

This measure simply calls the name of the author and the year of the most representative articles for a given topic.

9. Topic co-occurrence in most representative articles:

This measure identifies, from the document-topic distribution, which other topics also have a relatively high probability of belonging to the most representative articles identified above for a given topic. The measure can help identify which and where topics overlap.

10. Topic trends:

As in the measure for domain topic prevalence, the estimateEffect function in the R stm package estimates a regression using the year of publication as a continuous covariate, with topic proportions as outcome variables. With this measure, topic trends can be identified as expected topic proportions change from one year to the next.

It is important to note that in some circumstances the expected topic proportion can be above 1 or below 0. This is because the function uses a Normal distribution, instead of alternatives constrained between 0 and 1. If a continuous variable goes above 0 or 1 within the range of the data, it may indicate that a more flexible non-linear specification is needed, such as using a spline, or a spline with greater degrees of freedom (Roberts et al. 2017a, p. 12).

The following analysis were implemented for additional interpretation and visualisation of the model results:

11. Topic correlations:

One of the advantages of STM compared to other statistical topic models is that it allows for correlations between topics. Topic correlations were explored to identify which topics had relatively large correlations, degree, and centrality.

12. Term correlations:

Used primarily for visualisation purposes.

3.9 Challenges and Limitations

The research strategy implemented by this research study has attempted to bridge the Arksey and O'Malley framework for scoping reviews with qualitative content analysis for the stages of charting the data, and the collating, summarising, and reporting the results. The purpose of this was to support a perceived methodological weakness in the scoping review framework, with a recognized strength of qualitative content analysis.

However, some of the methods implemented by this research offered challenges, and others revealed limitations. The most salient challenge was the use of JEL codes for selecting journal articles, and for classifying them as belonging to the ERE domain or PE domain.

Regarding selecting articles using JEL codes, the most challenging problem was using them to filter for articles on online platforms, including scientific literature search engines. In many journal's online platforms, articles could be searched using JEL codes, but search hits were dependant to if the authors had included the JEL codes in the abstract or keywords. This meant that articles that might have also matched the inclusion criteria were not included, not because of inclusion/exclusion criteria, but because of a lack of

standardised use among authors and publishers of JEL codes. In this research, this limitation was coped by choosing only top journals that shared a same online platform with search parameters for searching with JEL codes, and with most of their articles including the JEL codes in the abstract. This was the case of the journals associated to AEA, which is not unexpected as the Journal of Economic Literature is among one of them (except for the Journal of Economic Perspectives, whose articles tended to lack the JEL codes in the abstract). The exception to this strategy was the inclusion of the JPE, justified for it being the only specialised journal relevant to either of this study's research domains of interest, and whose lack of JEL codes was relatively mitigated by the creation of a parallel set of search keywords that attempted to mirror the JEL codes.

The other limitation of using JEL codes was using them to classify articles as belonging to the ERE or PE research domain. This approach implied grouping articles into exclusive sets, when an article could actually belong to both research domains, or none. In the recommendations chapter a better strategy for this method is suggested, by implementing a classification method that allows a continuous measure for articles to be associated to ERE and PE. This can be done by filtering a corpus' tokenised object using a domain ontology, and calculating the number of word type matches and their frequency; matrix density would imply a high association to the research domain, while matrix sparsity the opposite. This method can allow an article to be associated to more than one research domain, and to quantify the degree it belongs to one or the other.

Another limitation is the construction of ontologies using textbooks as domain anchors. Although this approach guarantees an academically established conceptual core and clearly defined research domain frontiers, a research study could risk building potentially outdated ontologies, especially if the research domain of interest is relatively new, is undergoing rapid change, or tends to contain key concepts coined as MWE. Strategies for mitigating this limitation are also suggested in the recommendations sections, particularly by replacing the use of domain anchor textbooks, with recent articles from specialised journals relevant to the research domain of interest. This method would lead to state-of-the-art research domain ontologies, with applications beyond topic modelling.

There is an important limitation in the sample selection, which engenders caveats for interpreting the study's results. Results presented by this research reflect trends and overlaps in top mainstreams economic journals. Except for JPE, all other journals selected lack specificity to one or another research domain. Many novel ERE and PE concepts and

topics may be found in specialised journals, and it might take time for them to make it to the top mainstream economic journals, if at all; not for lack of quality, but because of domain-specificity, and/or topic attractiveness to the general academic community. Thus, results from this study refer to ERE an PE topic trends and overlaps in top mainstream economic journals, and cannot be extrapolated to topic trends in more domain-specialised journals. Also recommended for future research, especially if following the previous strategy of building ontologies with specialised journals, is to have an article selection criterion that includes articles from top mainstream economic journals, and articles from specialised journals. This would allow for novel domain-specific topics to be picked up by the topic model, and by using journals as a covariate, the topic prevalence could be mapped across the literature and detect which of these novel topics are moving to the economic mainstream, and which are stagnating within their research niche.

Adding more articles to the sample would not be a problem, as the sample size can be significantly increased; modern personal computers can easily and quickly run a STM (3 processor cores, less than 3 minutes for this research's corpus size). A future research study could synthesise thousands of full articles, if not more. However, as already mentioned in the removing stopwords step in the corpus pre-processing section, cleaning file format encoding errors and text added to the article by publishers and online platforms can be very challenging. Recommendations for this are i) downloading articles in other formats besides pdf, and/or ii) allotting a sufficiently large space in the calendar for this task. A pragmatic rule of thumb for the latter is four to eight hours per journal. This implies that, hypothetically speaking, a researcher synthesising articles from twenty journals could take from ten days (dedicated full time to the task) to three weeks (half-time) just for cleaning the data.

Related to data cleaning, a problem experienced in this research was manually typing the corpus-specific stopwords. For example, when typing into the stopwords list the names of the months of the year, "august" was misspelled as "agust" and effectively not removed from the corpus. This risk can be mitigated in the future by copy-pasting the words in the corpus that need to be blacklisted in the stopwords list.

A limitation to the visualisation of topic trend results is that the model estimates expected topic proportion in confidence intervals. This is convenient for analysis, but not for visualising the results when there is a high number of topics in the model. As this research

synthesised the selected literature into 42 topics, only the mean expected topic proportion was used for ease of presenting results.

Finally, another limitation in the context of topic trends is that there were only 9 articles for 2017. It was initially considered to drop them from the sample. However, there were only 19 articles for 2007, 18 for 2008, and 12 for 2014, making the argument of dropping a year for having only 9 articles untenable. However, it does raise a flag when interpreting topic trends in the scientific literature only from 2017. For this reason, this research analyses topic trends, either as novel topics or resurfacing topics, in a window of time between 2015 and 2017.

4 Results

4.1 Introduction

The results chapter presents the results of the Structural Topic Model (STM) described in the methods section, designed with the objective of identifying recent trends and overlaps of ERE and PE research topics in top economic journals. Through the results of the STM, this research's specific objective 3 is met:

1. Identify published research mapping ERE.
2. Construct ontologies of ERE and PE, delineating a conceptual core of each research domain.
3. Map ERE and PE research topics in articles published between 2007 and 2017 in selection of top economic journals.
4. Develop a framework for mapping topics of specific research domains within large corpora of scientific writing.

The mapping of ERE and PE research topics from the corpus of selected journal articles is presented by exhibiting results on:

- Topic-term distributions and topic names
- Topic domain prevalence and overlaps
- Topic proportions
- Topic coherence and term exclusivity
- Map of literature synthesis:
  - Most representative articles by topic
  - Most representative domains of representative articles
  - Most representative authors of representative articles
  - Topic co-occurrence in most representative articles
- Topic trends
- Topic correlations
- Term correlations

4.2 Topic-Term Distributions and Topic Names

Table 4.1 lists the 42 topics estimated by the STM, with the corresponding seven FREX terms with highest probability of belonging to each of them. For the full list of top terms for each of the four highest probability weighting measures (highest probability, FREX, Lift, and Score) see Appendix 5. Topic names have been assigned to each topic, taking into account the topic-term distributions across all four weighting measures.

Identifying topic names for topic is sometimes intuitive by simply looking at top terms, such as for topics 2 through 7. For other topics, more information is required, such as

from reading the abstracts of the most representative articles. Most representative articles are presented in one of the next sub-sections.

Topic	Top FREX Terms	Topic Name
1	seller, buffalo, buyer, hide, export, shipment, cia	Trade
2	polic, black, litig, lawyer, registri, victim, racial	Race & Gender
3	fuel, automak, carbon, ethanol, flexibl, cafe, scrap	Fuel Standards
4	citizen, sender, signal, talk, cheap, ruler, media	Information
5	candid, voter, poll, vote_shar, adjac, charact, platform	Voting
6	temperatur, eros, climate_chang, crop, acr, ogallala, parcel	Climate Change
7	zone, hous, voucher, rent, rental, properti, residenti	Housing
8	jurisdict, deposit, downstream, upstream, valuat, competit, capit	Money
9	catastroph, avert, optimal_tax, taxat, income_tax, redistribut, distort	Taxes & Redistribution
10	ethnic, coloni, segreg, cultur, gini, chief, africa	Segregation & Inequality
11	stove, smoke, et, regulatori, disclosur, certifi, qualiti	Smoking Regulations
12	procur, bidder, bid, corrupt, audit, tunnel, auction	Public Expenditure
13	cast, cultiv, villag, land, farm, fallow, water	Land Use
14	punish, moral, ethic, cooper, norm, social, contribut	Public Good Contribution
15	agent, princip, exert, action, contract, effort, project	Contract Theory
16	metro, air_pollut, plant, birth, pollut, open, toll	Air Pollution
17	lobbyist, inflat, congress, fed, forecast, senat, committe	Lobbying
18	eitc, cigarett, excis, tax, tax_rat, bunch, kink	Cigarette Tax
19	constitu, republican, vote, ideolog, overconfid, democrat, conserv	Elections
20	electr, mwh, solar, coal, wind, natural_ga, shortag	Renewable Energy
21	fta, agreement, free_trad, coalit, tariff, negoti, bargain	Free Trade
22	household, food, migrant, transfer, cash, progresa, pension	Household Income
23	player, team, contest, round, battl, switch, conflict	Games
24	newspap, berlusconi, coverag, media, advertis, congruenc, news	Media
25	council, faction, municip, spend, district, redistrict, mayor	Local Government
26	store, alcohol, ticket, lotteri, retail, sale, zip	Lotteries & Alcohol
27	manufactur, sector, agricultur, industri, product, international_trad, countri	Economic Productivity
28	debt, treasuri, bond, spread, matur, default, investor	Public Debt
29	fish, pirat, captain, piraci, fisheri, crew, vessel	Fisheries & Law
30	student, grade, orlean, school, enrol, attend, child	Child Welfare
31	budget, crash, drive, donor, fiscal, host, spring	Incentive Policies
32	medicaid, afdc, mortal, insur, user, movi, nonwhit	Medicaid
33	physician, organiz, divis, manag, employe, patient, decentr	Firms
34	ozon, vehicl, nox, mexico, smog, facil, car	Vehicle Emissions
35	worker, talent, wage, skill, occup, fertil, citi	Urban Employment
36	court, deliber, justic, judg, bureaucrat, plaintiff, committe	Decision Making
37	militari, tabellini, elit, coup, repress, democraci, public_good	Political Power
38	reelect, drug, pan, women, victori, mill, slave	Gender & Politics
39	oil, farmer, specul, crude_oil, phone, crise, kilian	Oil Prices
40	youth, utility_funct, collect, choic, unitari, pareto, identif	Collective Decisions
41	war, civil, assassin, autocraci, peac, democraci, natural_resourc	War & Conflict
42	dirti, patent, clean, innov, inventor, invent, tech	Tech & Innovation

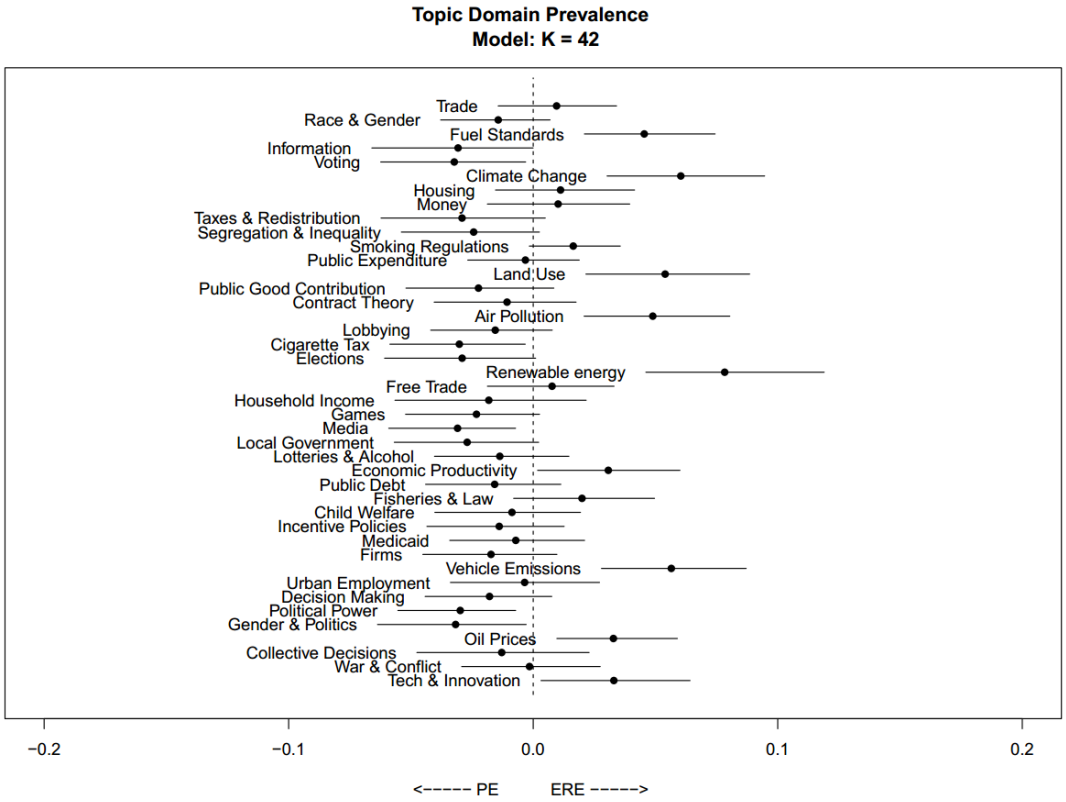
Table 4.1 - Top 7 FREX Terms per Topic and Manually Assigned Topic Names

4.3 Topic domain prevalence and overlaps

The model performs a regression where the topic proportions are the outcome variables, the journal articles are the units, and the research domains are the covariates. Figure 4.1 shows the mean difference in topic proportions, i.e. the outcome variable, based on the regression coefficients of the ERE and PE research domain covariates. The result is a normally distributed research domain spectrum, mapping how each estimated topic aligns in relation to its correlation to ERE and/or PE.

Topics to the left of the vertical dotted line have a higher topical prevalence of PE, while those to the right have a higher topical prevalence of ERE. The further away from the

vertical line, the higher the probability of a topic belonging to only that research domain. The closer a topic is to the vertical line, the more ERE and PE overlap on that topic.



The topics with the highest correlation to ERE are Renewable Energy, Climate Change, Vehicle Emissions, Land Use, Air Pollution, and Fuel Standards. The topics with the highest correlation to PE are Gender & Politics, Voting, Cigarette Tax, Elections, Information, and Media. The topics in which ERE and PE overlap the most are Urban Employment, War & Conflict, Public Expenditure, Free Trade, Money, and Housing.

The top six topics correlated to ERE had a mean domain prevalence measure (0.0583) almost twice as large as that of the top six topics correlated to PE (-0.0325), meaning that PE topics tended to be closer to ERE, while ERE topics tended to be further away from PE.

For example, the topic with highest correlation to ERE, Renewable Energy, had a domain prevalence measure of 0.0864, while PE's Gender & Politics had a domain prevalence of (-0.0346). This effect was observed in the literature with the highest probability of belonging to the Renewable Energy topic, which showed little thematic relation to PE. The most relevant issues explored by it were: "heterogeneity in the marginal impact of renewable electricity on pollution" (Novan 2015), "US nuclear plants in financial trouble"

(Davis, Hausman 2016), "economic value of large-scale renewable energy" (Gowrisankaran et al. 2016), "three largest companies control one-third of US nuclear capacity" (Davis, Wolfram 2012), and "emissions leakage in an incompletely regulated and imperfectly competitive industry" (Fowlie 2009). On the other hand, the literature with the highest probability of belonging to the Gender & Politics topic did have ERE related topics. An example is Cole (2009), who finds that "government-owned bank lending tracks the electoral cycle, with agricultural credit increasing by 5-10 percentage points in an election year", and uses agricultural output as a measure of analysis.

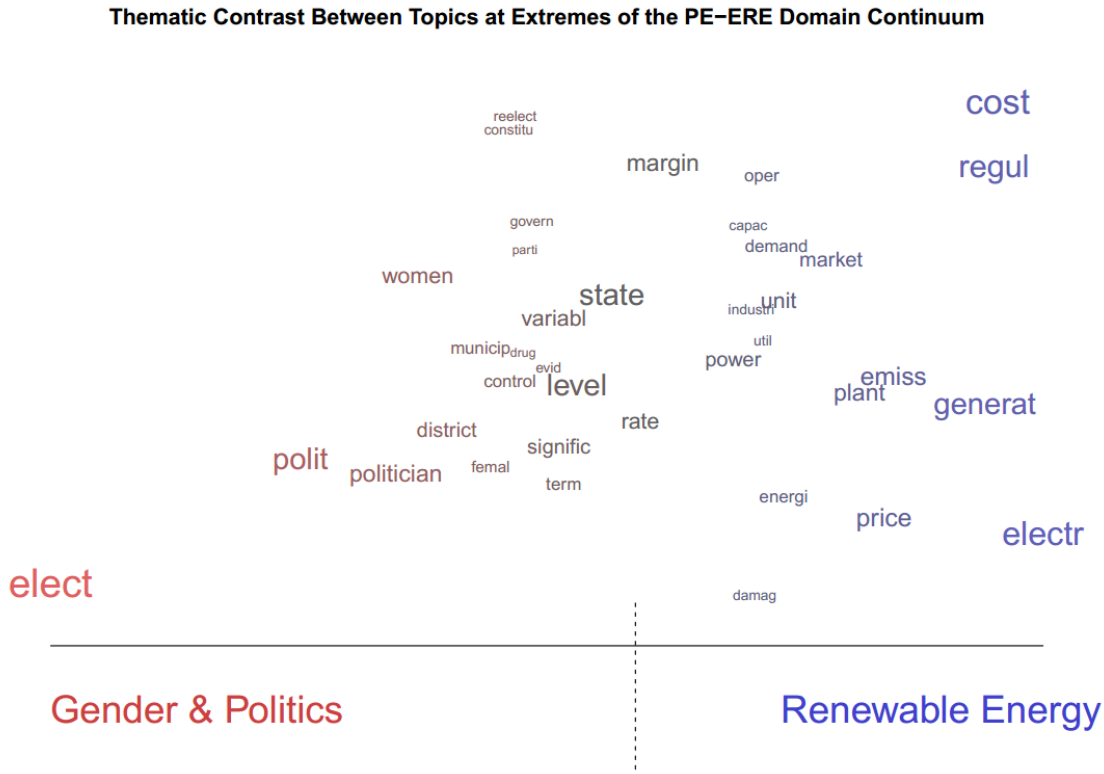


Figure 4.2 – Thematic Contrast Between Gender & Politics and Renewable Energy

Figure 4.2 compares terms used by the Gender & Politics PE topic and the Renewable Energy ERE topic. Word size reflects the weight each term has between the two topics combined, while the position along the X-axis reflects how much each term favours one research domain over the other. It can be clearly observed how the most important terms in the topic with the highest correlation to PE gravitate towards the centre of the topic continuum, while the most important terms in the topic with the highest correlation to ERE gravitate away from the centre.

