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Article

Deep Journalism and DeepJournal V1.0: A Data-Driven Deep Learning Approach to Discover Parameters for Transportation (As A Case Study)

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Abstract: We live in a complex world characterised by complex people, complex times, and complex social, technological, and ecological environments. There is clear evidence that governments are failing at most public matters. The recent COVID-19 pandemic is a high example of global governance failure both at preventing such pandemics and managing the COVID-19 pandemic. It is time that all of us take responsibility and look into ways of collaboratively improving the governance of public matters, our matters. While there are many reasons for government failures, we believe the lack of information availability is a fundamental reason that limits the government's ability to act smartly and allows the lack of transparency to creep into policy and action leading to corruption and failure. To this end, this paper introduces the concept of deep journalism, a data-driven deep learning-based approach for discovering multi-perspective parameters related to a topic of interest. We build three datasets (a newspaper, a technology magazine, and a Web of Science dataset) and discover the academic, industrial, public, governance, and political parameters for the transportation sector as a case study to introduce deep journalism and our tool DeepJournal (Version 1.0) that implements our proposed approach. We elaborate on 89 transportation parameters and hundreds of dimensions reviewing 400 technical, academic, and news articles. The findings related to the multi-perspective view of transportation reported in this paper show that there are many important problems seen by the public that industry and academia seem to not place their focus on. On the other hand, academia produces much broader and deeper knowledge on the subject such as a wide range of pollutions affecting the people and planet do not get to reach the public eye. Our deep journalism approach could find the gaps and highlight them to the public and other stakeholders.

Keywords: Natural language processing (NLP); topic modelling; BERT; transportation; newspaper; magazine; academic research; journalism; deep learning; smart cities

1. Introduction

1.1. A Complex World, Governance Failures, and Deep Journalism

We live in a complex world characterised by complex people, complex times, and complex social and technological environments. Because this was not enough, with our complex activities, we have created complex effects on our ecological environment. This is not an easy time for our governments to govern public matters, matters that affect our social, economic, and environmental sustainability. There is clear evidence that governments are failing at most public matters, education, healthcare, public safety, and the list goes on [1–9]. The recent COVID-19 pandemic is a high example of global governance failure both at preventing such pandemics (caused by the effects of our lifestyles, processed food we eat, and other activities that damage our planet's environment) and managing the COVID-19

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pandemic [10–15]. Governments are elected by people and in a way, government failure actually is also considered a failure by the public. It is time that we take responsibility for both success and failure, and look into ways of collaboratively improving the governance of public matters, our matters.

While there are many reasons for government failures, we believe the lack of information availability is a fundamental reason that limits government ability to act smartly and allows the lack of transparency to creep into policy and action leading to corruption and failure. While sincerity and intention of people involved could be a major cause for shortcomings in any institution or system, particularly large-scale public institutions and systems, practical efforts can be made to reduce silos and segmentations, and bridge the gaps that exist in the information and knowledge available to various communities working in different sections of a sector through direct or indirect cross-sectional conversations and collaborations enabled through automated and autonomous technologies such as deep learning, big data analytics, and others.

To this end, this paper introduces the concept of deep journalism, a data-driven deep learning-based approach for discovering multi-perspective parameters related to a topic of interest. We discover the academic, industrial, public, governance, and political parameters for the transportation sector as a case study to introduce deep journalism and our tool DeepJournal (Version 1.0) that implements our proposed approach. The concept of deep journalism will be illustrated in the rest of this section (and this paper) as we introduce the challenges facing the transportation sector and our work on detecting parameters for it as viewed by the public, governments, industry, and academia. The production and distribution of multi-perspective parameters are expected to provide a holistic and multi-perspective view of a sector and help bridge the knowledge and collaboration gaps that exist to reduce inefficiencies and failures.

1.2. Transportation and Challenges

Transportation is fundamental to modern societies and economies. However, human and goods transportation is a grand challenge considering the many issues that this sector faces and the design parameters that need considering in developing successful policies, systems, and operations for transportation. The issues facing transportation include the safety of people and goods, rising costs, growth of megacities, long commutes for work, parking problems, damages to health and the planet, and more.

Several modes of transportation exist, road, rail, air, and marine transportation, each with its own challenges. Road transportation is considered the backbone of modern economies albeit it costs globally over one million deaths and 50 million human injuries annually [16]. Rail transport requires huge capital investments and thereby is subject to monopolies, is relatively inflexible in terms of adjustments to individual passenger needs, cannot be moved around such as a bus, may run underutilised in different times and situations (such as during the recent COVID-19 pandemic), heavy-utilised trains are prone to frequent faults [17], cancellations [18,19] and accidents [20–22], etc [23]. Air transportation faces many challenges including pollution [24,25], high costs [26], high safety [27,28] and security risks [29,30], huge capital investments, fuel requirements [31], and others. Marine transportation also faces many challenges such as pollution, security risks [32–34], increasing costs, and environmental regulations [35,36]. These challenges are threatening the sustainability of our societies, economies, and our planet.

There is a need for innovative approaches based on collaborative thinking enabled through the availability of integrated information. Academia is not being used to its full potential [37]. What is possible in terms of technology and the potential of academia and people is not being matched with what is being done. Policy and action need to work together through dialogue and information availability to all bodies working in the transportation sector, the government, industry, academia, journalists, and the public. Deep Journalism could provide a solution.

1.3. Summary of the Proposed Work

In this work, we bring together a range of deep learning, big data, and other technologies to discover transportation parameters from three different perspectives using three different types of data sources, viz. a newspaper (The Guardian), a transportation technology magazine (Traffic Technology International), and academic literature on transportation (from Web of Science). The three types of data sources provide three different views of the transportation domain, that is, a view as seen by the public and governed by the political and other institutions, a second view from the transportation industry, and a third view as seen by the academics and researchers. Certainly, these views are not entirely mutually exclusive and are affected by each other to some extent but do represent different perspectives with considerable differences. We call this approach Deep Journalism for two reasons. Firstly, we call it deep in the actual sense of the word because it allows capturing and reporting a relatively deeper view of a topic (e.g., transportation) from multiple perspectives, dimensions, stakeholders, and depths. Secondly, we use deep learning to automatically discover multi-perspective parameters about a topic.

The newspaper dataset that we built to discover parameters for public, governance, and political aspects of transportation is collected from a UK-based newspaper, The Guardian. We collected all the articles from the Guardian newspaper that contain the word "transport" (in the title of the news, the full text of the news article, or the meta-information about the article) and found a total of 14,381 unique articles dated between September 1825 [38] and January 2022 [39]. We discovered a total of 25 parameters from the Guardian dataset and grouped them into six macro-parameters, namely Road Transport; Rail Transport; Air Transport; Crash & Safety; Disruptions & Causes; and Employment Rights, Disputes, & Strikes.

The industry and technology magazine dataset that we built to discover parameters about industrial aspects of transportation is collected from a technology-focussed magazine, Traffic Technology International (TTI), a popular magazine reporting the latest transport technologies and news. We collected all the articles, a total of 5,193 articles dated between February 2015 [40] and January 2022 [41], from the magazine website without any filters or search queries because this magazine only covers transportation-related news. We discovered a total of 15 parameters from the TTI dataset and grouped them into five macro-parameters, namely Industry, Innovation, & Leadership; Autonomous & Connected Vehicles; Sustainability; Mobility Services; and Infrastructure.

The academic-view dataset that we built to discover parameters for the academia-focussed aspects of transportation is collected from an academic database, Web of Science. We collected in aggregate 21,446 research article abstracts (with titles and keywords) in the English language only from about 20 categories of academic disciplines in Web of Science, such as transportation science and technology, engineering, environmental science, telecommunications, economics, computer science, business, and others. The collected article abstracts were limited to the publishing years 2000 [42] to 2022 [43]. We discovered 49 transportation parameters from the academic dataset and grouped them into six macro-parameters. These are Policy, Planning & Sustainability; Transportation Modes; Logistics & SCM; Pollution; Technologies; and Modelling.

We implement the proposed Deep Journalism approach into a tool called DeepJournal (Version 1.0). The tool is able to discover transportation parameters using the datasets described above. The tool comprises four software components; Data Collection & Storage, Data Pre-Processing, Parameter Modelling & Discovery, and Validation & Visualization. The three datasets are collected using web scraping and other techniques and are pre-processed to remove duplicate and irrelevant data, tokenize data, clean up the data, and lemmatize data to generate data in a form that can be processed by the deep learning processing engine. We use a pre-trained BERT (Bidirectional Encoder Representations from Transformers) word embedding model [44] to capture the contextual relations within the data. The BERT model is used along with UMAP (Uniform Manifold Approximation and Projection) [45] (a dimension reduction technique), HDBSCAN (Hierarchical Density-

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Based Spatial Clustering of Applications with Noise) [46] (a clustering algorithm), and a class-based TF-IDF (Term Frequency-Inverse Document Frequency) score, to automatically group documents in the datasets into document clusters.

Subsequently, we discover transportation parameters and macro-parameters from each dataset using the document clusters along with the domain knowledge and a range of quantitative analysis methods performed on the clustered data including similarity metrics [47], hierarchical clustering [48], term score [49], keyword score [50], and intertopic distance map [51]. A range of visualization methods are used to elaborate on the datasets, document clusters, and the discovered parameters. These include dataset histograms [52], taxonomies, similarity matrices [53], temporal progression plots, word clouds, and others. Multiple taxonomies of transportation from public, industry, and academic views are extracted using automatic clustering of datasets. Figure 1 depicts a high-level combined multi-perspective taxonomy of transportation as viewed by the public, industry, and academia. The first and second level branches in the figure show the discovered macro-parameters and parameters, respectively.

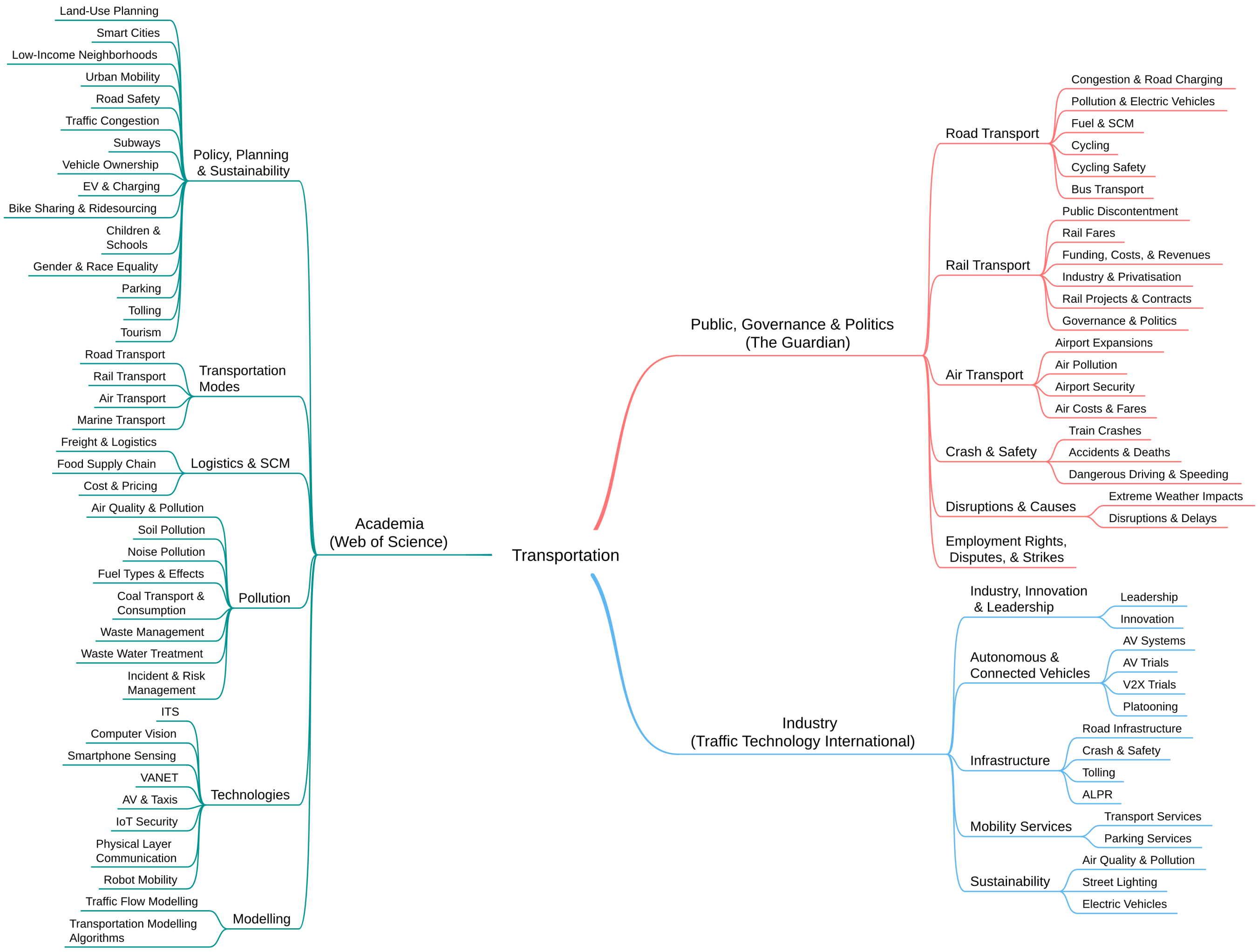

Figure 1. A Multi-Perspective Taxonomy of Transportation

The findings related to a multi-perspective view (public, governance, political, industry, and academia) of transportation show that there are many important problems such as transportation operations and public satisfaction that industry and academia seem to not place their focus on or perhaps if they do the solutions do not get to reach the highlights by the policymakers and industrialists. We can also see that academia produces much broader and deeper knowledge on the subject while many important issues such as a wide

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range of pollutions affecting the people and planet do not get to reach the public eye. Our deep journalism approach could find the gaps and highlight them to the public and other stakeholders.

The validation of our results can be considered internal or external. The internal validation is performed by investigating whether the articles and documents belonging to a certain parameter are related to the parameter. We have provided discussions on many articles in each dataset as to how those articles relate to the parameters. The external validation is performed by comparing parameters, keywords, and quantitative metrics across the three datasets (i.e., the three perspectives of transportation). The external validation is also performed by using sources other than the three dataset sources. Moreover, both the internal and external validation is performed using the depictions produced by various visualization methods.