4.4 Topic proportions

Among the 42 topics estimated by the STM, Household Income was the most frequent topic across the corpus, covering close to 5% of the thematic share. Second and third most frequent topics were Taxes & Redistribution and Renewable Energy respectively, with around 4% thematic share each. The least frequent terms were Fuel Standards, Smoking Regulations, and Trade, at around 1.5% of thematic share.

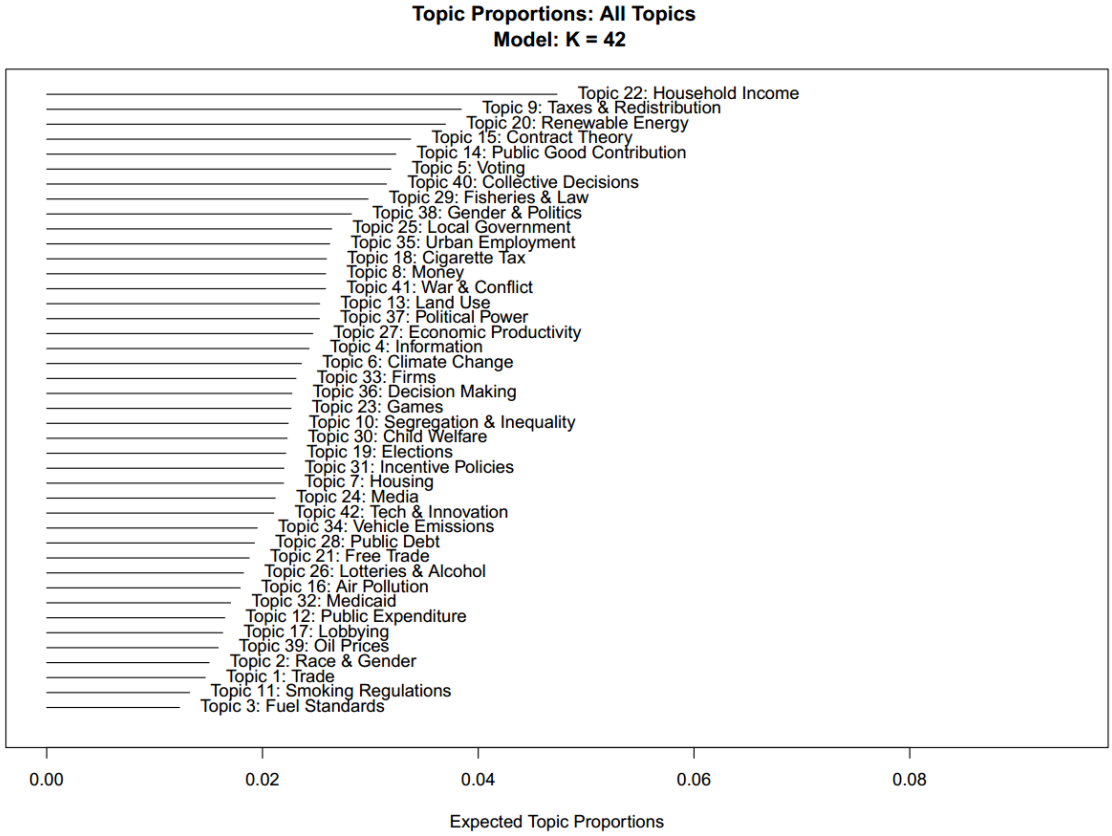


Figure 4.3 – Topic Proportions for All Topics Across Corpus

The distribution of topic proportions was relatively homogenous for all topics, without any one of them being significantly predominant. The topic proportion median was 2.2%, with the maximum below 5% and the minimum above 1.5%.

Using the topic-domain prevalence from Figure 4.1, topics were separated into ERE and PE topics. The most frequent ERE topics were Renewable Energy at around 4% of thematic share of the corpus, followed by Fisheries & Law and Money at 3% and 2.5% respectively. The least frequent ERE terms were the same three least frequent terms in the overall rank, i.e. Fuel Standards, Smoking Regulations, and Trade.

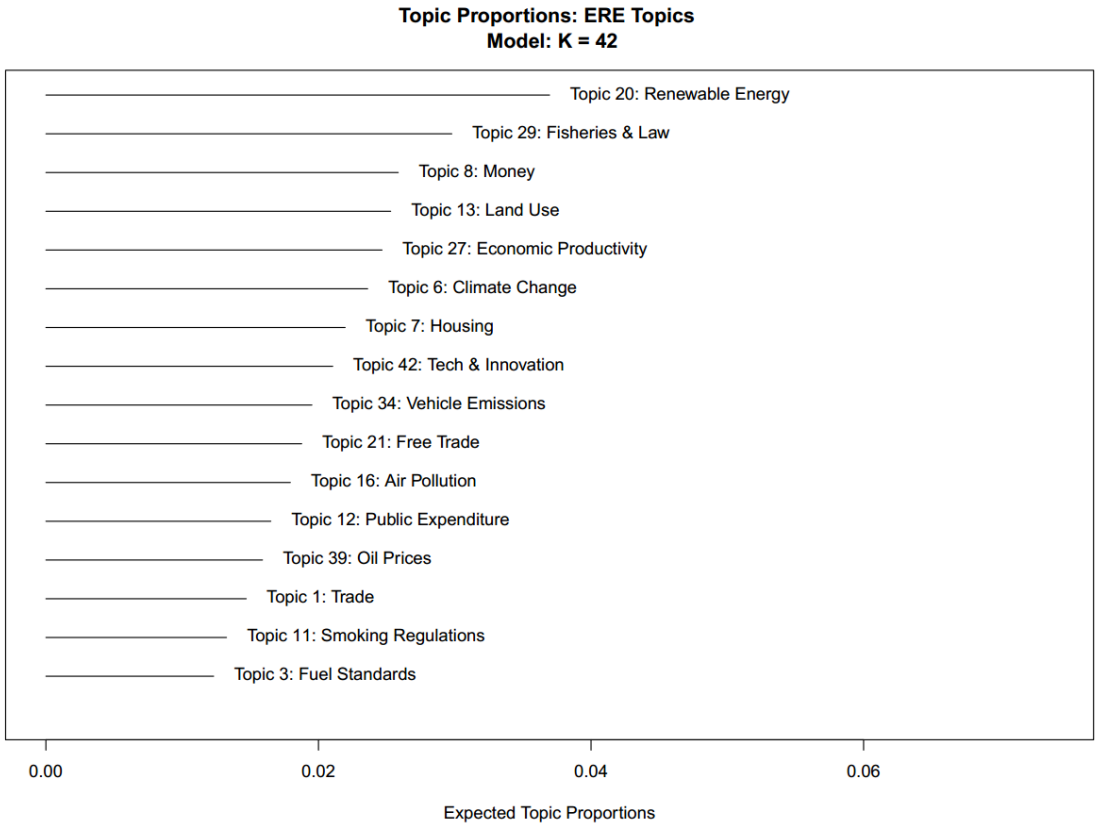


Figure 4.4 – Topic Proportions for ERE Topics Across Corpus

The most frequent PE topics in the corpus were Household Income, Taxes & Redistribution, and Contract Theory with 5%, 4%, and 3.5% of thematic share respectively. Surprisingly, the topic Voting came in 5th with approximately 3% of share, the topic Elections came in 19th with only a little over 2% of share, and the topic Lobbying came in second to last with around 1.5% of share. The least frequent PE terms were Race & Gender, Lobbying, and Medicaid at around 1.5% all of them.

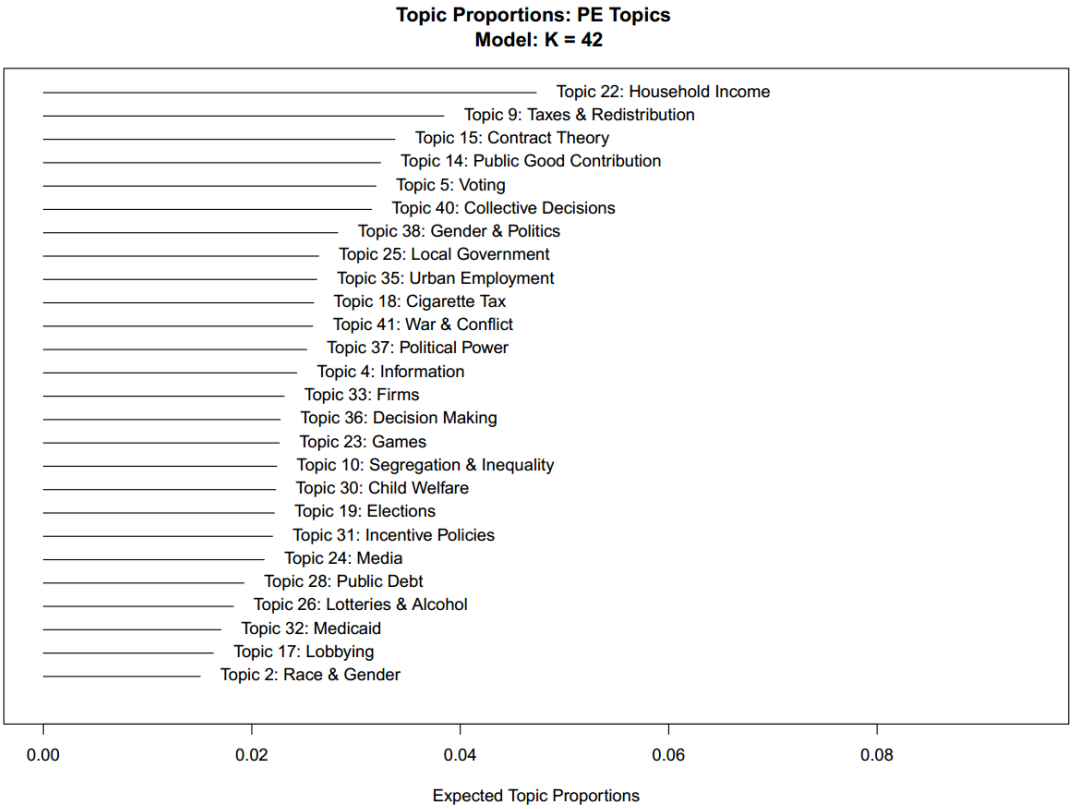


Figure 4.5 – Topic Proportions for PE Topics Across Corpus

4.5 Topic coherence and term exclusivity

Semantic coherence measures when terms with the highest probability in a given topic frequently co-occur together. Term exclusivity identifies topics that have terms with high probability in it, but which have low probabilities in all other topics. A topic with high semantic coherence and high term exclusivity implies that its term with the highest probability tend to occur usually among themselves. This could be interpreted as an isolated topic with relatively low correlation with other topics. In the context of this research, topic coherence is ideally high and topic exclusivity moderate, so as to map correlated or overlapping topics instead of isolated thematic islands.

Figure 4.6 shows semantic coherence of topics in the X-axis, where larger values (to the right of the axis) signify higher semantic coherence, and term exclusivity on the Y-axis, where larger values signal a higher exclusivity of a topic's terms.

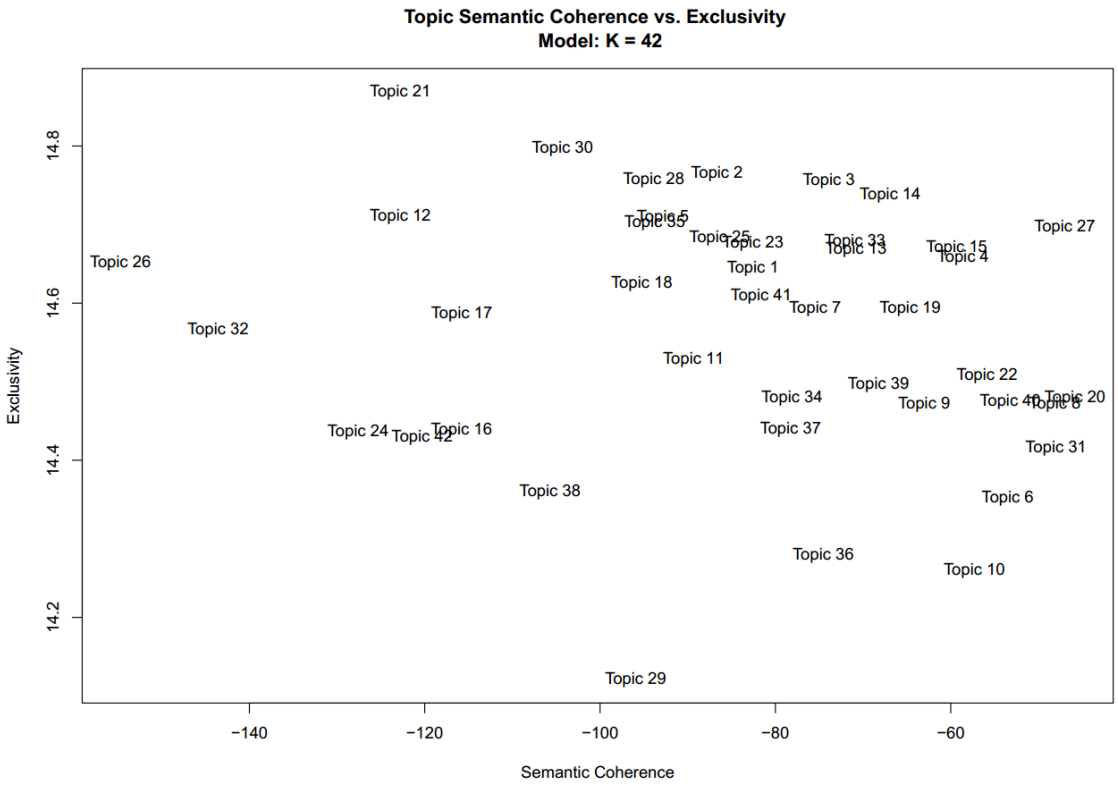


Figure 4.6 – Topic Semantic Coherence and Exclusivity

The model produced the highest density of topic coherence-exclusivity in the top right quarter, signifying a high proportion of well-defined coherent topics within the corpus of journal articles. Only one topic had significantly low semantic coherence, Lotteries and Alcohol, while only one topic had significantly low term exclusivity, Fisheries and Law.

The articles with the highest probability of belonging to Lotteries and Alcohol did have a logical thread connecting lotteries with alcohol, but in fact covered three distinct subtopics: lottery gambling (Guryan, Kearney 2008, 2010; Knight, Schiff 2012), liquor monopoly (Seim, Waldfogel 2013), and death related to alcohol consumption in Russia (Bhattacharya et al. 2013). Lottery and liquor were connected through the concept of "regulation" and "stores", the latter which sold both products, and liquor connected to alcohol consumption and anti-drinking campaigns in Russia. Although the first two subtopics are coherent together, the connection to alcohol in Russia made the overall topic semantically incongruent. They topic did have a relatively high level of exclusivity as the three subtopics indeed shared a similar lexicon, rare to all other topics.

Regarding Fisheries and Law, the opposite to Lotteries and Alcohol is true. The three articles with the highest probability of belonging to the topic did share high probability terms that co-occurred together, as they all used historical cases for explaining the legal

structure of economic development. However, the topic was not exclusive as the articles used relatively common terms in economics and law. One of the articles examines the law and economics of pirate organizations (Leeson 2007); another explores the key determinants of financial development and growth using ancient Rome as an example (Malmendier 2009); the third one uses five international historical examples to understand financial crisis and credit abundance from a political perspective (Rousseau 2016).

4.6 Map of Top Articles per Topic

This research study produced a practical map of the literature synthesis which can help researchers identify resources in the scientific literature of top mainstream economic journals, to conduct future research studies in identifying overlaps and potential research gaps between ERE and PE. Table 4.4 presents this literature synthesis map in tabular form, for easy referencing of the identified resources. The map includes the topic names, the domain prevalence of each topic (as codified in section 4.3), the names of the top two article with the highest probability of belonging to each topic, the research domain of each article (as codified in section 3.7.1), a short reference of the authors of each article, and the highest topic co-occurrence per article.

The highest topic-co-occurrence reveals the second highest topic estimated in each article. This is useful for future research studies reviewing the recent scientific literature on ERE and PE, as every article can be composed of more than one prominent topic, and helps to understand how an article can connect a specific topic with several other topics. For example, the highest probability article in the Fuel Standards topic, “Using Loopholes to Reveal the Marginal Cost of Regulation. The Case of Fuel-Economy Standards.” (Anderson, Sallee 2011), had its highest topic co-occurrence with the topic Vehicle Emissions. However, the second highest probability article in the Fuel Standards topic, “Greenhouse Gas Reductions under Low Carbon Fuel Standards.” (Holland et al. 2009), had its highest topic co-occurrence with the topic Trade.

For adjusting the tabular map into printed form, only the highest topic co-occurrence is included in Table 4.4. However, since the STM estimates a probability distribution of all topics for every article, another approach to using the literature synthesis map is by selecting a set of articles with high probability of belonging to a given topic, and observing the probability distribution of topics for each of the selected articles. For

example, if a researcher is interested in identifying how Child Care is influenced by ERE issues, he or she can select the top articles in the topic Child Care, and explore if and which ERE topics have a relatively high correlation to each of those articles. From this research study's results, selecting the top two articles of Child Welfare, "Katrina's Children. Evidence on the Structure of Peer Effects from Hurricane Evacuees" (Imberman et al. 2012) as Doc1, and "When the Saints Go Marching Out. Long-Term Outcomes for Student Evacuees from Hurricanes Katrina and Rita" (Sacerdote 2012) as Doc2, gives the following results:

Topic	Doc1
Child Welfare	0.9990
Housing	0.0002
Household Income	0.0001
Urban Employment	0.0001
Oil Prices	0.0001
Climate Change	0.0001

Table 4.2 – Top Topics Imberman et al. (2012)

Topic	Doc2
Child Welfare	0.9913
Housing	0.0045
Gender & Politics	0.0020
Race & Gender	0.0005
Segregation & Inequality	0.0004
Air Pollution	0.0003
Household Income	0.0002
Land Use	0.0002
Climate Change	0.0002
Oil Prices	0.0001
Incentive Policies	0.0001

Table 4.3 – Top Topics for Sacerdote (2012)

From these results, it can be inferred that the highest co-occurring topic in both the articles most highly associated to the topic Child Care is Housing, a topic on the ERE side of the ERE-PE domain overlap zone. Additionally, the model identifies the ERE topics Oil Prices and Climate Change also as present in both articles, plus Air Pollution and Land Use in Doc2 (Table 4.3).