Further details on the methodology and design of our Deep Journalism approach and the DeepJournal tool are presented in Section 3.

1.4. Broader Aim, Novelty and Contributions

The broader aim of our work is to investigate the use of ICT technologies for solving pressing problems in smart cities and societies. Specifically, in this paper, we investigate the use of deep learning and digital methods to discover and analyse cross-sectional multi-perspective information to enable better decision making and develop better instruments for academic, corporate, national and international governance. The contributions of this paper can be summarised as follows.

1. We investigate the use of deep learning and big data analytics methods in transportation and show that important parameters related to the design and operations, and the broader environmental parameters, can be automatically discovered using cutting-edge technologies. The parameters can be discovered from multiple perspectives involving specific foci, stakeholders, etc. The transportation sector is used as a case study and the approach can be applied to other sectors. Important parameters and insights are reported and explained.
2. We discover 25 parameters and six macro-parameters for transportation from the public, governance, and political perspectives using a newspaper, The Guardian.
3. We discover 15 parameters and five macro-parameters for transportation from an industrial perspective using a transportation magazine, Traffic Technology International (TTI).
4. We discover 49 parameters and six macro-parameters for transportation from an academic perspective using the well-known database of scientific literature, Web of Science.
5. We built three datasets specifically for the work presented in this paper. These datasets will be provided openly to the community for further research and development.
6. We brought the three analytics from multiple perspectives together, and introduced and investigated the novel concept of Deep Journalism that could be applied to any problem, sector, or domain.
7. We developed a complete big data analytics tool, DeepJournal Version 1.0, from scratch for this purpose. The tool is general and can be used on other datasets and sectors.
8. We elaborated on 89 transportation parameters and hundreds of dimensions reviewing 400 technical, academic, and news articles.

The literature review (Section 2) establishes that this work is novel in several respects, the proposed scheme of deep journalism, the developed digital methods and tools for the purpose, the use of three (or more) data sources to create a multi-perspective view of the transportation sector, the three datasets, the specific findings, and more.

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1.5. Software and Hardware

The work reported in this paper was developed on the Aziz supercomputer that comprises a total of 500 CPU, GPU, and Intel MIC nodes. In addition, we also used Google Colab to run some experiments. Specifically, we used an Nvidia V100 GPU with 32GB RAM, which combines 5120 CUDA cores and 640 Tensor cores for deep learning and other HPC loads. The V100 has a double performance of 7.066 TFLOPS and a single performance of 14.13 TFLOPS. The software and platforms used in this work include Python as the programming language, along with Pandas [54], Numpy [55], BERTopic [56], NLTK [57], Scikit-Learn [58], Gensim [59], SentenceTransformer, and PyTorch [60]. The data visualisation libraries used in this work include Seaborn [61], Plotly [62], and Matplotlib [63].
Section Organisation

The rest of the paper is structured as follows. Section 2 reviews the related works and establishes the research gap. Section 3 describes the deep journalism methodology and the design of our tool. Section 4 introduces and discusses the parameters for Public, Governance & Politics. Section 5, and 6 discuss the parameters for industry, and academia, respectively. Section 7 provides discussion. Section 8 concludes and gives directions for future work.

2. Literature Review

We discuss in this section the works related to the proposed work in this paper. We conducted an extensive review of academic research on the use of artificial intelligence (AI) and data analytics for transportation. We did not find any work directly related to our paper. However, to place our work in the context of the overall body of works on data analytics in transportation, we review works in three areas. Firstly, we discuss studies related to the use of AI and machine learning for transportation. Subsequently, we review research works that analyse and detect transport-related events by using social media data. Finally, we discuss works on the scientometric analysis of the general transportation literature, including scientometric analysis studies on specific areas of transportation.

Researchers have used machine learning for different problems in transportation. For example, a large body of works on the use of deep learning is in object detection, environment perception, health effect, resilience in transport, etc [64]. For example, Wang et al. [65] proposed a model MobileNetv1_yolov3lite to detect objects and speed in real-time, Zhu et al. [66] presented an overview of datasets, evaluation criteria, and future work on environment perception, i.e., vehicle tracking, scene understanding, traffic sign detection, lane and road detection, etc. for intelligent vehicles. Deep learning has also been used for many transport modelling problems including collaborative decision making for environment perception [67], incident detection [68], disaster management [69], rapid transit systems for megacities [70], and traffic flow modelling [71]. Some other research works are on traffic flow prediction [72], autonomous vehicles [73], vehicular networking [74], automatic license plate recognition [75], crash prediction [76], and others.

Researchers have also used various social media data to analyse and detect different events to discover and solve transportation issues. For example, Alomari et al. [77] used a tool and machine learning algorithms for traffic event detection by using a total of 2,511,000 tweets, and transportation-related concerns detection during the COVID-19 pandemic [78]. Later, in another study, they [16] used 33.5 million tweets for event detection and road traffic social sensing by using distributed machine learning algorithms. Their research demonstrated Twitter's efficacy in spotting big occurrences without previous information. Suma et al. used a big data tool for automatic event detection [79] from Twitter data and also used apache spark to automatically detect and validate the events [80]. Traffic incident detection is another challenge for the transportation system. Zhang [81] proposed LDA and a clustering-based algorithm to detect traffic incidents by using the Twitter dataset. They used the Carlo K-test to validate their research outcomes. There is other research on using social media datasets for various topics in transportation, such as transportation planning and management, the traffic monitoring system, traffic event detection, etc. Wang

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et al. [82] proposed a traffic management system (i.e., traffic alert and warning) using Twitter data and the LDA topic modelling algorithm. In 2020, a BERT-based automatic traffic alert system was developed by Wan et al. [83]. The authors used Twitter data to evaluate their system. Additionally, they implemented a question-answering model to extract the location, time, and nature of the traffic events.

The works that can be considered more related to this paper are those where researchers have used scientometric analysis for transportation-related topics. For example, Heilig et al. [84] used scientometric analysis to perform a study on academic research on public transportation, which offers a better knowledge of articles, authors, countries, and keywords based on citation information. They used 7,868 research articles with 160,132 references from 2009 to 2013. This is the only work that have looked into the transportation area as a whole. All others works on scientometric analysis have focussed on specific topics in transportation and these are discussed in the following paragraph.

Das et al. [85] analysed 15,357 paper abstracts from 7 years of Transportation Research Board (TRB) yearly meetings (2008–2014) by using LDA to show the research patterns and intriguing histories of transport research. Sun and Yin [86] proposed an LDA-based topic modelling approach to find the research topics and temporal information over the last 25 years of transportation. They collected transport-related abstracts of 17,163 articles from 22 journals between 1990 and 2015 and applied LDA to discover 50 key academic research topics. In 2021, Putri et al. [87] proposed a systematic review of ITS by using the LDA and named entity recognition. They retrieved 23,823 titles and abstracts from the Scopus database between 1974 and 2020. Their research findings include the evolution of ITS development and related research areas. There is some other research work that has been done on several transport-related topics. For example, road safety is a significant component of the transportation system. Zou et al. [88] presented a scientometric analysis to reveal the core research area of road safety. The authors found that road safety studies mostly focused on driver psychological behaviour, prevention of traffic accidents, the impact of driver risk factors, and the analysis of the consequences and frequency of road crashes. In another research, Gao et al. [89] presented a scientometric analysis on traffic safety sign research from 1990 to 2019. The authors collected 3,102 articles from the Web of Science database and used Citespace to analyze and visualization of the research domain. They discovered that most of the research had been done in the last ten years. Their research also found that the United States is in the lead position in traffic sign research. AV is the most heavily researched topic to improve the transportation system. A scientometric analysis on autonomous vehicles was conducted by Faisal et al. [90]. They collected a total of 4,645 research articles between 1998 and 2017 to perform the scientometric analysis. Their research presented the development of AV systems by analyzing the authors, affiliations, citations, and publications in AV research.