In Table 4.4, for most topics, their top two articles shared different highest co-occurring topics, implying relatively higher degrees of thematic correlation to other topics, than topics whose top two articles shared the same highest co-occurring topic. In the case of the latter, these topics tended to correlate stronger with fewer topics. The topics whose top two articles always co-occurred with the same topic were:

- Voting with Information
- Public Good Contribution with Games
- Contract Theory with Games
- Lotteries & Alcohol with Cigarette Tax
- Economic Productivity with Urban Employment
- Public Debt with Money
- Child Welfare with Housing
- Oil Prices with Public Debt

Table 4.4 presents a simplified tabular map of the results from the literature synthesis, in order to highlight the most relevant features:

Topic Name	Topic Domain	Article	Article Domain	Author	Highest Topic Co-Occurrence
Trade: Highest	ERE	The Value of Relationships. Evidence from a Supply Shock to Kenyan Rose Exports.	ERE	Macchiavello & Morjaria, 2015	Contract Theory
Trade: Second	ERE	A Balls-and-Bins Model of Trade. Comment.	ERE	Blum et al., 2016	Economic Productivity
Race & Gender: Highest	PE	The Effect of Court-Ordered Hiring Quotas on the Composition and Quality of Police.	PE	McCrary, 2007	Local Government
Race & Gender: Second	PE	Gender Gaps in Performance. Evidence from Young Lawyers.	PE	Azmat & Ferrer, 2017	Urban Employment
Fuel Standards: Highest	ERE	Using Loopholes to Reveal the Marginal Cost of Regulation. The Case of Fuel-Economy Standards.	ERE	Anderson & Sallee, 2011	Vehicle Emissions
Fuel Standards: Second	ERE	Greenhouse Gas Reductions under Low Carbon Fuel Standards.	ERE	Holland et al., 2009	Trade
Information: Highest	PE	Bayesian Persuasion.	PE	Kamenica & Gentzkow, 2011	Lobbying
Information: Second	PE	State Censorship.	PE	Shadmehr & Bernhardt, 2015	Voting
Voting: Highest	PE	Flip-Flopping, Primary Visibility, and the Selection of Candidates.	PE	Agranov, 2016	Information
Voting: Second	PE	Information and Extremism in Elections.	PE	Boleslavsky & Cotton, 2015	Information
Climate Change: Highest	ERE	The Economic Impacts of Climate Change. Evidence from Agricultural Output and	ERE	Deschênes & Greenstone, 2007	Oil Prices

Topic Name	Topic Domain	Article	Article Domain	Author	Highest Topic Co-Occurrence
		Random Fluctuations in Weather.			
Climate Change: Second	ERE	Climate Change, Mortality, and Adaptation. Evidence from Annual Fluctuations in Weather in the US.	ERE	Deschênes & Greenstone, 2011	Collective Decisions
Housing: Highest	ERE	Housing Market Spillovers. Evidence from the End of Rent Control in Cambridge, Massachusetts.	PE	Autor et al., 2014	Collective Decisions
Housing: Second	ERE	Housing Vouchers and the Price of Rental Housing.	PE	Eriksen & Ross, 2015	Household Income
Money: Highest	ERE	Ensuring Sales. A Theory of Inter-firm Credit.	PE	Daripa & Nilsen, 2011	Public Debt
Money: Second	ERE	Pass-Through as an Economic Tool. Principles of Incidence under Imperfect Competition.	PE	Weyl & Fabinger, 2013	Collective Decisions
Taxes & Redistribution: Highest	PE	Transfer Program Complexity and the Take-Up of Social Benefits.	PE	Kleven & Kopczuk, 2011	Household Income
Taxes & Redistribution: Second	PE	Generalized Social Marginal Welfare Weights for Optimal Tax Theory.	PE	Saez & Stantcheva, 2016	Collective Decisions
Segregation & Inequality: Highest	PE	Ethnic Inequality.	PE	Alesina et al., 2016	Urban Employment
Segregation & Inequality: Second	PE	Segregation and the Quality of Government in a Cross Section of Countries.	PE	Alesina & Zhuravskaya, 2011	Local Government
Smoking Regulations: Highest	ERE	Public-Place Smoking Laws and Exposure to Environmental Tobacco Smoke (ETS).	ERE	Carpenter et al., 2011	Household Income
Smoking Regulations: Second	ERE	Regulatory Races. The Effects of Jurisdictional Competition on Regulatory Standards.	ERE	Carruthers & Lamoreaux, 2016	Fisheries & Law
Public Expenditure: Highest	ERE	Bid Preference Programs and Participation in Highway Procurement Auctions.	PE	Krasnokutskaya & Seim, 2011	Contract Theory
Public Expenditure: Second	ERE	Set-Asides and Subsidies in Auctions.	ERE	Athey et al., 2013	Lotteries & Alcohol
Land Use: Highest	ERE	Subsidized Farm Input Programs and Agricultural Performance. A Farm-Level Analysis of West Bengal's Green Revolution, 1982-1995.	ERE	Bardhan & Mookherjee, 2011	Gender & Politics
Land Use: Second	ERE	Caste as an Impediment to Trade.	ERE	Anderson, 2011	Segregation & Inequality

Topic Name	Topic Domain	Article	Article Domain	Author	Highest Topic Co-Occurrence
Public Good Contribution: Highest	PE	Social Preferences, Beliefs, and the Dynamics of Free Riding in Public Goods Experiments.	PE	Fischbacher & Gachter, 2010	Games
Public Good Contribution: Second	PE	Imperfect Public Monitoring with Costly Punishment. An Experimental Study.	PE	Ambrus & Greiner, 2012	Games
Contract Theory: Highest	PE	Achieving Efficiency in Dynamic Contribution Games.	ERE	Cvitanić & Georgiadis, 2016	Games
Contract Theory: Second	PE	Formal versus Informal Monitoring in Teams.	PE	Gershkov & Winter, 2015	Games
Air Pollution: Highest	ERE	Green Infrastructure. The Effects of Urban Rail Transit on Air Quality.	ERE	Chen & Whalley, 2012	Vehicle Emissions
Air Pollution: Second	ERE	Every Breath You Take—Every Dollar You'll Make. The Long-Term Consequences of the Clean Air Act of 1970.	ERE	Isen et al., 2017	Urban Employment
Lobbying: Highest	PE	Political Pressures on Monetary Policy during the US Great Inflation.	PE	Weise, 2012	Trade
Lobbying: Second	PE	Is It Whom You Know or What You Know. An Empirical Assessment of the Lobbying Process.	PE	Bertrand et al., 2014	Information
Cigarette Tax: Highest	PE	Playing with Fire. Cigarettes, Taxes, and Competition from the Internet.	PE	Goolsbee et al., 2010	Lotteries & Alcohol
Cigarette Tax: Second	PE	Smoke Gets in Your Eyes. Cigarette Tax Salience and Regressivity.	PE	Goldin & Homonoff, 2013	Taxes & Redistribution
Elections: Highest	PE	Does Less Income Mean Less Representation.	PE	Brunner et al., 2013	Voting
Elections: Second	PE	The Political Economy of the US Mortgage Default Crisis.	PE	Mian et al., 2010	Public Debt
Renewable Energy: Highest	ERE	Valuing the Wind. Renewable Energy Policies and Air Pollution Avoided.	ERE	Novan, 2015	Vehicle Emissions
Renewable Energy: Second	ERE	Market Impacts of a Nuclear Power Plant Closure.	ERE	Davis & Hausman, 2016	Air Pollution
Free Trade: Highest	ERE	A Political-Economy Theory of Trade Agreements.	PE	Maggi & Rodríguez-Clare, 2007	Money
Free Trade: Second	ERE	When Is It Optimal to Delegate. The Theory of Fast-Track Authority.	PE	Celik et al., 2015	Elections

Topic Name	Topic Domain	Article	Article Domain	Author	Highest Topic Co-Occurrence
Household Income: Highest	PE	Labor Supply Responses to Large Social Transfers. Longitudinal Evidence from South Africa.	PE	Ardington et al., 2009	Segregation & Inequality
Household Income: Second	PE	Investing Cash Transfers to Raise Long-Term Living Standards.	PE	Gertler et al., 2012	Public Debt
Games: Highest	PE	Decentralized Organizational Learning. An Experimental Investigation.	PE	Blume et al., 2009	Medicaid
Games: Second	PE	Asymmetric Contests with Conditional Investments.	PE	Siegel, 2010	Money
Media: Highest	PE	Media Markets and Localism. Does Local News en Español Boost Hispanic Voter Turnout.	PE	Oberholzer-Gee & Waldfogel, 2009	Public Good Contribution
Media: Second	PE	The Effect of Newspaper Entry and Exit on Electoral Politics.	PE	Gentzkow et al., 2011	Elections
Local Government: Highest	PE	The Cabals of a Few or the Confusion of a Multitude. The Institutional Trade-Off between Representation and Governance.	PE	Brooks et al., 2011	Elections
Local Government: Second	PE	Distributive Politics and Electoral Incentives. Evidence from Seven US State Legislatures.	PE	Aidt & Shvets, 2012	Voting
Lotteries & Alcohol: Highest	PE	Is Lottery Gambling Addictive.	PE	Guryan & Kearney, 2010	Cigarette Tax
Lotteries & Alcohol: Second	PE	Spatial Competition and Cross-Border Shopping. Evidence from State Lotteries.	PE	Knight & Schiff, 2012	Cigarette Tax
Economic Productivity: Highest	ERE	The Missing Food Problem. Trade, Agriculture, and International Productivity Differences.	ERE	Tombe, 2015	Urban Employment
Economic Productivity: Second	ERE	Selection, Agriculture, and Cross-Country Productivity Differences.	ERE	Lagakos & Waugh, 2013	Urban Employment
Public Debt: Highest	PE	Default and the Maturity Structure in Sovereign Bonds.	PE	Arellano & Ramanarayanan, 2012	Money
Public Debt: Second	PE	The Aggregate Demand for Treasury Debt.	PE	Krishnamurthy & Vissing-Jorgensen, 2012	Money
Fisheries & Law: Highest	ERE	Anarrghchy. The Law and Economics of Pirate Organization.	ERE	Leeson, 2007	Games

Topic Name	Topic Domain	Article	Article Domain	Author	Highest Topic Co-Occurrence
Fisheries & Law: Second	ERE	Law and Finance at the Origin.	PE	Malmendier, 2009	Segregation & Inequality
Child Welfare: Highest	PE	Katrina's Children. Evidence on the Structure of Peer Effects from Hurricane Evacuees.	ERE	Imberman et al., 2012	Housing
Child Welfare: Second	PE	When the Saints Go Marching Out. Long-Term Outcomes for Student Evacuees from Hurricanes Katrina and Rita.	ERE	Sacerdote, 2012	Housing
Incentive Policies: Highest	PE	Spring Forward at Your Own Risk. Daylight Saving Time and Fatal Vehicle Crashes.	ERE	Smith, 2016	Vehicle Emissions
Incentive Policies: Second	PE	Will There Be Blood. Incentives and Displacement Effects in Pro-social Behavior.	PE	Lacetera et al., 2012	Public Good Contribution
Medicaid: Highest	PE	Public Insurance and Mortality. Evidence from Medicaid Implementation.	PE	Goodman-Bacon, 2017	Air Pollution
Medicaid: Second	PE	NA	NA	NA	NA
Firms: Highest	PE	Organizing for Synergies.	PE	Dessein et al., 2010	Contract Theory
Firms: Second	PE	Organizing to Adapt and Compete.	PE	Alonso et al., 2015	Money
Vehicle Emissions: Highest	ERE	Clunkers or Junkers. Adverse Selection in a Vehicle Retirement Program.	ERE	Sandler, 2012	Fuel Standards
Vehicle Emissions: Second	ERE	Clearing the Air. The Effects of Gasoline Content Regulation on Air Quality.	ERE	Auffhammer & Kellogg, 2011	Air Pollution
Urban Employment: Highest	PE	Productive Cities. Sorting, Selection, and Agglomeration.	PE	Behrens et al., 2014	Housing
Urban Employment: Second	PE	A Theory of Occupational Choice with Endogenous Fertility.	PE	Mookherjee et al., 2012	Child Welfare
Decision Making: Highest	PE	Can Words Get in the Way. The Effect of Deliberation in Collective Decision-Making.	PE	Iaryczower et al., 2017	Collective Decisions
Decision Making: Second	PE	The Value of Information in the Court. Get It Right, Keep It Tight.	PE	Iaryczower & Shum, 2012	Elections
Political Power: Highest	PE	A Theory of Military Dictatorships.	PE	Acemoglu et al., 2010	War & Conflict
Political Power: Second	PE	Inefficiency in Legislative Policymaking. A Dynamic Analysis.	PE	Battaglini & Coate, 2007	Local Government

Topic Name	Topic Domain	Article	Article Domain	Author	Highest Topic Co-Occurrence
Gender & Politics: Highest	PE	Electoral Rules and Politicians' Behavior. A Micro Test.	PE	Gagliarducci et al., 2011	Voting
Gender & Politics: Second	PE	Are Female Leaders Good for Education. Evidence from India.	PE	Clots-Figueras, 2012	Child Welfare
Oil Prices: Highest	ERE	Not All Oil Price Shocks Are Alike. Disentangling Demand and Supply Shocks in the Crude Oil Market.	ERE	Kilian, 2009	Public Debt
Oil Prices: Second	ERE	The Simple Economics of Commodity Price Speculation.	ERE	Knittel & Pindyck, 2016	Public Debt
Collective Decisions: Highest	PE	Opening the Black Box of Intrahousehold Decision Making. Theory and Nonparametric Empirical Tests of General Collective Consumption Models.	PE	Cherchye et al., 2009	Household Income
Collective Decisions: Second	PE	Linear Social Interactions Models.	PE	Blume et al., 2015	Child Welfare
War & Conflict: Highest	PE	Hit or Miss. The Effect of Assassinations on Institutions and War.	PE	Jones & Olken, 2009	Collective Decisions
War & Conflict: Second	PE	Oil and Conflict. What Does the Cross Country Evidence Really Show.	ERE	Cotet & Tsui, 2013	Oil Prices
Tech & Innovation: Highest	ERE	The Environment and Directed Technical Change.	ERE	Acemoglu et al., 2012	Taxes & Redistribution

Table 4.4 – Synthesis Map: Top-two Articles per Topic, with Author, and Highest Co-Occurring Topic

4.7 Topic trends

The literature synthesis map in Table 4.4 helps identifying useful resources for conducting future research. One aspect it still lacks is identifying the trends in ERE and PE topics. However, the STM uses the model's results to estimates a regression using the year of publication as a continuous covariate, and topic proportions as outcome variables. With this measure, topic trends can be identified as expected topic proportions change from one year to the next.

Figure 4.7 shows topics aggregated by research domain. A clear inverse relationship can be observed between changes in the mean ERE topic proportion and the mean PE topic proportion. The fact that the relationship is inverse is expected, as the entire corpus has

been divided into either ERE topics or PE topics. However, the synchronised variability between the curves suggests that the model effectively identified thematic domain differences within the corpus. If this had not been the case, both domain trendlines would be flatter.

The scientific literature composing this study's corpus shows a clear predominance of mean PE topic proportions, oscillating between 3% and 3.5% throughout the 2007-2017 period, compared to between 0.5% and 1.5% for the average ERE topic proportion during the same period.

Average ERE topic proportions started off by sharply declining during the analysed time period. They then experienced the strongest rise in the decade between 2009-2011 period, followed by a sharp decline in 2012. Mean ERE topic proportions rose slightly and held between 2013 and 2015, experiencing another sharp rise in 2016. The time frame ended with the biggest decline in mean ERE topic proportions in 2017, falling below 0.5%.

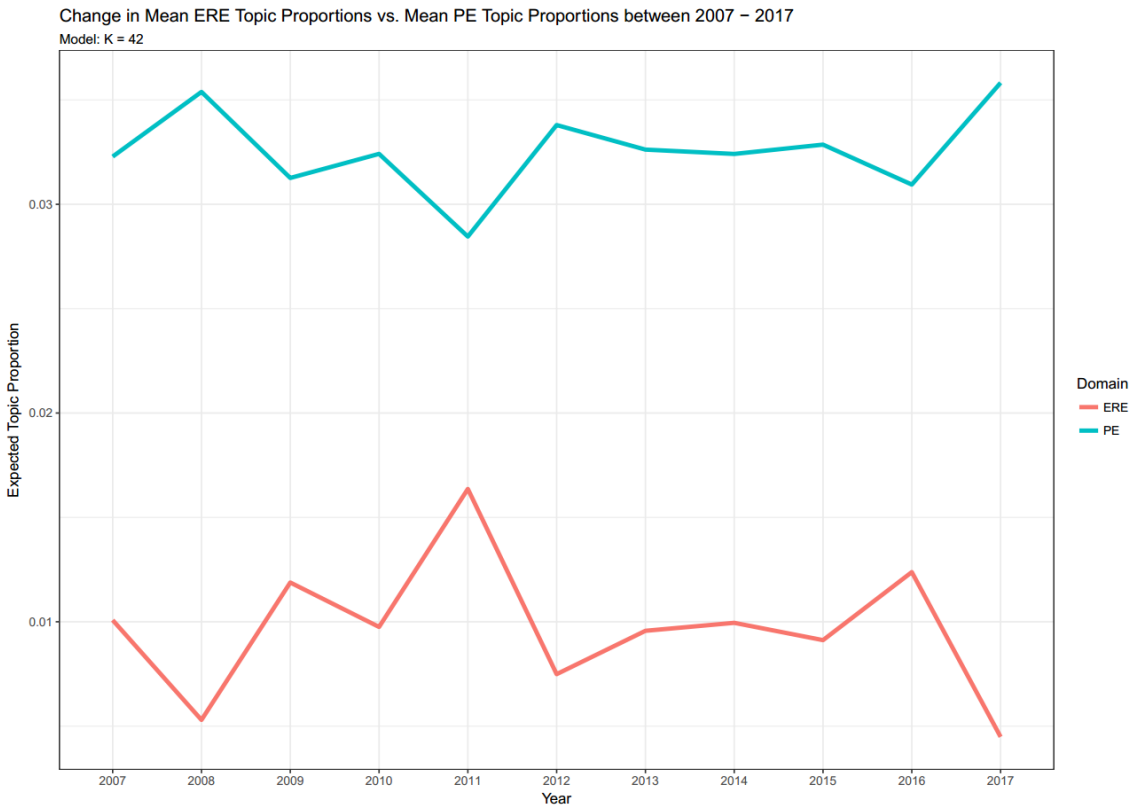


Figure 4.7 – Domain Aggregated Topic Trend Proportions in the Corpus between 2007 - 2017

Conversely, the mean PE topic maintained a relatively stable corpus proportion across the timeframe, with a sharp decline in 2011 as a consequence of the spike in the mean ERE topic proportion. It then gained a relative stability around 3.3% once again, until 2017 when it rose significantly pass 3.5% in response to the crash in the mean ERE topic proportion.

With regard to specific ERE topics, Trade exhibited the biggest and most stable growth in topic proportions, rising steadily from 0.85% in 2007 to 3.25% in 2017. Public Expenditure also performed well during the 11-year period, albeit experiencing high inter-year variability, displaying a cycle-like pattern. ERE topics trending in the last two years are Renewable Energy, which experienced the biggest proportion among ERE topics in 2016, and Tech & Innovation. Air Pollution was the largest topic in 2017, having been virtually non-existent during the previous ten years. Figure 4.8 and Table 4.5 show the trends and number for these topic behaviours.

Several traditional ERE topics performed negatively during the timeframe. Fisheries and Law exhibited a steady decline until virtually disappearing after 2014. Climate Change started 2007 among the top three ERE topics with 3.29%, but seems to completely disappears from the conversation except for 2011 when it resurfaces with a little over 2% of topic proportion. Finally, Vehicle Emissions appeared to be non-existent in the selected scientific literature except for a brief appearance in 2012.