2.1. Research Gap

The literature review shows that the existing research on the use of machine learning in transportation has mainly focused on autonomous vehicles, object detection, and others. There are some works on social media data analysis for detecting events in transportation. The very few works that have focused on scientometric analysis are very different from our work. We did not find any research papers that have used newspapers, transport magazines, and academic research articles altogether. Our work is novel in several respects, the proposed scheme of deep journalism, the developed digital methods and tools for the purpose, the use of three (or more) data sources to create a multi-perspective view of the transportation sector, the three datasets, the specific findings, and more.

3. DeepJournal V1.0: Methodology and Design

The proposed system methodology and design is depicted in Figure 2 to analyse contextual topics that discover the transportation issues, challenges, development, and future planning by using newspaper, magazine, and research article abstracts. The software architecture consists of four software components, which are described in the following subsections. The methodology overview, including the master algorithm, is provided in Section 3.1. In this research, we used three types of data sources named "The Guardian", "Traffic Technology International", and "Web of Science", which are summaries in Section 3.2. Sections 3.3, 3.4, and 3.5 discuss the data collection algorithm and description of the datasets. Sections 3.6, 3.7, 3.8 and 3.9 cover data pre-processing, parameter modelling, Parameter Discovery & Quantitative Analysis, and validation & visualization, respectively.

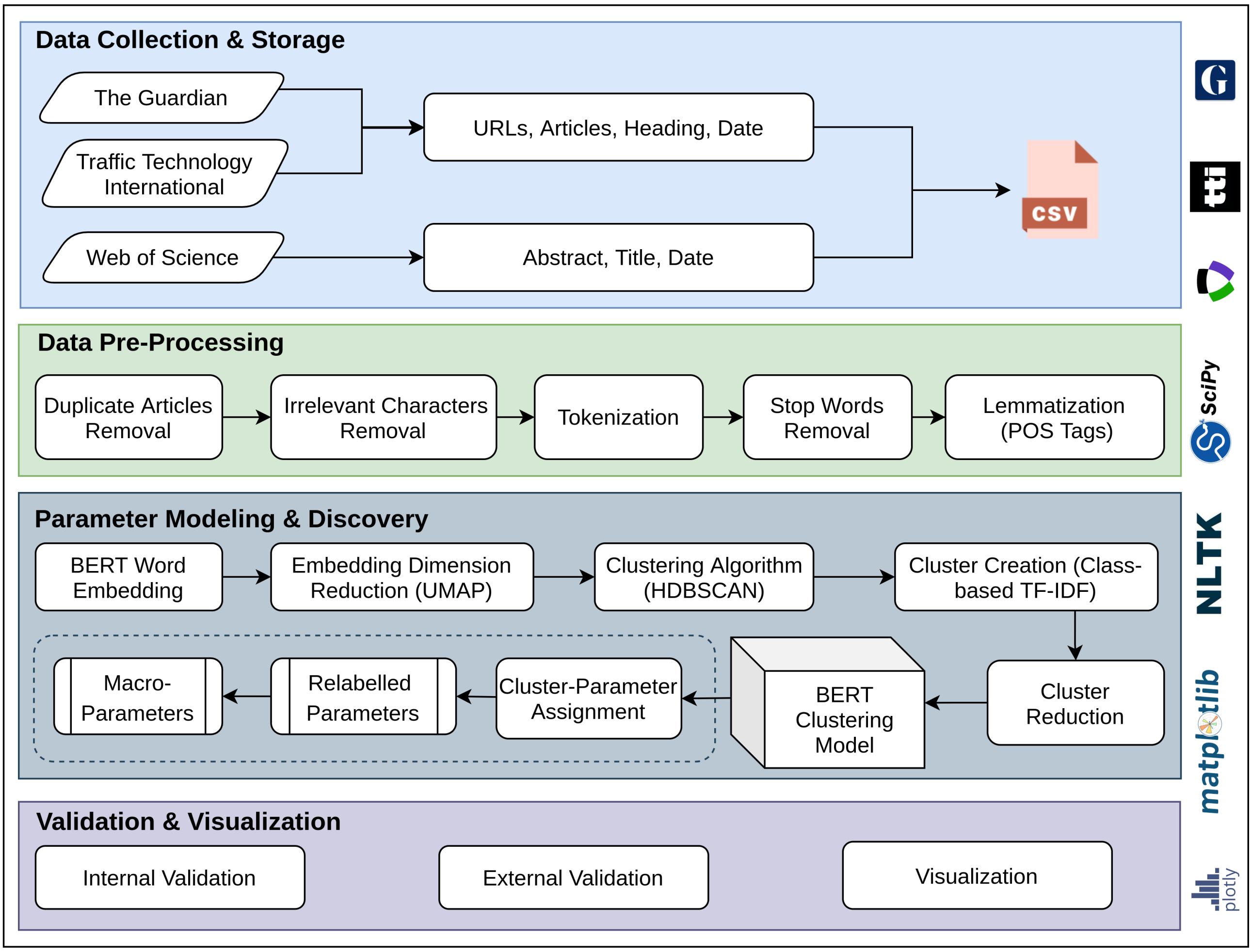

Figure 2. DeepJournal V1.0: The System Architecture

3.1. Methodology Overview

Algorithm 1 outlines the master algorithm where the inputs are the search queries and website URLs, which are needed for the data collection. The dataset was collected using the web scraping technique and stored in a CSV file. Then, the CSV file is loaded into the Pandas data frame and the articles are passed to the data pre-processing function, which removes duplicate articles, accomplishes tokenization, removes irrelevant characters and stop words from the articles, as well as performs lemmatization with allowed POS (Part-of-speech) tags, i.e., noun, adjective, verb, and adverb, and generates cleaned tokens. After that, a pre-trained BERT (Bidirectional Encoder Representations from Transformers) [44] word embedding model is used to capture the contextual relations between the words. Subsequently, we use the UMAP (Uniform Manifold Approximation and Projection) [45], which is a dimension reduction technique, HDBSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise) [46], which is a clustering algorithm, and a class-based TF-IDF (Term Frequency-Inverse Document Frequency) score to calculate the importance of words for each cluster. Additionally, we reduced the number of clusters by

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merging the most similar clusters. After that, we saved the clustering model and assigned the cluster to each article. Then, the clusters are relabelled as parameters, and further, the parameters are grouped into macro-parameters using the domain knowledge along with similarity matrix, hierarchical clustering, and other quantitative analysis methods. Finally, we visualised and validated the parameters against external and internal sources.