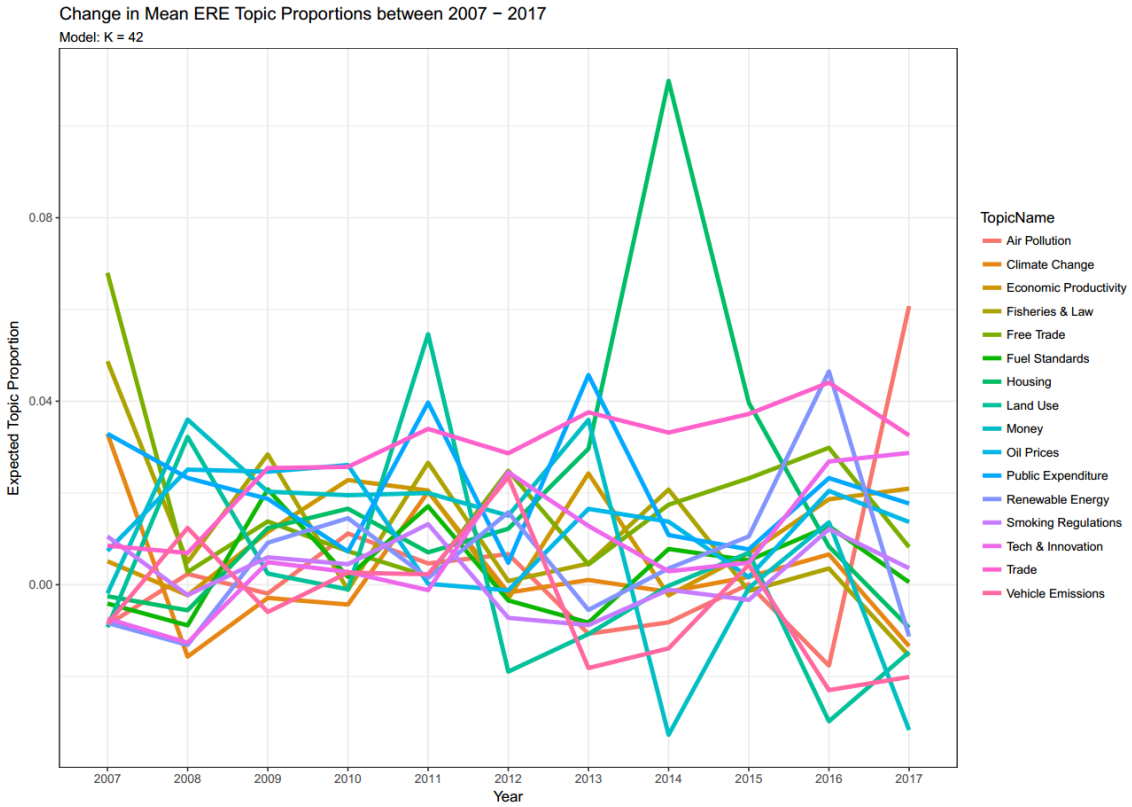


Figure 4.8 – Topic Trends in ERE Topic Proportions in the Corpus Between 2007 - 2017

2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Trend	Topic Name
-0.88%	0.23%	-0.19%	1.12%	0.46%	0.67%	-1.07%	-0.82%	0.01%	-1.76%	6.07%		Air Pollution
3.29%	-1.57%	-0.29%	-0.43%	2.03%	-0.17%	0.10%	-0.15%	0.17%	0.66%	-1.34%		Climate Change
0.51%	-0.23%	1.15%	2.28%	2.05%	-0.30%	2.43%	-0.23%	0.69%	1.86%	2.10%		Economic Productivity
4.87%	0.50%	2.84%	-0.11%	2.66%	0.08%	0.46%	2.07%	-0.13%	0.35%	-1.55%		Fisheries & Law
6.80%	0.28%	1.38%	0.73%	0.18%	2.48%	0.44%	1.74%	2.32%	2.99%	0.82%		Free Trade
-0.41%	-0.89%	2.08%	0.17%	1.71%	-0.34%	-0.83%	0.78%	0.53%	1.27%	0.06%		Fuel Standards
-0.25%	-0.56%	1.23%	1.66%	0.71%	1.22%	2.96%	10.99%	3.97%	0.83%	-0.94%		Housing
-0.93%	3.22%	0.24%	-0.10%	5.46%	-1.89%	-1.08%	-0.02%	0.69%	-2.98%	-1.47%		Land Use
-0.19%	3.60%	2.03%	1.95%	2.00%	1.51%	3.59%	-3.27%	-0.07%	1.36%	-3.17%		Money
0.74%	2.51%	2.46%	2.61%	0.02%	-0.12%	1.65%	1.38%	0.16%	2.05%	1.37%		Oil Prices
3.29%	2.33%	1.87%	0.73%	3.97%	0.48%	4.57%	1.08%	0.77%	2.32%	1.77%		Public Expenditure
-0.84%	-1.31%	0.92%	1.45%	0.15%	1.58%	-0.55%	0.36%	1.05%	4.65%	-1.13%		Renewable Energy
1.05%	-0.23%	0.60%	0.45%	1.32%	-0.72%	-0.88%	-0.11%	-0.33%	1.21%	0.36%		Smoking Regulations
-0.74%	-1.26%	0.49%	0.28%	-0.12%	2.45%	1.28%	0.29%	0.48%	2.69%	2.87%		Tech & Innovation
0.85%	0.69%	2.54%	2.57%	3.40%	2.86%	3.76%	3.32%	3.72%	4.41%	3.25%		Trade
-0.85%	1.24%	-0.59%	0.26%	0.23%	2.34%	-1.82%	-1.39%	0.44%	-2.30%	-2.01%		Vehicle Emissions

Table 4.5 – Topic Trends in ERE Topic Proportions in the Corpus Between 2007 - 2017 *Red dot in trend column indicates topic's highpoint during timeframe*

Figure 4.9 and Table 4.6 show the topic trends on the PE side of the domain continuum. The topic Information appears to have been the only topic consistently strong and on a steady rise during the last five years. The topics Games and Public Good Contribution were stronger than Information during the first half of the timeframe, but have declined from around 8% of topic share proportion to around 4%. Topics Gender & Politics and Taxes & Redistribution also showed topic prominence although in cycles of highs and

lows. Topics which virtually disappeared from the corpus in the last two years were Collective Decisions and Household Incomes, with Political Power close by in a long steady decline.

Two PE topics appear to be resurfacing as trending topics, having had significantly high topic proportions in 2007. These were Decision Making with 9.6% and Race & Gender with 5.73%. However, they appear to have disappeared from the corpus for ten years, until resurfacing again in 2017 with topic proportions of 14.0% and 9.1% respectively. A third trending topic is Medicaid, which exhibited low topic proportions between 2007 and 2014, but rose sharply up to 11.3% of topic share in 2017.

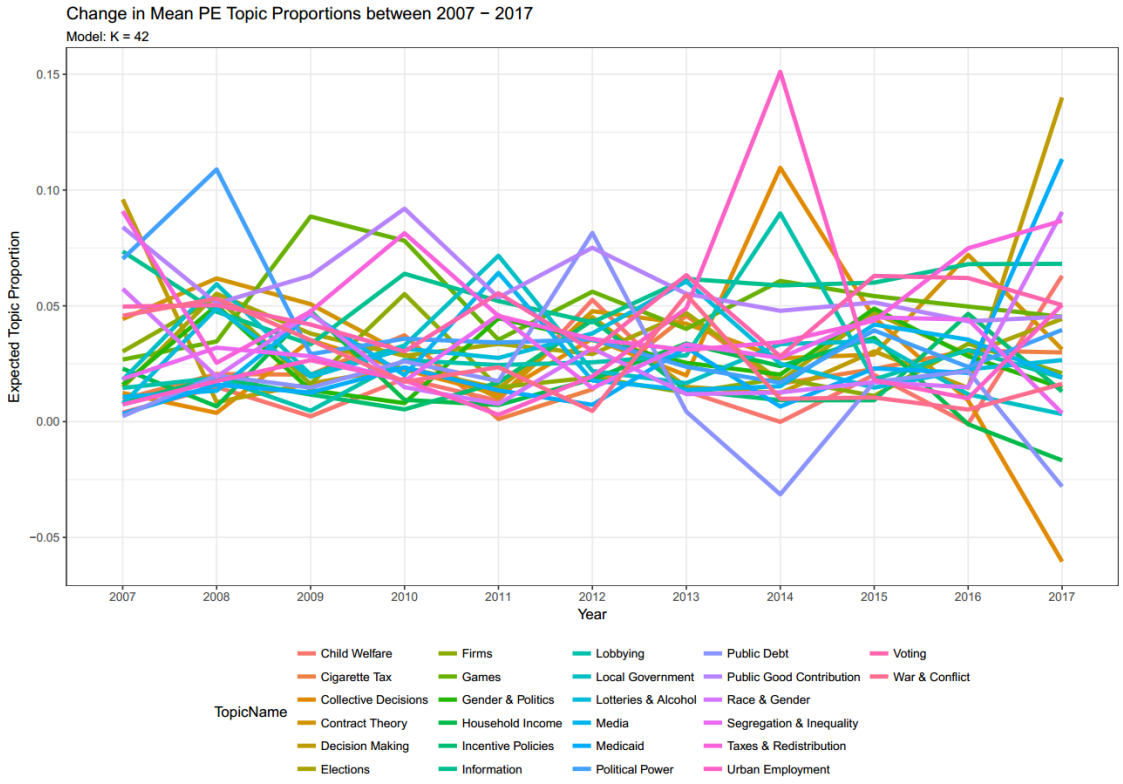


Figure 4.9 – Topic Trends in PE Topic Proportions in the Corpus Between 2007 - 2017

Topic Name	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Trend
Child Welfare	0.39%	1.49%	0.23%	1.86%	0.90%	5.26%	1.31%	-0.01%	2.02%	-0.10%	6.30%	
Cigarette Tax	0.97%	2.06%	2.03%	3.73%	0.11%	1.39%	4.57%	1.64%	2.27%	3.07%	2.99%	
Collective Decisions	1.24%	0.38%	3.52%	2.25%	1.18%	3.59%	2.00%	10.96%	4.49%	0.91%	-6.04%	
Contract Theory	4.43%	6.19%	5.07%	2.91%	1.03%	4.77%	4.23%	2.73%	2.90%	7.20%	3.12%	
Decision Making	9.60%	0.84%	1.65%	2.34%	1.44%	4.51%	1.50%	1.24%	3.04%	1.46%	14.00%	
Elections	1.47%	5.52%	3.80%	2.84%	3.36%	2.92%	4.69%	1.76%	4.68%	2.90%	4.44%	
Firms	3.03%	5.35%	1.62%	5.51%	1.48%	1.91%	1.25%	1.87%	1.11%	3.36%	2.09%	
Games	2.68%	3.46%	8.86%	7.81%	3.54%	5.61%	4.01%	6.08%	5.42%	4.97%	4.53%	
Gender & Politics	1.59%	5.01%	1.36%	0.80%	4.47%	3.52%	2.54%	2.03%	4.88%	2.83%	1.45%	
Household Income	2.29%	0.66%	4.77%	0.94%	0.72%	1.84%	3.37%	2.40%	3.62%	-0.11%	-1.67%	
Incentive Policies	0.83%	1.88%	1.17%	0.53%	1.69%	4.38%	1.35%	0.93%	0.92%	4.66%	1.30%	
Information	7.35%	4.75%	3.33%	6.39%	5.21%	4.29%	6.17%	5.88%	6.00%	6.80%	6.81%	
Lobbying	1.45%	1.89%	0.47%	2.66%	2.44%	2.56%	2.86%	8.99%	1.82%	3.09%	1.90%	
Local Government	1.80%	5.94%	2.03%	3.29%	7.17%	2.19%	1.66%	3.35%	3.47%	1.18%	0.33%	
Lotteries & Alcohol	0.75%	4.89%	1.93%	3.15%	2.75%	3.81%	6.06%	2.50%	1.47%	2.26%	2.66%	
Media	1.07%	1.33%	4.63%	2.01%	6.42%	1.77%	1.37%	1.53%	4.19%	3.54%	1.91%	
Medicaid	0.33%	1.59%	1.26%	2.34%	1.35%	0.73%	3.20%	0.65%	2.30%	2.11%	11.34%	
Political Power	7.03%	10.89%	2.91%	3.58%	3.42%	3.55%	2.37%	1.68%	3.94%	2.36%	3.96%	
Public Debt	0.23%	1.99%	1.46%	2.60%	1.75%	8.15%	0.43%	-3.14%	1.72%	2.18%	-2.80%	
Public Good Contribution	8.40%	5.10%	6.30%	9.20%	5.36%	7.51%	5.52%	4.79%	5.15%	4.33%	4.54%	
Race & Gender	5.73%	1.94%	4.68%	1.49%	0.76%	3.16%	1.19%	1.26%	1.71%	1.49%	9.06%	
Segregation & Inequality	1.84%	3.19%	2.83%	1.75%	4.61%	1.45%	3.34%	2.75%	4.50%	4.41%	0.37%	
Taxes & Redistribution	9.09%	2.54%	4.76%	8.14%	4.57%	3.57%	3.09%	3.43%	4.36%	7.48%	8.68%	
Urban Employment	0.74%	1.75%	2.65%	1.78%	0.30%	1.96%	4.89%	15.11%	1.79%	1.01%	5.05%	
Voting	4.97%	5.03%	4.19%	3.03%	5.55%	3.07%	6.33%	2.82%	6.29%	6.20%	5.03%	
War & Conflict	4.57%	5.32%	3.52%	1.72%	2.35%	0.46%	5.48%	0.98%	1.04%	0.52%	1.63%	

Table 4.6 – Topic Trends in PE Topic Proportions in the Corpus Between 2007 - 2017 *Red dot in trend column indicates topic's highpoint during timeframe*

4.8 Topic correlations

A topic correlations graph was produced from the marginal topic proportion correlation matrix estimated by the STM. Truncating to zero any topic correlations below 0.0001, the remaining non-zero correlations were aggregated and assigned as topic vertex degrees. This measure is reflected in Figure 4.10 as node size, representing a topics level of correlation to other topics. That is, a large node represents a topic with many correlations to other topics above the correlation threshold, reflecting some level of centrality for that topic. As the STM allows for correlations between topics for estimating the model, edges below a weighted threshold of 0.01 were deleted in order to have a cleaner visual of the topics strongest connections. Finally, domain prevalence was assigned to each topic in a scale from green (ERE) to red (PE), and where topics that overlapped both research domains faded to white.

Figure 4.10 shows two major clusters of ERE topics. The largest cluster is tightly composed by the topics Renewable Energy, Air Pollution, Vehicle Emissions, Fuel Standards, Economic Productivity, and Tech & Innovation. The smaller cluster is composed by Land Use, Oil Prices, and Fisheries & Law. These two clusters are connected to each other through two nodes: Climate Change, and Tech & Innovation. Climate Change connects Economic Productivity with Fisheries and Law, but has no other connections to other topics. However, Tech & Innovation also connects the two

clusters by bridging Economic Productivity with Fisheries & Law, but also connects them by bridging Fuel Standards with Fisheries and Law. Additionally, Tech & Innovation connects the overlap topic Money to both ERE clusters, plus connecting them on a second degree to the PE topics Firms and Information. In the second ERE cluster, Land Use has close direct connection to the strong PE topics of Gender & Politics and Segregation & Inequality.

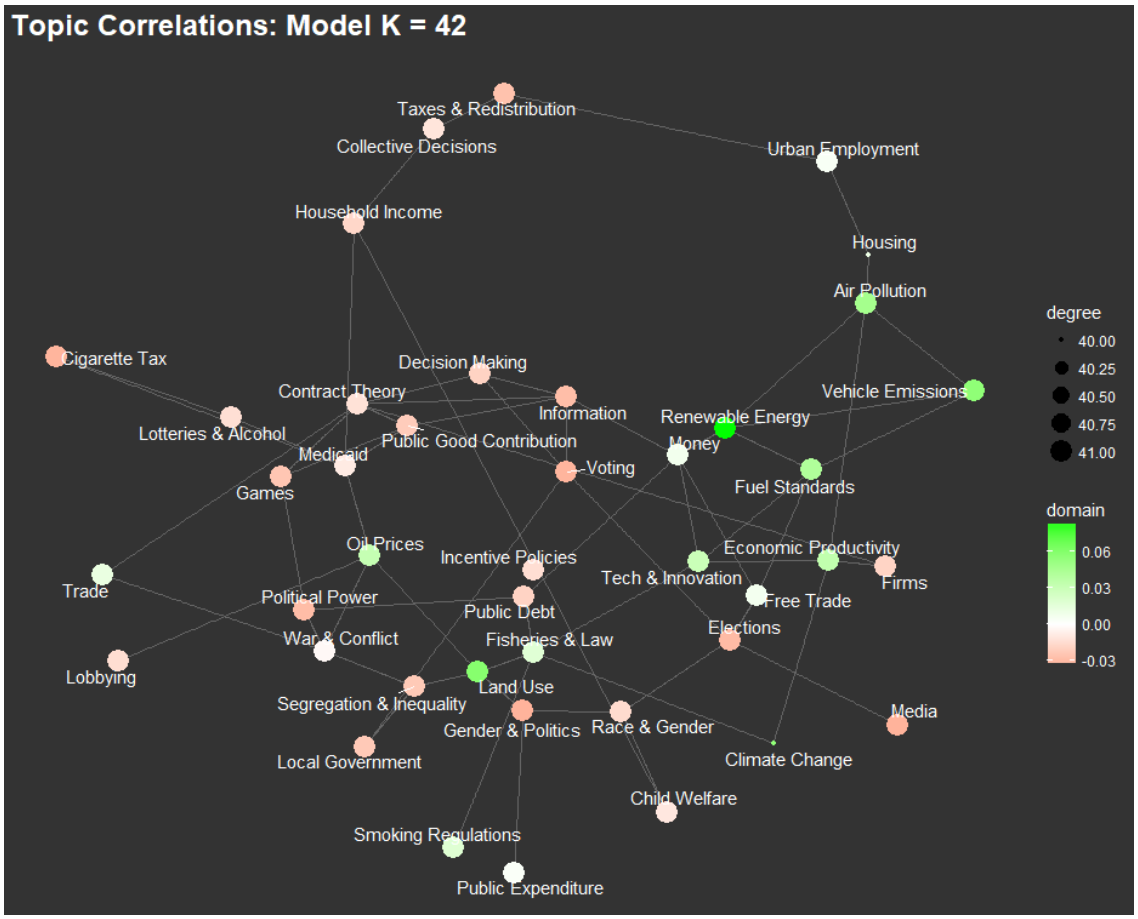


Figure 4.10 – Topic Correlation, Degree, and Domain Prevalence

Finally, figure 4.11 shows the graph of each topic's top 10 terms from each of the four term distribution measures (Highest Probability, FREX, Lift, and Score) only for visualisation purposes. Only the labels of the highest weighted terms by number of edges are visible.

Future research studies can look for research domain overlaps and conceptual gaps by applying graph functions to a graph constructed from a subset of chosen topics from the results of a STM. This would produce finer-grained semantically discrete terms and concepts of the specific research topics of interest.