Algorithm 1 Master Algorithm

Input: *searchQuery, weblink*
Output: *article with lebelled parameter & visualization*

$CSV\_file \leftarrow dataCollection(searchQuery)$
$article\_DF \leftarrow read\_CSV(CSV\_file)$
$process\_artcle \leftarrow dataPreProcessing(article\_DF)$
$word\_embedding \leftarrow createBERT\_Embedding(process\_artcle)$
$umap\_embedding \leftarrow dimensionReduction(word\_embedding)$
$HDBSCAN\_clustering \leftarrow dimensionReduction(umap\_embedding)$
$calculate\_ClassTFIDF \leftarrow clustering(HDBSCAN\_clustering)$
$clusters \leftarrow clusterReduction(calculate\_ClassTFIDF)$
$model \leftarrow saveModel(BERTClusteringModel)$
$parameters \leftarrow relabelled(clusters)$
$parameter\_visualization(parameters)$

3.2. Data Collection

We have used three types of data sources in this research: The Guardian (newspaper), Traffic Technology International (magazine), and the Web of Science (academic research). We utilised web scraping techniques (i.e., Python, BeautifulSoup, Requests, and Pandas) to get the "The Guardian" and TTI datasets from their corresponding websites. We collected the Web of Science dataset from their website as they allow users to download the dataset as a CSV format. We discussed the data collection steps for the Guardian, Traffic Technology International and Web of Science in Sections 3.3, 3.4, and 3.5, respectively.

3.3. Dataset: Newspaper Articles (The Guardian)

The newspaper dataset was collected from the UK-based newspaper "The Guardian" from September 1825 to January 2022. We retrieved all transport-related articles from the website using the web scraping technique and collected about 14,855 articles.

Algorithm 2 shows the steps of the data collection process. Initially, we used "transport" keywords to search for the related articles on the website. After that, we passed the web link to the newspaper as a parameter in the algorithm. We divided our data collection methodology into two functions: article link collection and data collection. In the first function, after acquiring all the links from the web page content, we remove the irrelevant links and save the links as a data frame. In the data collection function, we analyse the HTML and JavaScript code to get the article, date, and headline from the web page content. For each news article, we acquired the related heading and publication date. We saved the data in a data frame and finally saved the data frame into a CSV file. After retrieving the articles, we encountered a few of duplicate articles. We eliminated all duplicate articles, resulting in 14,381 unique articles from the Guardian newspaper.

Algorithm 2 Data Collection (The Guardian)

Input: searchQuery, weblink
Output: CSV file

```
function ARTICLELINK(weblink)                     ▷ weblink: https://www.theguardian.com/uk/
    pages ← length(totalPage)                     ▷ total web page after searching
    for pageNumber ← 1 to pages do
        url ← weblink/transport?page=pageNumber
        content ← get content from URL
        links_DF ← save links as DataFrame from content    ▷ remove irrelevant links
    end for
end function
function DATACOLLECTION(links_DF)
    links ← length(links_DF)
    for pageNumber ← 1 to links do
        content ← get content from link
        article ← get article from content
        headline ← get headline from content
        date ← get publication date from content
        guardian_DF ← article, headline, date
        guardian_CSV ← guardian_DF
    end for
end function
```

Figure 3 shows the histogram of "The Guardian" news articles. The y-axis indicates the number of news articles for the increasing word count per news article. We noticed that the prevalence of news articles is 200–500 words. The number of news articles that contain more than 800 words is relatively small. The maximum number of words in a document is 8341. For more visual understanding, the zoomed portion inside the graph is shown. The figure also shows the density against the increasing number of words per news article. The maximum density is around 0.0016.

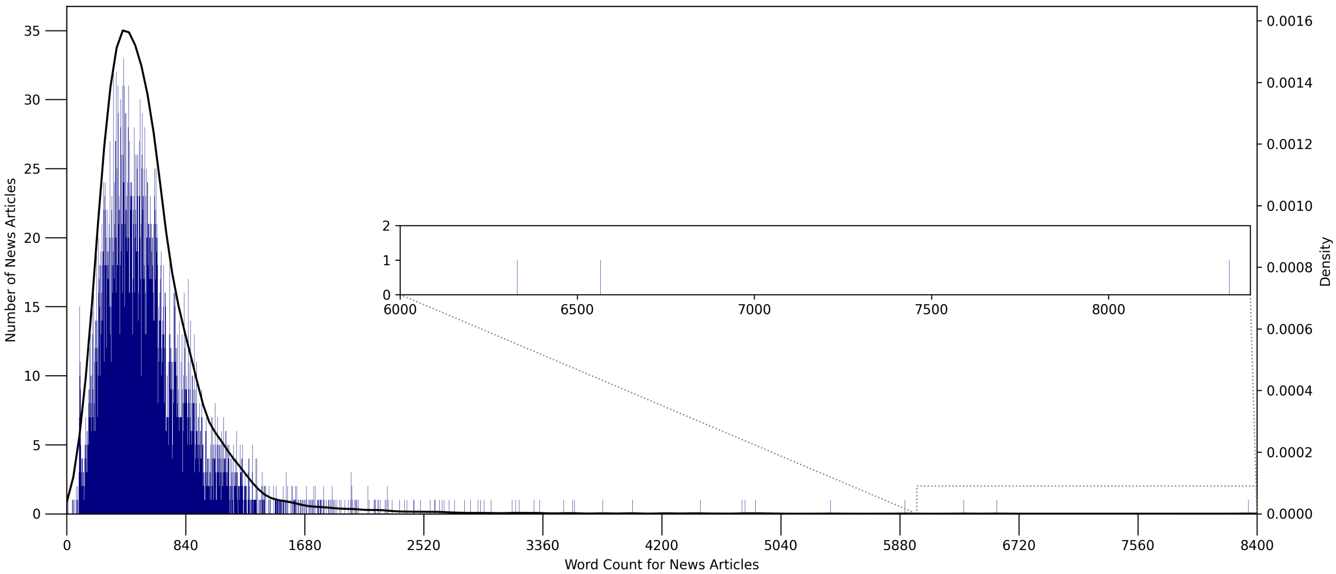

Figure 3. Histogram (The Guardian News Articles)

3.4. Dataset: Technology Magazine Articles (Traffic Technology International)

TTI stands for "Traffic Technology International", which is a popular magazine related to the latest transport technology. From February 2015 to January 2022, we gathered 10,620 articles from all categories on the TTI website using the web scraping approach.

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Algorithm 3 shows the steps of the data collection process. We divided the algorithm into two functions: article link collection and data collection. In the beginning, we passed the web link to the article link collection function. We used two loops, where the first loop is for the category list and the second loop is for the total web page number for each category. We used a dictionary-type variable to store the category as a key and the total web page number for that category as a value. After getting all the links from the web pages, we remove the irrelevant links and save the links as a data frame. In the data collection function, we analyse the HTML and JavaScript code to get the article, publication date, and headline from the web page content. For each news article, we received the related heading and publication date. We saved the data in a data frame and finally saved the data frame into a CSV file. After saving the data, we found a lot of duplicate data as some articles are common in multiple categories. So, we removed the duplicate articles from the dataset, and finally, we found 5,193 unique articles.

Algorithm 3 Data Collection (Traffic Technology International)

Input: weblink
Output: CSV file

```
function ARTICLELINK(weblink)    ▷ weblink: https://www.traffictechnologytoday.com/
    categoryList ← list of the category
    pagesDict ← dictionary type variable (key: category, value:pages number)
    for category ← 1 to length(categoryList) do
        for pageNumber ← 1 to pagesDict[categoryList[category]] do
            url ← weblink/news/categoryList[category]/page/pageNumber
            content ← get content from URL
            links_DF ← save links as DataFrame from content    ▷ remove irrelevant links
        end for
    end for
end function
function DATACOLLECTION(links_DF)
    links ← length(links_DF)
    for pageNumber ← 1 to links do
        content ← get content from link
        article ← get article from content
        headline ← get headline from content
        date ← get publication date from content
        TTI_DF ← article, headline, date
        TTI_CSV ← TTI_DF
    end for
end function
```

Figure 4 depicts the histogram of the "Traffic Technology International" magazine articles. The y-axis and x-axis demonstrate the number of magazine articles and the increasing word count for magazine articles, respectively. The majority of magazine articles are between 300 and 450 words long and 500 to 600 words long (see graph peaks).The number of news articles that contain more than 600 words is relatively small. The maximum number of words in a document is 2323. The magnified plot inside the figure is presented for the convenience of the reader. The graph also depicts the density in relation to the increasing quantity of words per magazine article. The highest density is around 0.005.

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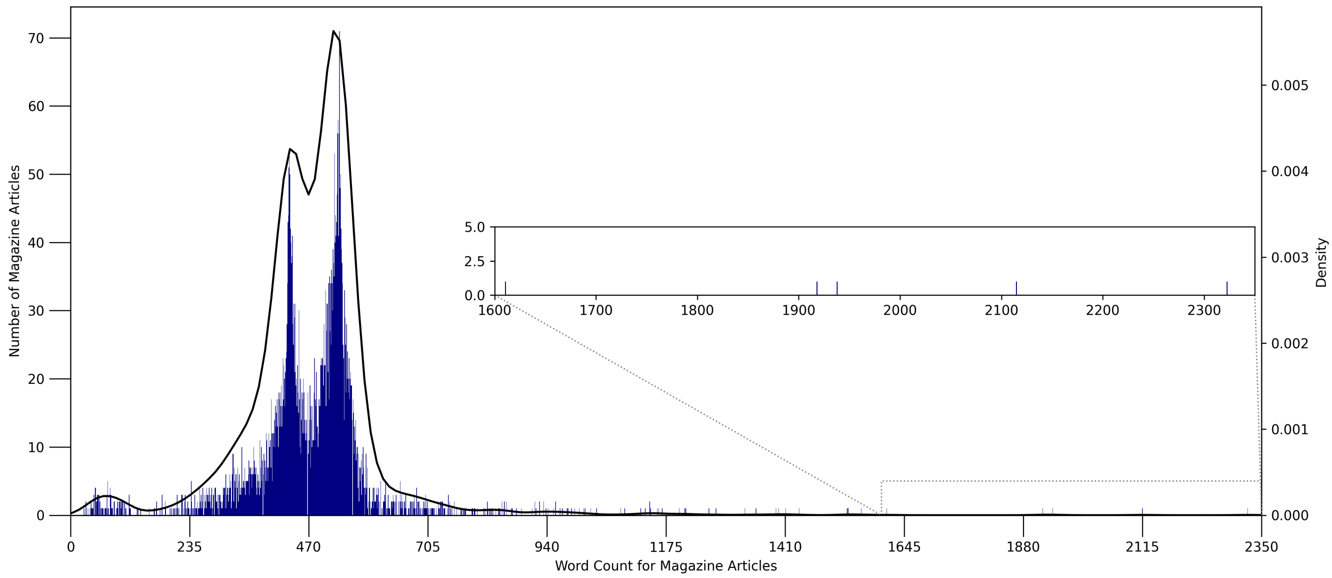

Figure 4. Histogram (Traffic Technology International Magazine Articles)

3.5. Dataset: Academic Articles (Web of Science)

We obtained the most pertinent documents from the Web of Science, the most comprehensive database with a consistent query language and data format. Furthermore, it facilitates access to subject indexes, citation indexes, and other databases from other disciplines, which assist in the discovery of relevant research and the evaluation of its findings. We collected 21,446 research articles by using "transportation" keyword from several Web of Science categories, for example, Transportation Science Technology, Engineering Electrical Electronics, Transportation, Environmental Science, Telecommunications, Economics, Computer Science Information System, Business, etc. The document type was limited to proceedings papers, articles, and review articles. Excluded were publications produced from news items, corrections, book chapters, data papers, book reviews, letters, editorial materials, and so on. Furthermore, we narrowed our search filtering option to the English language and the publishing years 2000–2022. In addition, we utilised advanced search and selected the "Topic Search" option, which yielded results from the title, abstract, and keywords columns.

Figure 5 illustrates the histogram of the Web of Science research article abstracts. The y-axis and x-axis show the number of article abstracts as well as the increasing word count for article abstracts. The majority of article abstracts contain between 150 and 250 words. A few article abstracts have more than 450 words. The number of article abstracts that contain more than 400 words is relatively small. The maximum number of words in an article abstract is 1132. The magnified plot inside the figure is presented for the convenience of the reader. The graph also shows the density in relation to the increasing quantity of words per article abstract. The highest density is around 0.006.

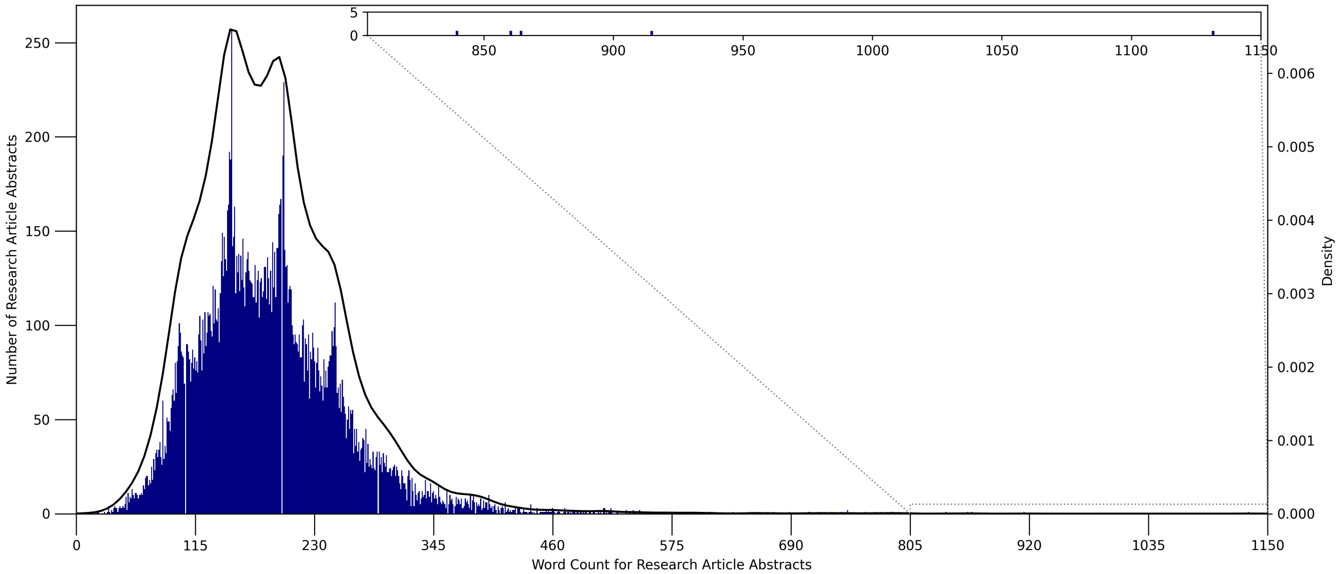

Figure 5. Histogram (Web of Science Article Abstracts)