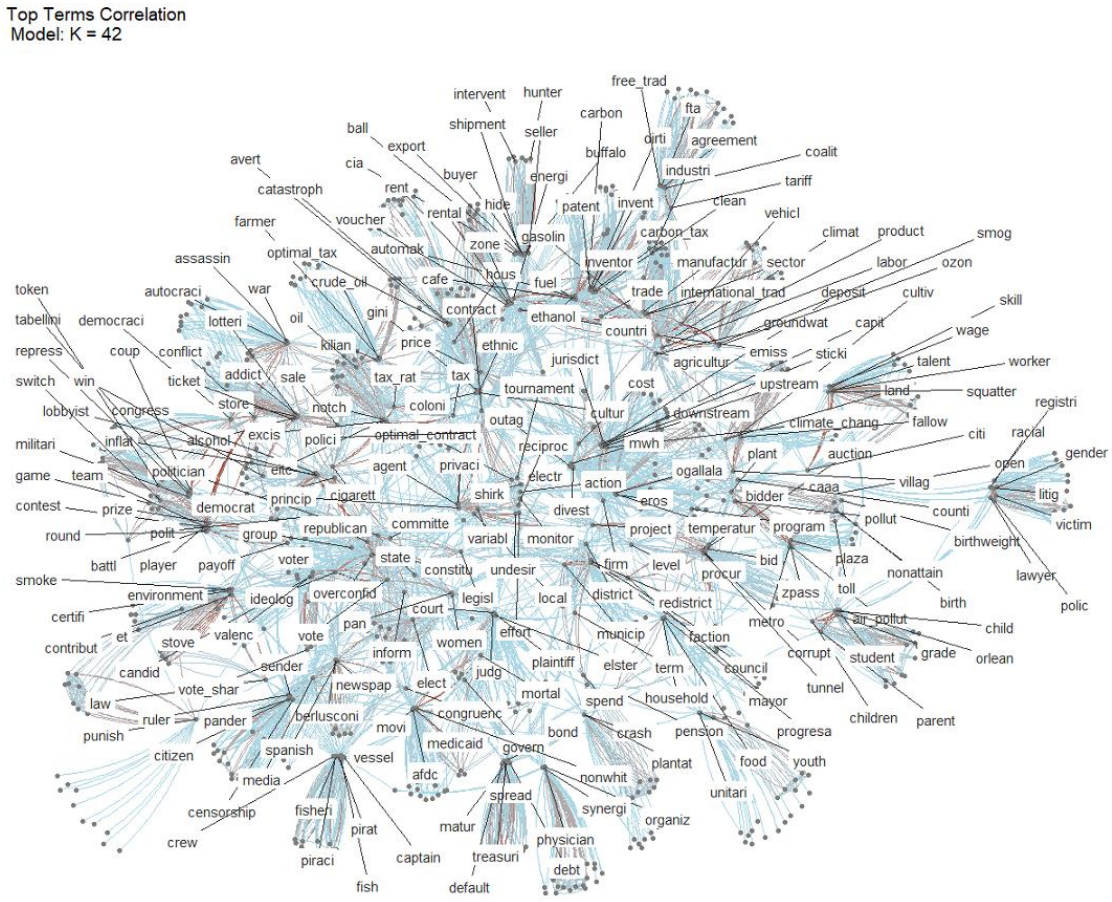


Figure 4.11 –Correlation of Topic's Most Frequent Terms

5 Discussion

5.1 Introduction

The Discussion chapter takes the results from the Structural Topic Model (STM) in the previous chapter, and interprets them to answer the research question of identifying recent trends and overlaps of ERE and PE research topics in top economic journals. Through the discussion of the results of the specific objective 3, conclusions can be drawn to answer the research question, and a final framework for future can be recommended in the next chapter:

1. Identify published research mapping ERE.
2. Construct ontologies of ERE and PE, delineating a conceptual core of each research domain.
3. Map ERE and PE research topics in articles published between 2007 and 2017 in selection of top economic journals.
4. Develop a framework for mapping topics of specific research domains within large corpora of scientific writing.

This section is divided into four sections: a comparison of the results with the literature review, analysis of topic trends, interpretation of research domain overlaps, and conclusions.

5.2 Synthesis of STM Results and Literature Mapping ERE Topics

The literature review only identified one study with comparable results to this research study, both in the context of mapping an ERE-related research area, as well as by having quantitative results from textual data. The name of the study is “Mapping research on carbon emissions trading: a co-citation analysis” by Yu, Xu (2017), and it uses qualitative analytical software for conducting a scientometric study of the literature on carbon emissions trading.

They conclude that “’Carbon market’ and ‘Input-output model’ are the new emerging research trend in CET research area and the research about ‘Cap-and-trade’ and ‘China’ has become the new research topics[sic] in recent years” (Yu, Xu 2017).

Comparing the results from this research with theirs, the following findings are identified:

- The term “carbon emissions trading” appeared in the ERE ontology both as “carbon emissions” and as “emissions trading”. It was picked up in the corpus through the thesaurus key “emission* trad*”, and codified in the model as “emissions_trad”. The term carbon emissions trading does not appear in any topic’s top 50 terms, when topic-term distribution is unweighted (high probability) or weighted with FREX. The term only occurs in topic Vehicle Emissions ranked between 40th and 50th when weighted with Lift or Score measures.
- The term “carbon market” was not present in either ontology, nor in the raw corpus, therefore it does not appear in any topic.
- The term “input-output model” appeared in the ontology both in singular and plural, and had “input*output model*” as thesaurus key. The term appeared only once in the raw corpus in its singular form (Levinson 2009), and once in its plural form (Hornbeck, Keskin 2015). However, it was trimmed out of the coding scheme that went into the model due to its low frequency, therefore it does not appear in any topic.
- The term “cap-and-trade” was not present in the ontology, but it did appear in the raw corpus 8 times in 5 different articles (Aldy et al. 2010; Fraas, Lutter 2012; Fowlie et al. 2016; Stavins 2011; Jaffe, Kerr 2015). For its low frequency, it was also trimmed out of the coding scheme, and does not appear in any topic.
- The term “china” was not present in the ontology, but appeared 397 times in the raw corpus. It only appeared in topic Trade, ranked between 30th and 40th in its topic-term distribution, when weighted with FREX.

Based on these findings, this research disagrees with the conclusions by Yu, Xu (2017) in the context of scientific literature published in top mainstream economic journals. Their general topic, carbon emissions trading, appears as a moderately small theme in the topic of Vehicle Emission. None of the CET terms they identify as recent trends or topics make it over this study’s coding scheme threshold, and the term “China”, which cannot be only associated to CET, appears ranked relatively low in the topic Trade.

It is important to highlight that the datasets between studies are not fully comparable, as this corpus was constructed from the full text of articles from top mainstream economic journals, while theirs was tailored specifically for carbon emissions trading from multiple sources. This study cannot reject the conclusions by Yu, Xu (2017) in the context of specialised scientific literature in carbon emissions trading

5.3 Topic Trends

5.3.1 ERE Topic Trends

An initial approach to interpreting the topic trends identified in the results chapter focussed on answering what made ERE topics dip in 2008, and what made them spike, first in 2011, and then again in 2016. From the STM results, topic themes and terms were analysed to infer clues on the causes for this behaviour of ERE topics.

The hypothesis considered for explaining the 2008 dip was that ERE topics were receding as a result of a previous rise in mean topic proportions, instigated by the 2005 Atlantic hurricane season. This had been the most active hurricane season in the Atlantic in recorded history, and the term “hurricane”, “Katrina”, and “Rita” were relatively salient terms in this study’s results. However, when analysed deeper, the first appearance of the term “hurricane” was in the 2009 article "Does the Media Matter? A Field Experiment Measuring the Effect of Newspapers on Voting Behavior and Political Opinions" (Gerber et al. 2009), from the PE research domain. The articles that actually cover the subject from a more ERE related approach were published in 2012. These were "Katrina's Children. Evidence on the Structure of Peer Effects from Hurricane Evacuees" (Imberman et al. 2012), and "When the Saints Go Marching Out. Long-Term Outcomes for Student Evacuees from Hurricanes Katrina and Rita" (Sacerdote 2012), both from the ERE topic Child Welfare. This is a 7-year lag between the publications on a social problem caused by a climate disaster, and the catalysing event. It is natural and adequate for this type of research to be conducted years after the fact, as effects take time to become visible. However, it raised a warning flag in attempting to identify a causal relation between trends in the scientific literature with global events directly related to the research topic under observation.

Since the STM results estimated a topic associated to oil prices, the second hypothesis considered for explaining trends in ERE topics was that the sharp increase in mean ERE topic proportions in 2011 was fuelled by the skyrocketing oil prices which peaked at 145 USD/bbl in 2008, and then again at 110 USD/bbl in 2011, and/or the oil spill from the Deepwater Horizon platform in the Gulf of Mexico. Again, a deeper analysis into the results to prove the hypothesis revealed that the real cause of the sharp spike in mean ERE topic proportions in 2011 was due to an increase in publications related to the topic Land Use. The most representative articles were "Subsidized Farm Input Programs and Agricultural Performance. A Farm-Level Analysis of West Bengal's Green Revolution,

1982-1995" (Bardhan, Mookherjee 2011), "Caste as an Impediment to Trade" (Anderson 2011), and "Public Provision and Protection of Natural Resources. Groundwater Irrigation in Rural India" (Sekhri 2011); all related to small-scale agriculture in India.

An additional hypothesis that had been posed for explaining the changes in ERE topic trends in 2011 was the disaster at the Fukushima Daiichi Nuclear Power Station in Japan. The hypothesis was discarded at the outset, as the disaster occurred in March 2011, therefore very little scientific literature on the subject could have been effectively written, reviewed and published within the same year. However, as the nuclear fallout from the disaster reignited the global debate on nuclear power, the literature synthesis results were analysed to identify if it had encouraged more research into nuclear power. Two articles from the Renewable Energy topic were on nuclear power, "Market Impacts of a Nuclear Power Plant Closure" (Davis, Hausman 2016), and "Deregulation, Consolidation, and Efficiency. Evidence from US Nuclear Power" (Davis, Wolfram 2012). However, both of them focussed on financial aspects of nuclear plants in the U.S., with not much of a thematic parallel to the Fukushima event. This was another warning flag at trying to infer topic trends in the scientific literature from global events.

Finally, the current rising trend in mean ERE topic proportions leading to the spike in 2016 was also attempted to be explained retroactively with global events that could have inspired researchers to choose the topics observed in the results. The hypothesis used for this spike in ERE topic proportions was that the build-up to the Paris COP 21 United Nations Climate Change Conference in late 2015, and the media attention it created, could have influenced researcher's choice of topics for studies. Again, analysis of the literature synthesis proved inconclusive for determining a tangible direct causality between the COP 21 and a rise in publications related to Climate Change. The topic Climate Change was virtually non-existent in the runup years to the COP 21, and had only one publication in 2016 with the article "Adapting to Climate Change. The Remarkable Decline in the US Temperature-Mortality Relationship over the Twentieth Century" (Barreca et al. 2016).

The literature synthesis suggested that the current trend in ERE topics that caused the rise in mean ERE topic proportions in 2016 was primarily driven by the topics Renewable Resources, Trade, Free Trade, and Tech & Innovation. The ERE vein into the topic Trade in 2016 was primarily defined by the article "A Balls-and-Bins Model of Trade. Comment" (Blum et al. 2016) which touches upon exports of mining and agricultural commodities. The ERE vein into the topic Free Trade was connected to the article "The

Strategic Value of Carbon Tariffs" (Böhringer et al. 2016). The ERE vein into the topic Tech & Innovation was associated to the articles "Transition to Clean Technology" (Acemoglu et al. 2016) and "Carbon Taxes, Path Dependency, and Directed Technical Change. Evidence from the Auto Industry" (Aghion et al. 2016), both of them by authors established in the PE domain.

5.3.2 PE Topic Trends

The results from the literature synthesis did offer tools for identifying PE topics trending under the surface. The STM used in this research study produced a literature synthesis which correlates the latent topics within the corpus of journal articles sampled. By identifying topics which currently don't show signs of trending, but which have high correlations to other topics that might be trending, this research detected topics with high potential to break out and start trending in the near future.

An example of this is the topic Child Welfare. Child Welfare was one of the three top PE topics in 2012 with a topic share of 5.26%, because two articles with high probability of belonging to that topic were published that year. However, Child Welfare was once again one of the top PE topics in 2017 with an even greater topic share of 6.30%, but had no articles published that year that directly belonged to it. This appeared to be counterintuitive. Analysing the literature synthesis map, it was detected that Child Welfare was consistently appearing as highest co-occurring topic in several other topics, from both PE and ERE, as well as with a topic from the overlap region. These were Collective Decisions, Race & Gender, and Gender & Politics on the PE side; Air Pollution and Economic Productivity on the ERE side, and Urban Employment from the overlapping topics. Even though no articles directly classified as Child Welfare were being published in 2017, Child Welfare was springing out as a latent topic from beneath a wide front of other topics. A possible explanation to this phenomenon is that, as the impact of economic crisis, environmental disasters and pollution to children's lives and health is becoming more visible to a wider public, the problem is becoming politically charged.

There were other PE topics with sharp rises in topic proportions in 2017. These were Decision Making with 14%, Medicaid with 11.34%, and Race & Gender with 9.06%. Their rise in topic share was explicitly explained by each of them having had articles published in 2017. The trend in these topics can be described as already having broken

out into the scientific literature. However, in the pursuit of proactively identifying a trending topic towards the future, Child Welfare appears to be the most likely.

5.4 Research Domain Overlaps

It can be assumed that all topics are somehow related to either ERE or PE since the journal articles that made up the corpus were sampled using ERE and PE-specific JEL codes. However, if the topic model had estimated a remotely related topic to either research domain (e.g. an article with a wrong JEL code classification was included in the corpus), this topic would appear at the PE extreme of the topic-domain prevalence continuum. The reason for this is because of the method used in this research to assign articles either to ERE or PE. Only articles that included a JEL code belonging to the general category "Q - Agricultural and Natural Resource Economics; Environmental and Ecological Economics" were assigned to ERE, while all other topics, either PE or unrelated (e.g. by a sampling mistake), were assigned to the PE domain. Although this approach is mentioned as a limitation in the methods chapter, its upside is that any topic in the middle of the continuum is a clear case of a topic overlapped by both research domains. This is because any topic that does not have some degree of ERE topic prevalence would find itself in the extreme PE side of the research domain continuum, as the ERE regression coefficient would have a strong inverse correlation effect with it. This inhibits the possibility of an unrelated topic to both research domains (e.g. again most likely from a sampling problem) to appear in the middle of the research domain continuum, giving the appearance of being a topic overlapped by both research domains, when in truth it has no topic prevalence from either.

Empirically, this can be assessed with the results from this research in Table 5.1. The topics that overlap in the middle of the ERE-PE continuum ($-0.01 < k < 0.01$, where k is the domain prevalence coefficient) are Urban Employment, War & Conflict, Public Expenditure, Free Trade, Money, and Housing. All these topics have a strong relationship with the overarching concept of "economic production factors": labour, capital, and land.

Topic Name	Prevalence Coefficient	Domain
Renewable Energy	0.0864	ERE
Climate Change	0.0583	ERE
Vehicle Emissions	0.0570	ERE
Land Use	0.0562	ERE
Air Pollution	0.0509	ERE
Fuel Standards	0.0412	ERE
Tech & Innovation	0.0314	ERE
Economic Productivity	0.0300	ERE
Oil Prices	0.0295	ERE
Fisheries & Law	0.0221	ERE
Smoking Regulations	0.0173	ERE
Trade	0.0115	ERE
Housing	0.0092	ERE
Money	0.0078	ERE
Free Trade	0.0065	ERE
Public Expenditure	0.0011	ERE
War & Conflict	-0.0005	PE
Urban Employment	-0.0017	PE
Medicaid	-0.0103	PE
Child Welfare	-0.0108	PE
Lotteries & Alcohol	-0.0124	PE
Contract Theory	-0.0130	PE
Lobbying	-0.0142	PE
Race & Gender	-0.0145	PE
Collective Decisions	-0.0150	PE
Incentive Policies	-0.0151	PE
Firms	-0.0169	PE
Decision Making	-0.0177	PE
Household Income	-0.0181	PE
Public Debt	-0.0185	PE
Games	-0.0224	PE
Local Government	-0.0227	PE
Public Good Contribution	-0.0230	PE
Segregation & Inequality	-0.0236	PE
Taxes & Redistribution	-0.0247	PE
Political Power	-0.0290	PE
Media	-0.0299	PE
Information	-0.0315	PE
Elections	-0.0317	PE
Cigarette Tax	-0.0334	PE
Voting	-0.0340	PE
Gender & Politics	-0.0346	PE

Table 5.1 – Topic Domain Prevalence: Topics that overlap research domains vs. topics at the extremes of the research domain continuum

From these overlapping topics, Urban Employment relates to labour, Money to capital, and Housing to land, with Housing (land) leaning most towards ERE, while Urban Employment (labour) leaning most towards PE. Between them, War & Conflict, Public Expenditure, Free Trade, and Money allude to means of controlling these productions factors. These topics that relate to controls of production factors appear scaled by degrees of governance, from violence on the one end, going through state intervention at the centre, to voluntary transactions on the other end.

Starting on the PE side, War & Conflict allude to means of controlling production factors in low governance environments and through the use of violence. Next in the governance scale is Public Expenditure, alluding to a state's power to command a nation's production factors through the use of fiscal policy. The fact that the model estimates Public Expenditure as neighbouring War & Conflict can also allude to a society's response to lack of governance, by replacing it with the state's monopoly on violence for resolving conflict and coordination problems. The next topic in the scale of production factor governance is Free Trade, which despite the word "free", it is still a highly regulated trade mechanism between two or more countries or regions, allowing market actors to interact with little to no interference by the state. This is nonetheless another step in the governance scale away from violent means, official or not, of controlling production factors. Ending on the ERE side of the research domain continuum, the final topic in this scale of production factor governance is Money. Still considered by many economists as a production factor in its own right for its history of being backed by gold or other tangible assets, in a fractional reserve monetary system using fiat currency, money behaves more and more as a mechanism of regulating labour, land, and materials through monetary policies of independent central banks and the practices of financial commercial institutions. In the context of this scale of production factor governance, money represents the capacity of market actors to voluntarily transact goods, services, or production factors, without the interference of the state.

This research also looked at topics that did not overlap in the corpus of selected articles. These topics at the extreme ends of the research domains continuum could be pointing towards topics that might have theoretical relevance to one of the research domains, while none to the other. They could also imply possible research gaps, where theoretical approaches from one research domain may enhance the other. This would manifest in a literature map as topics that might complement each other, but do not often appear together in the scientific literature. This is left for future research, as areas identified as

research gaps in the scientific literature synthesised in this corpus of articles from top mainstream economic journals, may well already have been covered in more specialised journals not included in this study.

However, from the scientific literature included in this research study, the top six ERE topics furthest away from the PE domain ($k > 0.04$) were Renewable Energy, Climate Change, Vehicle Emissions, Land Use, Air Pollution, and Fuel Standards. All topics clearly related to the environment and the use of resources. Perhaps an intersecting concept traversing these six topics is "energy", particularly exosomatic energy in the topics Renewable Energy, Climate Change, Vehicle Emissions, Air Pollution, and Fuel Standards; and endosomatic energy in the topic of Land Use (e.g. agriculture). Another possible traversing concept is "air", branching into "air quality" with the topics Fuel Standards, Air Pollution, and Vehicle Emissions; and into "greenhouse gasses" with the topics Renewable Energy, Climate Change, and Land Use. Either way, what is interesting about these topics being furthest away from PE in this corpus, is that they seem to have not entered the scientific literature on elections, voting, information, and media (at the opposite end of the ERE-PE continuum). This leads to asking the question: is the ERE academic community mainly approaching the solution to environmental problems from a regulatory top-down path?

Interestingly, the topic following the top six ERE topics furthest away from PE mentioned above, is Tech & Innovation. Some of the concepts inside the Tech & Innovation topic are "endogenous and directed technical change" discussed by Acemoglu and Aghion (Acemoglu et al. 2012), "innovation in environmentally friendly technologies" in Gans (2012), "transition to clean technology" in Acemoglu et al. (2016) , "incentives to innovate" in Spulber (2013), and "can directed technical change be used to combat climate change?" in Aghion et al. (2016). Except for Joshua Gans, who has environmental economics in his background, all authors come from fields different to ERE. Particularly, Daron Acemoglu and Phillippe Aghion have a prominent career in the field of Political Economics, while Daniel Spulber is an economist with a focus on management and law. Based on this interpretation of the literature synthesis map, it appears that the topic Tech & Innovation is a proxy being used by researchers from PE to engage with ERE topics, particularly climate change, clean technologies and carbon taxes.

On the other side of the domain continuum, the topic Public Good Contribution was mapped by the model closer to the end of the PE domain continuum than to the centre,

and ranked 5th as the most frequent topic in the corpus. The reason this topic was classified as belonging to PE was because the articles that ranked highest for this topic covered subjects such as “decline of cooperation is driven by individual preferences for imperfect conditional cooperation” (Fischbacher, Gächter 2010), “effects of a costly punishment option on cooperation and social welfare” (Ambrus, Greiner 2012), “well designed fines, subsidies, and the like minimize crowding out” (Bowles, Polanía-Reyes 2012), “after an exogenous reduction of group size […] nonblocked contributors decrease their contributions” (Zhang, Zhu 2011), and “the idiosyncratic but powerful roles that leaders may play [lead] to substantial variation in group cooperation outcomes” (Kosfeld, Rustagi 2015). None of these articles made direct reference to ERE related subjects, although public goods provisioning is a known and relevant area of research in ERE. These results show that it is a topic being actively developed by PE, hinting at a possible opportunity of theoretical complement between the two research domains on this subject.

5.5 Conclusions

This research study set out to answer what were the trends in top economic journals of ERE and PE research topics, and where were they overlapping. To answer this, current ERE and PE literature had to be mapped. To this end, this study implemented a scoping review framework, enhanced by qualitative content analysis for charting the data and collating results, and executed it using qualitative analytical software.

The results concluded that trends in ERE topics appeared not to be synchronised to major global events related to ERE, hindering causal explanations of changes in ERE topic proportions during the last decade. The topics with highest ERE domain prevalence currently trending were Renewable Energy and Tech & Innovation, the latter being primarily developed by authors from the PE research domain.

On the PE side, the topic Child Welfare showed promise of becoming a trending topic in the near future, as research from several other topics was converging around it, both from PE and ERE.

The topics where ERE and PE overlapped reflected economic production factors, i.e. Urban Employment (labour), Money (capital), and Housing (land). These lay at the borders of the thematic overlap zone of the research synthesis map. In between these topics on economic production factors, was a spectrum of topics reflecting mechanisms for controlling them, i.e. War & Conflict (violence), Public Expenditure (government

fiscal policy), Free Trade (large-scale trade), and Money (individual transactions). The spectrum of mechanisms ranged from unregulated violence in the PE side, going through state intervention in the middle, to voluntary market transactions on the ERE side of the spectrum.

An ERE topic seeing contributions from PE is Tech & Innovation. It was not located in the research domain overlap zone, but was identified as a proxy used by PE researchers advancing ERE subjects, such as climate change, clean technologies, and carbon taxes.

A PE topic which could see mutual theoretical benefits between ERE an PE is Public Good Contribution. It has been developed primarily by PE researchers, while appearing to be neglected by ERE researchers. As provisioning of public goods is a known and relevant area of research in ERE, this topic may offer opportunity for cross research domain collaboration in the future.

6 Contribution to Research Synthesis Approaches: Framework for Mapping Research Domains

6.1 Introduction

The Contributions chapter integrates the methods implemented in this study into a cohesive research strategy which may help guide future research looking to undertake a mapping study of an area of scientific knowledge. With this contribution to research synthesis approaches, the specific objective 4 is met:

1. Identify published research mapping ERE.
2. Construct ontologies of ERE and PE, delineating a conceptual core of each research domain.
3. Map ERE and PE research topics in articles published between 2007 and 2017 in selection of top economic journals.
4. Develop a framework for mapping topics of specific research domains within large corpora of scientific writing.

6.2 Background

The research strategy implemented in this study consisted of three main components. As its backbone was the Arksey & O'Malley framework for scoping reviews. The framework was enhanced by incorporating qualitative content analysis for developing a systematic coding scheme to chart the data and collate results. Finally, qualitative analytical software was used to implement the qualitative content analysis. The result is a framework that can map the complete scientific literature of large and multiple research domains, leveraging the breadth of scoping reviews, the depth of qualitative content analysis, and the computational power of qualitative analytical software.

This deep scoping review framework consists on the first five stages of the Arksey & O'Malley framework as the foundation, with the sixth stage of stakeholder consultation encouraged as an ongoing activity across all stages:

Stage 1: Identifying the research question
Stage 2: Identifying relevant studies
Stage 3: Study selection
Stage 4: Charting the data
Stage 5: Collating, summarising and reporting the results
Stage 6: Stakeholder consultation

From qualitative content analysis, steps 3 through 7 are implemented. Steps 3 and 4 are used early on for defining the domain anchors used to create the ontologies, and then train

the ontologies respectively. Steps 5 and 6 are used for selecting the metadata covariates and pre-processing the corpus of scientific literature. Finally step 7 is used for estimating and evaluating the topic model:

Step 1: Formulating the research question
Step 2: Selecting the sample
Step 3: Defining the categories to be applied
Step 4: Outlining the coding process and the coder training
Step 5: Implementing the coding process
Step 6: Determining trustworthiness
Step 7: Analysing the results of the coding process

In fusing the two methods, some stages from the scoping review framework and some steps from qualitative content analysis do not overlap as discrete processes. While stage 5 does match with step 7, the remaining steps imported from qualitative content analysis either are added to the framework as new stages, divide existing stages into different sub-stages, or are fused into a single stage.

For instance, stage 4 of charting the data is divided into two distinct aspects of the coding scheme. The first aspect relates to defining domain anchors and training the ontologies (steps 3 and 4 of QCA), while the second aspect relates to selecting metadata covariates and pre-processing the corpus of scientific literature (steps 5 and 6 of QCA). However, selecting metadata covariates only relates to step 5, while corpus pre-processing is analogous to both implementing the coding process (step 5) and determining trustworthiness (step 6).

The final framework for a deep scoping review is composed of eight discrete stages, covering three epochs of the literary synthesis. The first epoch consists of creating the coding scheme for identifying and selecting potential sources of literature and the corresponding literature from them. The second epoch consists of the actual identification and selection of sources of literature and corresponding literature. The third epoch consists of creating the coding scheme for processing and evaluating the corpus of selected literature, and implementing the structural topic model.

6.3 Framework for a Deep Scoping Review

Epoch 0: Research Question

As for all literature synthesis approaches, the first stage is to define a clear research question that implicitly frames the breadth and depth of the deep scoping review.

Epoch I: Coding Scheme for Literature Sources and Documents

Stage 1: Define the research domain, field, or subject area to map

A deep scoping review can map a single or multiple knowledge domains. As existing classifications of scientific fields and subject areas may be too wide or ambiguous, it is recommended to define the research domains in terms of collections of specific topics, authors, journals, etc. of interest to the research team. This can help to better delineate the specific section in the map of scientific knowledge wanted to map.

Stage 2: Identify one or several domain anchors

From the collection used to define the research domain in the previous stage, select one or several elements that best embody the knowledge domain object of research. It is recommended to select highly specialised journals in the research domain being researched; this improves specificity of domain, as well as access to the most recent topics and terms in it.

Other alternatives can be selecting a set of specific articles of interest to the research team; this is useful when the research area of interest is not fully formed in its own right, or a specific aspect of an existing domain wants to be filtered and mapped. The size of the set of articles depends on the breadth of the knowledge domain object of research. However, a good rule of thumb is the more the better, as long as the specificity of the domain of interest is not diluted.

If a research team is interested in scoping the topics and terms contained in a single (or few) documents, it is recommended to perhaps also explore other methods, such as document scaling.

Less recommended, but also practical alternatives, are using specialized books and textbooks by domain experts, or using domain dictionaries if available. The downside to these alternatives is that the domain anchors may become quickly out of date.

Stage 3: Construct domain ontologies: semi-supervised keyword selection

In order to leverage the domain specificity of the selected domain anchors, it is recommended to use qualitative analysis software to extract Multi-Word Expressions (MWE) from the domain anchors. The quanteda package in the R free software

environment for statistical computing is highly recommended for this purpose, as it is both powerful and very easy to use and interpret. The extracted MWE can be converted into a dictionary or thesaurus, using keys with wildcard characters for matching word derivations of key domain-specific terms.

A second recommended measure for constructing the ontologies is identifying frequent terms using TF-IDF, also possible with the quanteda package. A word of caution: including single-word terms into an ontology can lead to volatile semantic associations to other research domains. The recommended size for ontology keys is two words (bigrams).

Epoch II: Identification and Selection of Sources and Documents

Stage 4: Identify relevant sources of literature

Leveraging its scoping review foundation, the deep scoping review can choose scientific literature from all types of sources, such as journals, conference proceedings, grey literature, etc.

Stage 5: Select sources and literature to map

Having selected the relevant sources of literature, the next step is to define the inclusion criteria both for sources and the literature. The inclusion criteria are applied on two dimensions: breadth and depth of the map. Breadth of map defines how wide is the scope of literature sources selected for mapping the knowledge domain, while the depth of map defines the domain-specificity of the documents selected from those sources. This is important, as not all the documents in some relevant sources of literature might be domain-specific or even relevant. This inclusion criteria gives the flexibility of choosing al types of sources, and then only choosing the documents within it that are relevant to the research domain of interest.

Breadth of map:

The breadth of the map can be defined using one of three different alternative inclusion criteria:

- Total population: All relevant sources identified in stage 4 are selected.
- Ontological selection: Sources are sampled using knowledge domain term sparsity. Corpora per potential source of literature is created, converted to document-term matrices (DTM), and the ontologies applied as dictionaries to measure term sparsity. A sparsity threshold can be set to discard sources of literature with sparsity above the threshold.
- Convenience sampling: The research team selects the sources based on supervised criteria.

Depth of Map:

The depth of the map is exactly the same method applied for defining the breadth of the map, but instead of applying it to measure term sparsity of sources, it is used to measure term sparsity of the documents from the selected sources after applying the breadth of map inclusion criteria:

- Total population: All relevant articles vetted through breadth of map criterion.
- Ontological selection: Articles are sampled using knowledge domain term sparsity. Corpora per vetted source of literature is created, converted to document-term matrices (DTM), and the ontologies applied as dictionaries to measure term sparsity of each document. A sparsity threshold can be set to discard documents with sparsity above the threshold.
- Convenience sampling: The research team selects the articles based on supervised criteria.

Again, for the use of ontological selection, the quanteda package in R is recommended.

Epoch III: Estimating the Structural Topic Model

Stage 6: Select metadata covariates

Metadata covariates will depend on the research team's research objectives, and limited to the available information from each source of literature or in the documents. Conventional covariates are authors, journal, type of publication, year of publication, country of residence of lead author, research institution, language, etc. However, the research team can always be systematically creative with the use of novel or research method-specific covariates.

Stage 7: Corpus pre-processing

For corpus pre-processing, conventional simple text mining techniques are recommended. However, the key step in this stage is to first tokenise the corpus, then compound the tokens using the ontology created in stage 3, and then remove the stopwords. This sequence guaranties preserving as best as possible the domain-specific terms in the ontology. Stemming and trimming is optional, depending on the size of the corpus and the research team's objectives.

An optional step is estimating an optimal number of topics into which codify the corpus. This can be a number of topics intuitively selected by the research team, depending on the level of thematic granularity required for the map. Conversely, software that estimates topic optimality can be used, such as the package ldatuning in R.

However, it is important to note that software estimates of optimal number of topics are not necessarily superior to the research team's research objective and intuition. The level of thematic detail of a topic model is as subjective as defining the unit size of an actual cartographic map. It depends on the level of detailed required.

Stage 8: Estimate structural topic model

For the summative content analysis, the stm package in R is recommended, as it estimates a structural topic model which identifies latent semantic patterns in the corpus, as well as identifying the influence that metadata covariates have on the estimated topics. Some recommended measures for analysing the results are:

- Topic-term distributions for assigning topic names
- Topic domain prevalence and overlaps
- Topic proportions
- Topic coherence and term exclusivity
- Map of literature synthesis:
  - Most representative articles by topic
  - Most representative authors of representative articles
  - Topic co-occurrence in most representative articles
  - Most representative research domains of representative articles (if comparing two or more research domains)
- Topic trends
- Topic correlations

This is not by all means an exhaustive list of available measures. The stm package in R offers more measures for analysis, as well as useful applications to easily visualize and analysis results on a browser.

7 Summary

This research study aims at mapping the current state of research topics in Environmental and Resource Economics (ERE) and Political Economy (PE) in top mainstream economic journals. The objective of this is to identify where these research domains overlap, and what are the trends driving their research topics. The study is grounded on the ERE theoretical domain, which is thus the main research object of this study. The research domain of PE is approached as a comparison variable to ERE. However, the methods in this study are applied equally to both research domains.

The research strategy implemented in this study consisted of three main components. As its backbone was the Arksey & O'Malley framework for scoping reviews. The framework was enhanced by incorporating qualitative content analysis for developing a systematic coding scheme to chart the data and collate results. Finally, qualitative analytical software was used to implement the qualitative content analysis. The result is a framework that can map the complete scientific literature of large and multiple research domains, leveraging the breadth of scoping reviews, the depth of qualitative content analysis, and the computational power of qualitative analytical software.

The results of mapping the literature from the selected top mainstream economic journals identified 42 latent topics across the corpus, 16 of them associated to ERE, while the remaining 26 to PE. The most predominant ERE topics were: Renewable Energy with 4% of corpus share, followed by Fisheries & Law with 3%, and Money with 2.5%. The least frequent ERE topics were Smoking Regulations and Fuel Standards with around 1.5% of share each. The most frequent PE topics in the corpus were Household Income, Taxes & Redistribution, and Contract Theory with 5%, 4%, and 3.5% of thematic share respectively. Surprisingly, the topic Voting came in 5th with approximately 3% of share, the topic Elections came in 19th with only a little over 2% of share, and the topic Lobbying came in second to last with around 1.5% of share. The least frequent PE terms were Race & Gender, Lobbying, and Medicaid at around 1.5% all of them.

The results concluded that trends in ERE topics appeared not to be synchronised to major global events related to ERE, hindering causal explanations of changes in ERE topic proportions during the last decade. The topics with highest ERE domain prevalence currently trending were Renewable Energy and Tech & Innovation, the latter being primarily developed by authors from the PE research domain. On the PE side, the topic

Child Welfare showed promise of becoming a trending topic in the near future, as research studies from several other topics were converging around it, both from PE and ERE.

The topics where ERE and PE overlapped reflected economic factors of production, i.e. Urban Employment (labour), Money (capital), and Housing (land). These lay at the borders of the thematic overlap zone of the research synthesis map. In between these economic factors of production, was a spectrum of topics reflecting mechanisms for controlling them, i.e. War & Conflict (violence), Public Expenditure (government fiscal policy), Free Trade (large-scale trade), and Money (individual transactions). This spectrum of mechanisms to control economic factors of production ranged from unregulated violence on the PE side, going through state intervention in the middle, to voluntary market transactions on the ERE side of the spectrum.

An ERE topic seeing contributions from PE is Tech & Innovation. It was not located in the research domain overlap zone, but was identified as a proxy used by PE researchers advancing ERE subjects, such as climate change, clean technologies, and carbon taxes. A PE topic which could see mutual theoretical benefits between ERE an PE is Public Good Contribution. It has been developed primarily by PE researchers, while appearing to be neglected by ERE researchers. As provisioning of public goods is a known and relevant area of research in ERE, this topic may offer opportunity for cross research domain collaboration in the future.

8 Appendix 1: Domain Ontologies

[1] "abate pollution" "abatement" "abatement cost*" "abatement effort*"
[5] "abatement level*" "abatement sector*" "abatement subsid*" "abatement target*"
[9] "abating nation*" "absent commitment*" "accountability" "accounting convention*"
[13] "accounting identit*" "acid rain*" "actual inflation" "additional incentive*"
[17] "adjustment path*" "adverse externalit*" "adverse selection" "adverse selection problem*"
[21] "agency" "agency problem" "agency theory" "agenda manipulation"
[25] "agenda setting" "aggregate capital" "aggregate demand" "aggregate investment"
[29] "aggregate spending" "agricultural chemical*" "agricultural land*" "agricultural output*"
[33] "agriculture manufacturing" "air" "air pollut*" "air pollut* control*"
[37] "air quality" "air water" "allocation* problem*" "allowable emission*"
[41] "alternating governments" "alternative instrument*" "ambient pollut*" "amendment right*"
[45] "amenity service*" "animal population*" "annex countr*" "announced polic*"
[49] "applied welfare economics" "appropriate rent*" "appropriated" "appropriation*"
[53] "assessment report" "assurance game*" "asymmetric information" "atmospheric concentration*"
[57] "available tax*" "average income" "average inflation" "average labo*"
[61] "backstop technolog*" "balance sheet*" "balance* budget*" "bank* independence"
[65] "bargain*" "bargain* power" "bargaining" "bargaining solution*"
[69] "base resource*" "baumol* disease" "benefit* function*" "benevolent government*"
[73] "benevolent social" "benevolent social planner" "benthamite utilitarian optimum" "benthamite welfare function*"
[77] "bertrand competition" "best polic*" "billion barrels" "binding commitment*"
[81] "binding electoral" "binding electoral promise*" "biodiversity conservation" "biodiversity loss*"
[85] "biological diversit*" "biological equilibri*" "biological growth" "biological growth function*"
[89] "biological oxygen demand" "biological war*of*attrition" "bliss point*" "bond* market*"
[93] "bond* redeem*" "bretton woods" "broad redistributive" "brundtland report"
[97] "budget constraint*" "budget deficit*" "budget process" "budget proposal*"
[101] "budgetary procedure*" "business cycle*" "campaign contribution*" "candidate*"
[105] "capital accumulation" "capital equipment" "capital flight" "capital income"
[109] "capital levy" "capital mobility" "capital stock" "capital stock*"
[113] "capital tax*" "capital theory" "capital* intensive industr*" "capital*intensive"
[117] "carbon" "carbon cycle*" "carbon dioxide" "carbon dioxide emission*"
[121] "carbon emission*" "carbon tax*" "career concern" "carrying capacit*"
[125] "cash flow*" "central bank*" "centralized polic*" "centrist part*"
[129] "ces production" "ces production function" "cfc emission*" "cge"
[133] "CGE model*" "chicago school" "chicken game*" "choice model*"
[137] "citizen* candidate*" "citizen* juries" "citizen* vote*" "citizens?? juries"
[141] "classical economics" "clean air" "clean water" "clean*up expenditure*"
[145] "climate change" "climate system*" "close substitute*" "closed econom*"
[149] "closed system*" "co2 concentration*" "coalition government*" "coalition partner*"
[153] "coalition*" "coase theorem" "cobb*douglas" "collective action*"
[157] "collective action* problem*" "collective choice*" "collective decision*" "commitment*"
[161] "commodit* consumption" "commodity price*" "common property" "common* agency"
[165] "common* knowledge" "common* knowledge distribution*" "common* pool" "common*pool problem"
[169] "comparative politic*" "comparative static*" "compensation test*" "competent incumbent*"
[173] "competing candidate*" "competitive devaluation*" "competitive market*" "complementary slackness"
[177] "complete exhaustion" "complete information" "complete knowledge" "computable general equilibrium"
[181] "concave preference*" "concave utility" "concentration rate*" "concern model*"
[185] "condorcet paradox" "condorcet winner*" "conflicting interest*" "congress vote*"
[189] "conservative central" "conservative government*" "constant consumption" "constant consumption level*"
[193] "constant population" "constitutional feature*" "constrained optimisation" "consumer problem*"
[197] "consumer sovereignty" "consumer* surplus" "consumption" "consumption constant"
[201] "consumption discount" "consumption discount rate*" "consumption efficienc*" "consumption indifference"
[205] "consumption indifference curve" "consumption level*" "consumption output*" "consumption path*"
[209] "consumption unit*" "contingent valuation" "continuation value*" "continuous time"
[213] "contract theor*" "contracting model*" "contribution schedule*" "control authorit*"
[217] "control cost*" "control instrument*" "control polic*" "control problem*"
[221] "control programme*" "control regulation*" "control right*" "control techn*"
[225] "cooperative behavio*" "cooperative equilibri*" "cooperative polic*" "cooperative solution"
[229] "cost curve" "cost estimate*" "cost function*" "cost minimisation"
[233] "cost saving*" "cost schedul*" "cost time saving" "cost*benefit analysis"
[237] "credibility problem*" "critical depensation" "crude oil" "current consumption"
[241] "current period*" "current polic*" "cutoff utilit*" "cvm"
[245] "damage cost*" "damage function*" "debt accumulat*" "debt issue*"
[249] "debt level*" "debt polic*" "debt repayment*" "debt structure*"
[253] "decay rate*" "decision rule*" "decision* maker*" "decision* making"
[257] "decision*making authority" "decision*making power" "decisive voter*" "deep ocean*"
[261] "default allocation*" "default polic*" "defensive expenditure*" "deforestation"