3.6. Data Pre-Processing

We employed the same pre-processing algorithm for the three datasets. Algorithm 4 shows the pre-processing steps as follows: (1) remove duplicate articles, (2) remove irrelevant characters, (3) tokenization, (4) stop word removal, and (5) lemmatization with POS tags. In the beginning, we read the CSV file using the Python package "Pandas" and saved it as a data frame (DF). In the second step, we removed all duplicate data to reduce the data redundancy, and in the third step, we removed all irrelevant characters, for example, several Unicode characters, from the texts. Furthermore, in the fourth step, we tokenized the texts using the simple_preprocess function, which is included in the Python package called "gensim". The fifth step is to remove the stop words from the article. Initially, we used the NLTK pre-defined stop words list for clustering and implemented the BERT parameter model. After getting the parameter from the BERT parameter model, we reviewed the corresponding keywords and explored the unnecessary keywords that were obtaining a high probability score in the parameter. After some testing, we finalised a list of stop words that do not carry significant importance for generating parameters. So, in our final model, we added those keywords to the stop words list and removed them from the articles. In the final step of data pre-processing, we used lemmatization using the "Spacy" engine and allowed only four types of parts of speech tags, including noun, verb, adjective, and adverb. After pre-processing step, we got the cleaned articles, which was used for parameter modelling.

Algorithm 4 Data Pre-Processing

Input: *articles*
Output: *clean articles*

1: $article\_DF \leftarrow read\_CSV(CSV\_file)$
2: $rd\_DF \leftarrow removeDuplicate(article\_DF)$
3: $ric\_DF \leftarrow removeIrrelevantCharacters(rd\_DF)$
4: $token\_DF \leftarrow tokenizer(ric\_DF)$
5: $rSW\_DF \leftarrow removeStopWords(token\_DF)$
6: $lemma\_DF \leftarrow lemmatization(rSW\_DF)$
7: $clean\_DF \leftarrow cleanArticle(lemma\_DF)$

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3.7. Parameter Modelling

We utilized the BERT topic modeling method [56] to cluster the data and discover parameters. At the beginning of parameter modelling, we generated a word embedding model using the BERT (Bidirectional Encoder Representations from Transformers), which is a transformer-based approach developed by Google [44]. Word embedding is a low-dimensional, dense vector representation of words, and BERT develops contextual embeddings. In this paper, we used the pre-trained "distilbert-base-nli-mean-tokens" model as it maintains the balance between performance and execution time. We implemented a dimensional reduction algorithm, UMAP, to keep the maximum information in a lower dimensionality. Furthermore, we used HDBSCAN to group identical articles together that define a cluster or parameter. HDBSCAN is a density-based approach that complements UMAP effectively, considering UMAP retains a range of local structures even at lower dimensionality. Additionally, HDBSCAN does not compel data points to clusters since they are considered outliers.

Furthermore, a class-based TF-IDF (Term Frequency-Inverse Document Frequency) score is used to calculate the importance of words for each parameter. By determining the frequency of a word in a given document as well as the measure of how prominent the word is in the entire corpus, TF-IDF provides a means of comparing the relevance of words between documents. However, if we consider all documents in a single group as a distinct document and then execute TF-IDF, we will achieve significance scores for words inside a cluster. This significance score is called the c-TF-IDF score. The more significant the words inside a cluster, the more representative the parameter. As a result, we can get keyword-based descriptions for every parameter. Equation 1 [50] describes the formula of the c-TF-IDF score, where f = the frequency of each word is derived for each class c and divided by the number of words w. The total number of unjoined documents (d) is then divided by the total frequency of words (f) throughout all classes (cc).

$$c - TF - IDF_c = \frac{f_c}{w_c} \times \log \frac{d}{\sum_p^{cc} f_p} \tag{1}$$

We fit all of the articles and train the BERT parameter model after obtaining the c-TF-IDF. The number of parameters is then decreased by recalculating the articles' c-TF-IDF matrices and then iteratively merging the most often occurring parameter with the most similar one based on the respective c-TF-IDF matrices.

Finally, we assigned parameters to all the articles and saved the model. As the parameter is originally represented as an integer number, we further scrutinised the corresponding parameter articles and relabelled the parameters and aggregated them into macro-parameters using domain knowledge and quantitative analysis methods, which are discussed in the next section.

3.8. Parameter Discovery & Quantitative Analysis

We discover the parameters and macro-parameters using domain knowledge and quantitative analysis methods (i.e., term score, keyword score, intertopic distance, hierarchical clustering, and similarity matrix).

3.8.1. Term Score

A list of keywords (terms) for each parameter does not express the context of the related parameter in the same way. To find a parameter, we must first determine how many keywords are required, as well as the starting and finishing positions of significant keywords. We visualise the keywords c-TF-IDF score for each parameter by sorting them in decreasing order [56]. This term score visualization has a significant influence on identifying the parameter.

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3.8.2. Intertopic Distance Map

The intertopic distance map is a two-dimensional representation of the parameters, with the area of the parameter circles proportional to the number of words in the dictionary associated with each parameter. The circles are formed using a MinMaxScaler algorithm depending on the words they contain, with parameters closer together sharing more words [56].

3.8.3. Keyword Score

In BERT parameter model, we get a set of keywords representing a parameter, where each keyword has an importance score or c-TF-IDF score (see Section 3.7) that describes the context of the parameter.

3.8.4. Hierarchical Clustering

The hierarchical clustering systematically pairs the parameters based on the cosine similarity matrices between the parameter embeddings [56]. By systematically pairing clusters, hierarchical clustering assembles a unique cluster of nested clusters. At each phase, beginning with the correlation matrix, all clusters are attempted in all possible pairs, and the pair with the greatest average inter-correlation within the experimental cluster is chosen as the new unique cluster.

3.8.5. Similarity Matrix

The similarity matrix is visualized as a heatmap using the Plotly library in Python to show the similarity between parameters based on the cosine similarity matrix [56]. We computed the similarity matrix by calculating the cosine similarity score between the parameters embedding to show the relationship between the parameters. We have used Plotly "BnGu" (green to blue) as the continuous color scale where the dark blue color represents the highest similarity relationship between parameters while the light green represents the lowest similarity.

3.9. Validation & Visualization

The validation of our results can be considered to be internal or external. The internal validation is performed by investigating whether the articles and documents belonging to a certain parameter are related to the parameter. We have provided discussions on many articles in each dataset as to how those articles relate to the parameters. The external validation is performed by comparing parameters, keywords, and quantitative metrics across the three datasets (i.e., the three perspectives of transportation). The external validation is also performed by using sources other than the three dataset sources. Moreover, both the internal and external validation is performed using the depictions produced by various visualization methods.