[265] "delayed* stabilization" "deliberative polling" "demand curve" "demand equation*"
[269] "demand function*" "demand management" "demand theory" "demographic transition*"
[273] "depletion model*" "depletion problem*" "design stage*" "developed countr*"
[277] "developed nation*" "developing countr*" "developing world" "development benefit*"
[281] "development economics" "development project*" "development report*" "dichotomous choice*"
[285] "diminishing marginal utility" "diminishing return*" "direct democrac*" "discount factor*"
[289] "discount rate*" "discount* factor*" "discount* rate*" "discount* value"
[293] "discounting future utility" "discretionary polic*" "distortionary tax*" "distribution function*"
[297] "domestic credibility" "domestic incentive" "domestic politic*" "domestic product"
[301] "domestic production" "dominant strateg*" "dornbusch overshooting" "double dividend hypothesis"
[305] "downsian electoral" "downsian electoral competition" "downsian model*" "dynamic adjustment*"
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[1545] "utility constant*" "utility discount rate*" "utility function*" "utility level*"
[1549] "utility maximi*" "utility possibility frontier" "utility substitution" "utility theory"
[1553] "valuation function*" "valuation method*" "valuation technique*" "value added"
[1557] "value function*" "vested interest*" "veto right*" "vot* behavio*"
[1561] "vot* district*" "vot* model*" "vot* rule*" "vot* sincerely"
[1565] "vot* strateg*" "vot* theor*" "vote shar*" "voter*"
[1569] "voter* choos*" "voter* evaluate*" "voter* prefer*" "voter* realiz*"
[1573] "voter* reelect*" "voter* utility" "voting" "wage sett*"
[1577] "waste accumulation" "waste disposal" "waste emission*" "waste flow*"
[1581] "waste water" "wasteful spending" "water" "water pollut*"
[1585] "water quality" "water suppl*" "water system*" "weak complementarity"
[1589] "weak sustainabilist*" "weak sustainability" "welfare economics" "welfare function*"
[1593] "welfare indifference curve*" "welfare maxim*" "welfare state*" "well*behaved utilit*"
[1597] "wilderness*" "willingness to accept" "willingness to pay" "willingness*to*pay"
[1601] "winner*takes*all" "winning candidate*" "winning coalition*" "without* commitment"
[1605] "without* cooperation" "wood pulp" "world price*" "world resource*"
[1609] "wta" "wtp" "young individual*" "young* voter*"
[1613] "zero inflation"

9 Appendix 2: Corpus Bibliography

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10 Appendix 3: List of Stopwords

Set 3: Corpus-Specific Stopwords:

```
 [1] "january"              "february"             "march"                "april"
 [5] "may"                  "june"                 "july"                 "agust"
 [9] "september"            "october"              "november"             "december"
[13] "manuscript"           "preprint"             "app"                  "pol"
[17] "doi"                  "aer"                  "jel"                  "mic"
[21] "percent"              "percentage"           "increase"             "decrease"
[25] "chicago"              "press"                "http"                 "www.journals.uchicago.edu"
[29] "journal"              "crossref"             "abstract"             "view"
[33] "pdf"                  "article"              "links"                "estimate"
[37] "estimates"            "estimation"           "estimations"          "column"
[41] "columns"              "table"                "tables"               "log"
[45] "logarithm"            "logit"                "logic"                "year"
[49] "years"                "yearly"               "month"                "months"
[53] "monthly"              "hour"                 "hours"                "hourly"
[57] "week"                 "weeks"                "weekly"               "day"
[61] "days"                 "daily"                "vol"                  "sample"
[65] "samples"              "sampling"             "dummies"              "baseline"
[69] "coefficient"          "coefficients"         "subject"              "subjects"
[73] "probably"             "oli"                  "ols"                  "across"
[77] "lag"                  "lagged"               "laggard"              "laggards"
[81] "online"               "appendix"             "cohort"               "cohorts"
[85] "Ã°tÃ¾"                 "Ã°mÃ¾"                 "Ã°1Ã¾"                 "panel"
[89] "panels"               "et"                   "etc"                  "eter"
[93] "eters"                "\tetrized"            "etion"                "eterizing"
[97] "\tetzc"               "ety"                  "eties"                "etary"
[101] "etionary"            "al"                   "scenario"             "scenarios"
[105] "item"                "items"                "\tcorollary"          "math"
[109] "mathematics"         "mathematical"         "mathematically"       "multiplication"
[113] "multiplied"          "multiplier"           "multipliers"          "multiplicity"
[117] "multiplicities"      "\tmultiplicative"     "data"                 "dataset"
[121] "equation"            "equation"             "2sls"                 "rev"
[125] "review"              "reviews"              "reviewed"             "reviewers"
[129] "lemma"               "lemmas"               "ac"                   "cialization"
[133] "cials"               "cial"                 "ciated"               "ciably"
[137] "ciable"              "cians"                "cian"                 "cialize"
[141] "cialized"            "cially"               "cialization"          "ciation"
[145] "ciations"            "ciaries"              "ciary"                "cialists"
[149] "cialist"             "ciative"              "ciating"              "Ã°vÃ¾"
[153] "Ã°yi"                 "Ã°aÃ¾"                 "axiom"                "Ã°sÃ¾"
[157] "Ã°xÃ¾"                 "Ã°pÃ¾"                 "Ã°cÃ¾"                 "lution"
[161] "lutionary"           "lutionize"            "xlvii"                "liii"
[165] "deu"                 "Ã°0Ã¾"                 "Ã°1Ã¾"                 "Ã°2Ã¾"
[169] "Ã°3Ã¾"                 "Ã°4Ã¾"                 "Ã°5Ã¾"                 "Ã°6Ã¾"
[173] "Ã°7Ã¾"                 "Ã°8Ã¾"                 "Ã°9Ã¾"                 "Ã°10Ã¾"
[177] "Ã°2000Ã¾"             "Ã°2001Ã¾"             "Ã°2002Ã¾"             "Ã°2003Ã¾"
[181] "Ã°2004Ã¾"             "Ã°2005Ã¾"             "Ã°2006Ã¾"             "Ã°2007Ã¾"
[185] "Ã°2008Ã¾"             "Ã°2009Ã¾"             "Ã°2010Ã¾"             "Ã°2011Ã¾"
[189] "Ã°2012Ã¾"             "Ã°2013Ã¾"             "Ã°2014Ã¾"             "Ã°2015Ã¾"
[193] "Ã°2016Ã¾"             "lognormal"            "lognormals"           "lognormality"
[197] "lognormally"         "coauthor"             "weekend"              "professor"
[201] "nov"                 "12d"                  "aaa"                  "xit"
[205] "nteer"               "nteers"               "nteered"              "nteering"
[209] "nteerism"            "1960s"                "equilibrium"          "theorem"
[213] "tp0"                 "yct"                  "diff"                 "nij"
[217] "yct"                 "Ã°and"                 "Ã°the"
```

Set: “english”:

```
 [1] "i"          "me"         "my"         "myself"     "we"         "our"        "ours"       "ourselves"  "you"
[10] "your"       "yours"      "yourself"   "yourselves" "he"         "him"        "his"        "himself"    "she"
[19] "her"        "hers"       "herself"    "it"         "its"        "itself"     "they"       "them"       "their"
[28] "theirs"     "themselves" "what"       "which"      "who"        "whom"       "this"       "that"       "these"
[37] "those"      "am"         "is"         "are"        "was"        "were"       "be"         "been"       "being"
[46] "have"       "has"        "had"        "having"     "do"         "does"       "did"        "doing"      "would"
[55] "should"     "could"      "ought"      "i'm"        "you're"     "he's"       "she's"      "it's"       "we're"
[64] "they're"    "i've"       "you've"     "we've"      "they've"    "i'd"        "you'd"      "he'd"       "she'd"
[73] "we'd"       "they'd"     "i'll"       "you'll"     "he'll"      "she'll"     "we'll"      "they'll"    "isn't"
[82] "aren't"     "wasn't"     "weren't"    "hasn't"     "haven't"    "hadn't"     "doesn't"    "don't"      "didn't"
[91] "won't"      "wouldn't"   "shan't"     "shouldn't"  "can't"      "cannot"     "couldn't"   "mustn't"    "let's"
[100] "that's"    "who's"      "what's"     "here's"     "there's"    "when's"     "where's"    "why's"      "how's"
[109] "a"         "an"         "the"        "and"        "but"        "if"         "or"         "because"    "as"
[118] "until"     "while"      "of"         "at"         "by"         "for"        "with"       "about"      "against"
[127] "between"   "into"       "through"    "during"     "before"     "after"      "above"      "below"      "to"
[136] "from"      "up"         "down"       "in"         "out"        "on"         "off"        "over"       "under"
[145] "again"     "further"    "then"       "once"       "here"       "there"      "when"       "where"      "why"
[154] "how"       "all"        "any"        "both"       "each"       "few"        "more"       "most"       "other"
[163] "some"      "such"       "no"         "nor"        "not"        "only"       "own"        "same"       "so"
[172] "than"      "too"        "very"       "will"
```

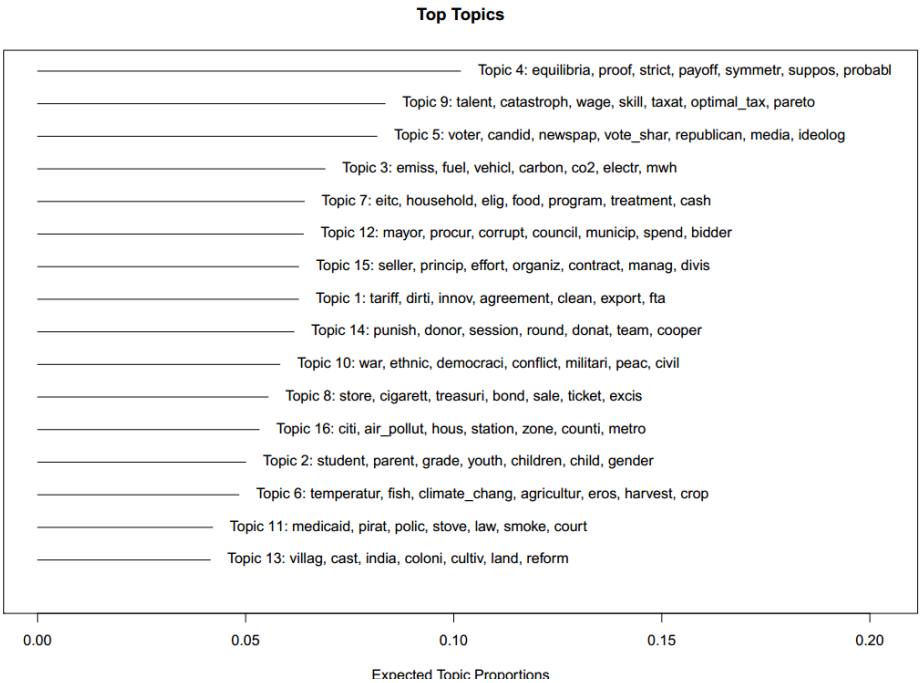
Set “SMART”:

```
[1] "a"           "a's"         "able"        "about"       "above"       "according"   "accordingly"
[8] "across"      "actually"    "after"       "afterwards"  "again"       "against"     "ain't"
[15] "all"        "allow"       "allows"      "almost"      "alone"       "along"       "already"
[22] "also"       "although"    "always"      "am"          "among"       "amongst"     "an"
[29] "and"        "another"     "any"         "anybody"     "anyhow"      "anyone"      "anything"
[36] "anyway"     "anyways"     "anywhere"    "apart"       "appear"      "appreciate"  "appropriate"
[43] "are"        "aren't"      "around"      "as"          "aside"       "ask"         "asking"
[50] "associated" "at"          "available"   "away"        "awfully"     "b"           "be"
[57] "became"     "because"     "become"      "becomes"     "becoming"    "been"        "before"
[64] "beforehand" "behind"      "being"       "believe"     "below"       "beside"      "besides"
[71] "best"       "better"      "between"     "beyond"      "both"        "brief"       "but"
[78] "by"         "c"           "c'mon"       "c's"         "came"        "can"         "can't"
[85] "cannot"     "cant"        "cause"       "causes"      "certain"     "certainly"   "changes"
[92] "clearly"    "co"          "com"         "come"        "comes"       "concerning"  "consequently"
[99] "consider"   "considering" "contain"     "containing"  "contains"    "corresponding" "could"
[106] "couldn't"  "course"      "currently"   "d"           "definitely"  "described"   "despite"
[113] "did"       "didn't"      "different"   "do"          "does"        "doesn't"     "doing"
[120] "don't"     "done"        "down"        "downwards"   "during"      "e"           "each"
[127] "edu"       "eg"          "eight"       "either"      "else"        "elsewhere"   "enough"
[134] "entirely"  "especially"  "et"          "etc"         "even"        "ever"        "every"
[141] "everybody" "everyone"    "everything"  "everywhere"  "ex"          "exactly"     "example"
[148] "except"    "f"           "far"         "few"         "fifth"       "first"       "five"
[155] "followed"  "following"   "follows"     "for"         "former"      "formerly"    "forth"
[162] "four"      "from"        "further"     "furthermore" "g"           "get"         "gets"
[169] "getting"   "given"       "gives"       "go"          "goes"        "going"       "gone"
[176] "got"       "gotten"      "greetings"   "h"           "had"         "hadn't"      "happens"
[183] "hardly"    "has"         "hasn't"      "have"        "haven't"     "having"      "he"
[190] "he's"      "hello"       "help"        "hence"       "her"         "here"        "here's"
[197] "hereafter" "hereby"      "herein"      "hereupon"    "hers"        "herself"     "hi"
[204] "him"       "himself"     "his"         "hither"      "hopefully"   "how"         "howbeit"
[211] "however"   "i"           "i'd"         "i'll"        "i'm"         "i've"        "ie"
[218] "if"        "ignored"     "immediate"   "in"          "inasmuch"    "inc"         "indeed"
[225] "indicate"  "indicated"   "indicates"   "inner"       "insofar"     "instead"     "into"
[232] "inward"    "is"          "isn't"       "it"          "it'd"        "it'll"       "it's"
[239] "its"       "itself"      "j"           "just"        "k"           "keep"        "keeps"
[246] "kept"      "know"        "knows"       "known"       "l"           "last"        "lately"
[253] "later"     "latter"      "latterly"    "least"       "less"        "lest"        "let"
[260] "let's"     "like"        "liked"       "likely"      "little"      "look"        "looking"
[267] "looks"     "ltd"         "m"           "mainly"      "many"        "may"         "maybe"
[274] "me"        "mean"        "meanwhile"   "merely"      "might"       "more"        "moreover"
```

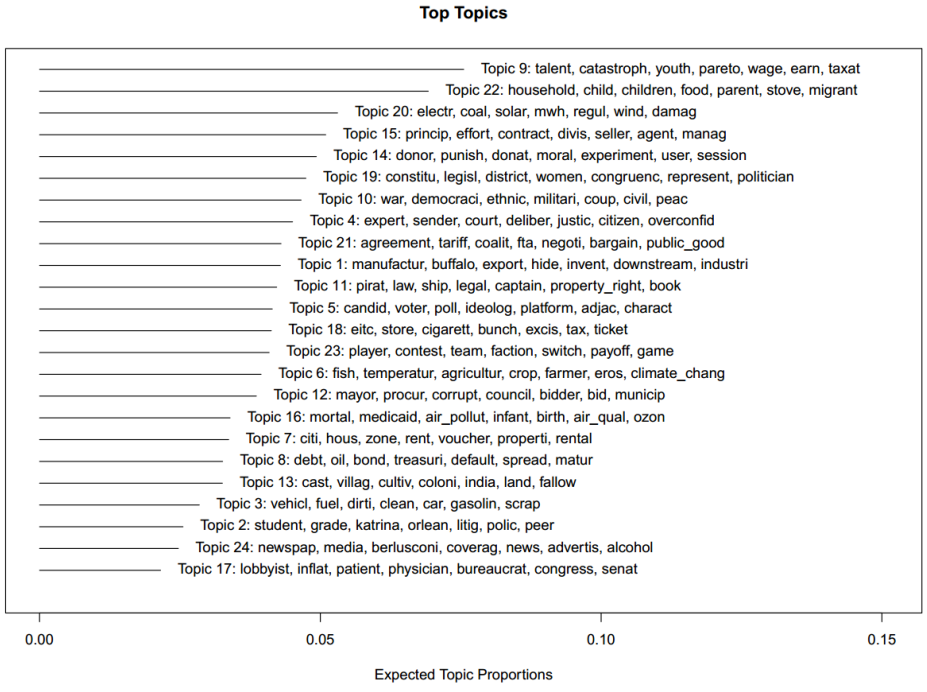
```
[281] "most"         "mostly"       "much"         "must"         "my"           "myself"       "n"
[288] "name"         "namely"       "nd"           "near"         "nearly"       "necessary"    "need"
[295] "needs"        "neither"      "never"        "nevertheless" "new"          "next"         "nine"
[302] "no"           "nobody"       "non"          "none"         "noone"        "nor"          "normally"
[309] "not"          "nothing"      "novel"        "now"          "nowhere"      "o"            "obviously"
[316] "of"           "off"          "often"        "oh"           "ok"           "okay"         "old"
[323] "on"           "once"         "one"          "ones"         "only"         "onto"         "or"
[330] "other"        "others"       "otherwise"    "ought"        "our"          "ours"         "ourselves"
[337] "out"          "outside"      "over"         "overall"      "own"          "p"            "particular"
[344] "particularly" "per"          "perhaps"      "placed"       "please"       "plus"         "possible"
[351] "presumably"   "probably"     "provides"     "q"            "que"          "quite"        "qv"
[358] "r"            "rather"       "rd"           "re"           "really"       "reasonably"   "regarding"
[365] "regardless"   "regards"      "relatively"   "respectively" "right"        "s"            "said"
[372] "same"         "saw"          "say"          "saying"       "says"         "second"       "secondly"
[379] "see"          "seeing"       "seem"         "seemed"       "seeming"      "seems"        "seen"
[386] "self"         "selves"       "sensible"     "sent"         "serious"      "seriously"    "seven"
[393] "several"      "shall"        "she"          "should"       "shouldn't"    "since"        "six"
[400] "so"           "some"         "somebody"     "somehow"      "someone"      "something"    "sometime"
[407] "sometimes"    "somewhat"     "somewhere"    "soon"         "sorry"        "specified"    "specify"
[414] "specifying"   "still"        "sub"          "such"         "sup"          "sure"         "t"
[421] "t's"          "take"         "taken"        "tell"         "tends"        "th"           "than"
[428] "thank"        "thanks"       "thanx"        "that"         "that's"       "thats"        "the"
[435] "their"        "theirs"       "them"         "themselves"   "then"         "thence"       "there"
[442] "there's"      "thereafter"   "thereby"      "therefore"    "therein"      "theres"       "thereupon"
[449] "these"        "they"         "they'd"       "they'll"      "they're"      "they've"      "think"
[456] "third"        "this"         "thorough"     "thoroughly"   "those"        "though"       "three"
[463] "through"      "throughout"   "thru"         "thus"         "to"           "together"     "too"
[470] "took"         "toward"       "towards"      "tried"        "tries"        "truly"        "try"
[477] "trying"       "twice"        "two"          "u"            "un"           "under"        "unfortunately"
[484] "unless"       "unlikely"     "until"        "unto"         "up"           "upon"         "us"
[491] "use"          "used"         "useful"       "uses"         "using"        "usually"      "uucp"
[498] "v"            "value"        "various"      "very"         "via"          "viz"          "vs"
[505] "w"            "want"         "wants"        "was"          "wasn't"       "way"          "we"
[512] "we'd"         "we'll"        "we're"        "we've"        "welcome"      "well"         "went"
[519] "were"         "weren't"      "what"         "what's"       "whatever"     "when"         "whence"
[526] "whenever"     "where"        "where's"      "whereafter"   "whereas"      "whereby"      "wherein"
[533] "whereupon"    "wherever"     "whether"      "which"        "while"        "whither"      "who"
[540] "who's"        "whoever"      "whole"        "whom"         "whose"        "why"          "will"
[547] "willing"      "wish"         "with"         "within"       "without"      "won't"        "wonder"
[554] "would"        "would"        "wouldn't"     "x"            "y"            "yes"          "yet"
[561] "you"          "you'd"        "you'll"       "you're"       "you've"       "your"         "yours"
[568] "yourself"     "yourselves"   "z"            "zero"
```

11 Appendix 4: Sensitivity Analysis

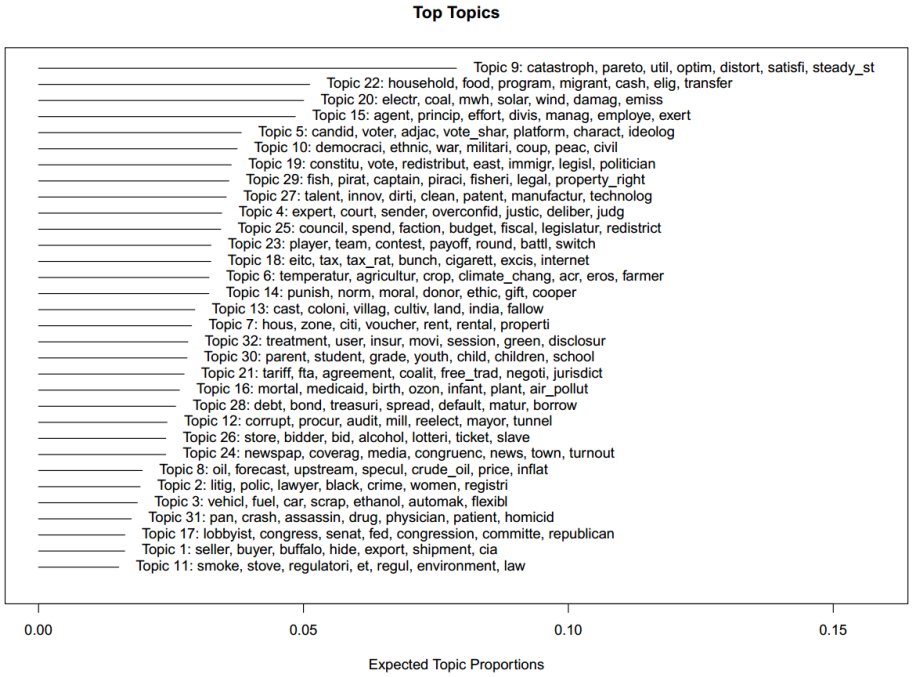
Topic Proportions and Top FREX Terms for Model with K = 16



Topic Proportions and Top FREX Terms for Model with K = 24



Topic Proportions and Top FREX Terms for Model with K = 32



12 Appendix 5: Highest Probability Terms per Topic

Topic	Type	Top Words	Topic Name
Topic 1	Hi p	seller, buyer, trade, price, relationship, export, hide	Trade
	FREX	seller, buffalo, buyer, hide, export, shipment, cia	
	Lift	ball, buffalo, leather, cia, seller, hide, shipment	
	Score	ball, seller, buffalo, buyer, shipment, cia, hide	
Topic 2	Hi p	black, polic, gender, race, citi, offic, perform	Race & Gender
	FREX	polic, black, litig, lawyer, registri, victim, racial	
	Lift	professor, registri, victim, lawyer, litig, bone, racial	
	Score	professor, client, polic, registri, lawyer, racial, litig	
Topic 3	Hi p	fuel, vehicl, price, energi, standard, carbon, cost	Fuel Standards
	FREX	fuel, automak, carbon, ethanol, flexibl, cafe, scrap	
	Lift	cafe, automak, ethanol, loophol, fuel, mpg, carbon_emiss	
	Score	automak, fuel, cafe, carbon, ethanol, vehicl, mpg	
Topic 4	Hi p	inform, type, citizen, signal, prefer, match, media	Information
	FREX	citizen, sender, signal, talk, cheap, ruler, media	
	Lift	censorship, chakraborti, razin, sender, pander, ruler, kamenica	
	Score	censorship, pander, sender, posterior, citizen, ruler, media	
Topic 5	Hi p	candid, voter, vote, parti, elect, inform, polici	Voting
	FREX	candid, voter, poll, vote_shar, adjac, charact, platform	
	Lift	punch, valenc, precinct, rational_vot, sincere_vot, voter_prefer, didat	
	Score	voter, vote, elect, vote_shar, candid, punch, valenc	
Topic 6	Hi p	counti, temperatur, agricultur, climate_chang, land, impact, state	Climate Change
	FREX	temperatur, eros, climate_chang, crop, acr, ogallala, parcel	
	Lift	ogallala, hydropow, electrif, demarc, farmland, dust, deschên	
	Score	ogallala, temperatur, acr, farmland, counti, climate_chang, parcel	
Topic 7	Hi p	hous, rent, control, properti, price, unit, build	Housing
	FREX	zone, hous, voucher, rent, rental, properti, residenti	
	Lift	voucher, geocod, shale, rental, msa, zone, renter	
	Score	voucher, shale, msa, rental, residenti, zone, hous	
Topic 8	Hi p	firm, price, condit, good, term, capit, competit	Money
	FREX	jurisdict, deposit, downstream, upstream, valuat, competit, capit	
	Lift	sticki, upstream, perfect_competit, weyl, downstream, deposit, oligopoli	
	Score	sticki, upstream, downstream, firm, deposit, jurisdict, dic	
Topic 9	Hi p	tax, optim, individu, incom, welfar, type, polici	Taxes & Redistribution
	FREX	catastroph, avert, optimal_tax, taxat, income_tax, redistribut, distort	
	Lift	avert, welfarist, boadway, kaplow, catastroph, optimal_tax, mirrle	
	Score	avert, catastroph, optimal_tax, tax_rat, profess, tag, income_tax	
Topic 10	Hi p	ethnic, countri, group, inequ, cultur, coloni, measur	Segregation & Inequality
	FREX	ethnic, coloni, segreg, cultur, gini, chief, africa	
	Lift	homeland, precoloni, linguist, gini, conquest, giuliano, ethnic	
	Score	homeland, ethnic, segreg, coloni, gini, linguist, sierra	
Topic 11	Hi p	qualiti, law, public, smoke, stove, regul, environment	Smoking Regulations
	FREX	stove, smoke, et, regulatori, disclosur, certifi, qualiti	

Topic	Type	Top Words	Topic Name
	Lift	et, stove, indoor, venu, smoke, restaur, smoker	
	Score	et, stove, smoke, smoker, indoor, certifi, meal	
Topic 12	Hi p	firm, corrupt, project, procur, small, bid, bidder	Public Expenditure
	FREX	procur, bidder, bid, corrupt, audit, tunnel, auction	
	Lift	tunnel, bidder, procur, stratum, seal, bid, overreport	
	Score	tunnel, bidder, procur, corrupt, auction, mayor, villag	
Topic 13	Hi p	land, villag, cast, water, level, agricultur, district	Land Use
	FREX	cast, cultiv, villag, land, farm, fallow, water	
	Lift	punjab, fallow, bengal, landless, canal, pradesh, tube	
	Score	villag, punjab, fallow, land, groundwat, cultiv, irrig	
Topic 14	Hi p	social, contribut, group, experi, punish, incent, behavior	Public Good Contribution
	FREX	punish, moral, ethic, cooper, norm, social, contribut	
	Lift	gächter, antisoci, wikipedia, kosfeld, guilt, herrmann, fehr	
	Score	wikipedia, punish, gächter, guilt, fehr, leader, moral	
Topic 15	Hi p	agent, contract, project, effort, action, incent, cost	Contract Theory
	FREX	agent, princip, exert, action, contract, effort, project	
	Lift	undesir, privaci, optimal_contract, undetect, englmaier, tournament, friday	
	Score	undesir, agent, privaci, payoff, optimal_contract, contract, reciproc	
Topic 16	Hi p	plant, counti, pollut, open, birth, level, air_pollut	Air Pollution
	FREX	metro, air_pollut, plant, birth, pollut, open, toll	
	Lift	zpass, birthweight, plaza, tsp, toll, cod, metro	
	Score	air_pollut, pollut, birthweight, zpass, metro, nonattain, plant	
Topic 17	Hi p	congress, inflat, lobbyist, politician, polit, committe, polici	Lobbying
	FREX	lobbyist, inflat, congress, fed, forecast, senat, committe	
	Lift	lobbyist, pac, transcript, earmark, inflat, chair, gorodnichenko	
	Score	lobbyist, republican, campaign_contribut, inflat, politician, monetary_polici, congress	
Topic 18	Hi p	tax, state, price, sale, incom, tax_rat, eitc	Cigarette Tax
	FREX	eitc, cigarett, excis, tax, tax_rat, bunch, kink	
	Lift	litter, mansion, filer, eitc, notch, excis, tax_avoid	
	Score	eitc, cigarett, litter, tax, notch, tax_rat, filer	
Topic 19	Hi p	vote, incom, democrat, constitu, republican, polit, legisl	Elections
	FREX	constitu, republican, vote, ideolog, overconfid, democrat, conserv	
	Lift	tercil, overconfid, canton, omnibus, postal, daughter, reproduct	
	Score	vote, tercil, republican, democrat, overconfid, constitu, ideolog	
Topic 20	Hi p	electr, cost, regul, generat, emiss, price, plant	Renewable Energy
	FREX	electr, mwh, solar, coal, wind, natural_ga, shortag	
	Lift	turbin, mwh, outag, divestitur, divest, intermitt, megawatt	
	Score	emiss, mwh, turbin, wind, outag, divest, electr	
Topic 21	Hi p	tariff, agreement, trade, countri, coalit, industri, region	Free Trade
	FREX	fta, agreement, free_trad, coalit, tariff, negoti, bargain	
	Lift	celik, fta, conconi, free_trad, bagwel, capital_mobl, treati	
	Score	fta, tariff, free_trad, celik, coalit, carbon, abat	
Topic 22	Hi p	household, program, incom, transfer, control, food, treatment	Household Income
	FREX	household, food, migrant, transfer, cash, progresa, pension	

Topic	Type	Top Words	Topic Name
	Lift	fetch, progresa, nonfood, oportunidad, skoufia, angelucci, obes	
	Score	household, villag, progresa, migrant, fetch, pension, children	
Topic 23	Hi p	player, round, team, game, payoff, conflict, group	Games
	FREX	player, team, contest, round, battl, switch, conflict	
	Lift	battl, intergroup, player, contest, schell, token, team	
	Score	battl, player, contest, payoff, team, session, round	
Topic 24	Hi p	newspap, media, elect, coverag, news, polit, advertis	Media
	FREX	newspap, berlusconi, coverag, media, advertis, congruenc, news	
	Lift	spanish, berlusconi, readership, newspap, viewer, slant, harsh	
	Score	spanish, berlusconi, congruenc, newspap, turnout, media, slant	
Topic 25	Hi p	district, state, spend, local, municip, govern, council	Local Government
	FREX	council, faction, municip, spend, district, redistrict, mayor	
	Lift	faction, redistrict, sunni, slice, counterinsurg, council, walli	
	Score	faction, redistrict, district, mayor, municip, council, rebel	
Topic 26	Hi p	store, sale, state, price, lotteri, win, alcohol	Lotteries & Alcohol
	FREX	store, alcohol, ticket, lotteri, retail, sale, zip	
	Lift	addict, store, alcohol, liquor, kearney, bottl, ticket	
	Score	addict, store, ticket, lotteri, alcohol, zip, liquor	
Topic 27	Hi p	product, countri, sector, industri, agricultur, firm, trade	Economic Productivity
	FREX	manufactur, sector, agricultur, industri, product, international_trad, countri	
	Lift	deterg, waugh, fdi, naic, manufactur, predat, multin	
	Score	deterg, tariff, agricultur, sector, manufactur, international_trad, unskil	
Topic 28	Hi p	debt, term, state, bond, period, spread, long	Public Debt
	FREX	debt, treasuri, bond, spread, matur, default, investor	
	Lift	treasuri, debt, labor_tax, government_debt, illiquid, sargent, matur	
	Score	treasuri, debt, bond, capital_tax, default, investor, government_debt	
Topic 29	Hi p	law, system, institut, fish, state, govern, legal	Fisheries & Law
	FREX	fish, pirat, captain, piraci, fisheri, crew, vessel	
	Lift	captain, piraci, pirat, crew, vessel, fishermen, open_access	
	Score	captain, pirat, fish, piraci, crew, vessel, fishermen	
Topic 30	Hi p	school, student, children, child, score, parent, educ	Child Welfare
	FREX	student, grade, orlean, school, enrol, attend, child	
	Lift	rita, parish, compass, orlean, aci, tertiari, grade	
	Score	rita, children, cct, child, katrina, student, grade	
Topic 31	Hi p	state, budget, drive, time, spend, level, incent	Incentive Policies
	FREX	budget, crash, drive, donor, fiscal, host, spring	
	Lift	crash, plantat, forget, sleep, fatal, stimulus, spring	
	Score	crash, donor, panchayat, sleep, plantat, blood, flyer	
Topic 32	Hi p	treatment, rate, insur, mortal, medicaid, inform, figur	Medicaid
	FREX	medicaid, afdc, mortal, insur, user, movi, nonwhit	
	Lift	movi, afdc, medicaid, nonwhit, info, medicar, gujarat	
	Score	movi, medicaid, afdc, mortal, nonwhit, copyright, stamp	
Topic 33	Hi p	manag, firm, divis, inform, organ, incent, employe	Firms
	FREX	physician, organiz, divis, manag, employe, patient, decentr	
	Lift	physician, synergi, division, garicano, boss, steen, raith	

Topic	Type	Top Words	Topic Name
	Score	physician, organiz, dessein, synergi, patient, garicano, boss	
Topic 34	Hi p	vehicl, emiss, program, ozon, cost, test, car	Vehicle Emissions
	FREX	ozon, vehicl, nox, mexico, smog, facil, car	
	Lift	vmt, smog, ozon, voc, psi, inland, vin	
	Score	emiss, ozon, vehicl, vmt, nox, smog, voc	
Topic 35	Hi p	wage, worker, citi, skill, product, condit, popul	Urban Employment
	FREX	worker, talent, wage, skill, occup, fertil, citi	
	Lift	squatter, demographic_transit, talent, evict, uneduc, longev, oligopolist	
	Score	squatter, talent, worker, fertil, citi, uneduc, skill	
Topic 36	Hi p	vote, court, inform, probabl, polici, decis, judg	Decision Making
	FREX	court, deliber, justic, judg, bureaucrat, plaintiff, committe	
	Lift	plaintiff, elster, stated_prefer, uphold, referenda, deliber, piv	
	Score	plaintiff, vote, elster, court, copyright, voting_rul, justic	
Topic 37	Hi p	state, polit, institut, democraci, public_good, assumpt, proposit	Political Power
	FREX	militari, tabellini, elit, coup, repress, democraci, public_good	
	Lift	tabellini, oligarchi, nondemocraci, winning_coalit, repress, coup, soldier	
	Score	tabellini, coup, repress, elit, democraci, militari, winning_coalit	
Topic 38	Hi p	elect, polit, politician, women, level, district, state	Gender & Politics
	FREX	reelect, drug, pan, women, victori, mill, slave	
	Lift	cane, traffick, homicid, pan, holdout, emancip, confisc	
	Score	cane, elect, reelect, women, slave, traffick, pan	
Topic 39	Hi p	price, oil, market, farmer, shock, energi, demand	Oil Prices
	FREX	oil, farmer, specul, crude_oil, phone, crise, kilian	
	Lift	niger, kilian, crude_oil, pineappl, soybean, hub, freight	
	Score	oil, niger, farmer, crude_oil, kilian, pineappl, soybean	
Topic 40	Hi p	condit, prefer, term, choic, time, individu, consumpt	Collective Decisions
	FREX	youth, utility_funct, collect, choic, unitari, pareto, identif	
	Lift	garp, misconcept, unitari, youth, dictatori, matric, public_consumpt	
	Score	garp, youth, unitari, parent, pareto, misconcept, consumpt	
Topic 41	Hi p	countri, war, conflict, democraci, democrat, resourc, civil	War & Conflict
	FREX	war, civil, assassin, autocraci, peac, democraci, natural_resourc	
	Lift	gleditsch, assassin, prio, angola, blattman, torvik, autocraci	
	Score	assassin, war, democraci, autocraci, democrat, peac, oil	
Topic 42	Hi p	technolog, innov, clean, dirti, price, polici, patent	Tech & Innovation
	FREX	dirti, patent, clean, innov, inventor, invent, tech	
	Lift	inventor, dirti, invent, patent, carbon_tax, pizer, newel	
	Score	inventor, dirti, emiss, patent, carbon_tax, invent, fossil_fuel	

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14 Declaration

I hereby declare that the present thesis has not been submitted as a part of any other examination procedure and has been independently written. All passages, including those from the internet, which were used directly or in modified form, especially those sources using text, graphs, charts or pictures, are indicated as such. I realize that an infringement of these principles which would amount to either an attempt of deception or deceit will lead to the institution of proceedings against myself.

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