A range of visualization methods are used to elaborate on the datasets, document clusters, and the discovered parameters. These include dataset histograms [52], taxonomies, similarity matrices [53], temporal progression plots, word clouds, and others. For example, we visualise the temporal progression for both parameters and macro-parameters. Initially, we merged the similar representable parameters and then counted the number of articles (intensity) by grouping the parameters and article publication year. Consequently, we get a list of intensities for each parameter with specific years. After that, we sorted the list according to the year and plotted the intensity against year for each parameter. We also plot the macro-parameter temporal progression in the same way by integrating the parameters of each macro-parameter.

We use several python libraries for these visualisations including Seaborn, Plotly, and Matplotlib.

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4. Public, Governance & Politics: Transportation Parameters Discovery

We discuss in this section the parameters detected by our BERT model from the Guardian newspaper dataset. The parameters are grouped into six macro-parameters. We provide an overview of the parameters and macro-parameters in Section 4.1. The quantitative analysis is discussed in Section 4.2. Subsequently, we discuss each macro-parameters in separate sections, Sections 4.3 to 4.8. Finally, Section 4.9 discusses the temporal analysis of the parameters and macro-parameters.

4.1. Overview and Taxonomy (The Guardian)

We detected a total of 25 parameters from the Guardian dataset using BERT. These 25 parameters were grouped into six macro-parameters using the domain knowledge along with similarity matrix, hierarchical clustering, and other quantitative analysis methods. The methodology and process of the discovery of parameters and their groupings into macro-parameters have already been discussed in Section 3.

Table 1 lists the parameters and macro-parameters of the Guardian newspaper dataset. The parameters are categorised into six macro-parameters, including Road Transport, Rail Transport, Air Transport, Crash & Safety, Disruptions & Causes, and Employment Rights, Disputes, & Strikes (Column 1). The parameters are listed in Column 2, where some of them are merged. For example, parameters 9 and 4 have been combined into a single parameter, Rail Projects & Contracts. The third column indicates the cluster number. The percentage of the number of articles is recorded in the fourth column. Our BERT model labelled 50.5% of articles as the outlier clusters. The outlier clusters is more analogous to the average article compared to any of the other clusters. Consequently, we ignored this clusters, and the rest of the 49.5% of articles are listed in the fourth column. The fifth column represents the top keywords associated with each parameter.

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Table 1. Parameter and Macro-Parameters for Transportation (Source: The Guardian)

Macro-Parameters	Parameters	No.	%	Keywords
Road Transport	CRC	7	2.25	road, congestion, traffic, motorway, transport, charge, scheme, car, lane, motorist, toll, government, year, city, pricing, vehicle, public, need, increase
	Pollution & EV	17	1.56	car, vehicle, emission, diesel, pollution, fuel, electric, air, petrol, clean, new, carbon, year, hydrogen, engine, power, government, manufacturer, hybrid, green
	Fuel & SCM	19	1.47	fuel, oil, price, petrol, driver, duty, tax, government, shortage, car, rise, supply, motorist, increase, cost, road, high, tanker, year
	Cycling	24	1.02	bike, cycling, cycle, cyclist, city, ride, road, bicycle, route, lane, scheme, year, car, traffic, transport, way, safe, work, street, day
	Cycling Safety	23	1.08	cyclist, cycle, road, bike, cycling, death, kill, pedestrian, traffic, ride, safety, accident, driver, year, lorry, safe, helmet, injury, lane, number
	Bus Transport	12	1.87	bus, service, routemaster, transport, route, local, public, new, passenger, year, cut, travel, run, operator, journey, city, old, work, time
Rail Transport	PD	6	2.34	train, rail, passenger, service, company, network, year, railtrack, franchise, timetable, railway, new, delay, operator, line, run, work, industry, time
	Rail Fares	11	2.06	fare, ticket, rise, rail, train, passenger, season, price, increase, inflation, travel, cost, year, commuter, cheap, pay, company, average, peak, buy
	FCR	3	2.67	rail, year, company, network, profit, bn, government, franchise, bus, train, cost, railtrack, passenger, fare, rise, increase, revenue, transport, public
	Industry & Privatisation	21	1.13	shareholder, railtrack, company, eurotunnel, byer, debt, government, tunnel, french, share, administration, creditor, investor, channel, group, year, bn, private, public
	Rail Projects & Contracts	9	2.16	franchise, rail, government, train, contract, railway, company, year, railtrack, run, network, service, line, new, transport, operator, bid, public, plan
		4	2.39	rail, project, line, transport, north, high, speed, government, new, network, plan, train, link, route, bn, cost, year, build, city
	Governance & Politics	2	2.75	government, byer, transport, labour, public, minister, private, railtrack, company, last, tory, year, plan, decision, tube, rail, political, privatisation, secretary
Air Transport	Airport Expansions	0	3.57	runway, airport, heathrow, expansion, third, government, new, aviation, decision, noise, flight, build, stanste, plan, air, capacity, climate, expand, environmental
	Air Pollution	8	2.19	emission, carbon, aviation, climate, airline, change, fuel, flight, air, environmental, government, biofuel, reduce, industry, offset, global, green, energy, scheme
	Airport Security	1	3.55	flight, airport, passenger, airline, plane, drone, security, fly, pilot, aircraft, delay, air, cancel, travel, heathrow, check, ash, staff
	Air Costs & Fares	18	1.48	airline, airport, year, flight, passenger, carrier, cost, price, baa, easyjet, business, market, ryanair, last, fly, profit, heathrow, industry, air
Crash & Safety	Train Crashes	15	1.78	crash, safety, train, railtrack, rail, signal, accident, report, inquiry, paddington, track, health, company, bar, railway, manslaughter, network, potter, disaster, prosecution
		22	1.10	train, carriage, crash, track, passenger, accident, incident, injure, scene, driver, derail, service, rail, safety, police, emergency, line, fire, injury, come
	Accidents & Deaths	16	1.72	police, crash, accident, incident, scene, woman, injure, die, man, injury, train, vehicle, driver, kill, hospital, car, family, motorway, death, cause
	DDS	14	1.79	driver, speed, limit, drive, camera, road, police, driving, mph, drink, penalty, motorist, offence, test, accident, drug, fine, safety, year, death
Disruptions & Causes	EWI	10	2.09	snow, weather, temperature, flood, road, cold, rain, heavy, condition, wind, service, warning, expect, ice, close, area, fall, cause, delay, morning
	Disruptions & Delays	13	1.82	train, service, weekend, holiday, passenger, expect, delay, busy, work, station, line, travel, day, fire, hour, weather, rail, disruption, run, traffic
ERDS	ERDS	5	2.38	strike, union, action, unite, staff, dispute, rmt, member, tube, crew, industrial, pay, talk, worker, ballot, offer, day, cabin, service, work
		20	1.24	strike, southern, rmt, train, dispute, union, service, action, member, guard, talk, driver, rail, passenger, staff, conductor, company, day, run, aslef

*CRC = Congestion & Road Charging; PD = Public Discontentment; FCR = Funding, Costs, & Revenues; DDS = Dangerous Driving & Speeding; EWI = Extreme Weather Impacts; ERDS = Employment Rights, Disputes, & Strikes

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Figure 6 provides a taxonomy of the transportation domain extracted from a newspaper-focussed on Public, Governance & Politics. The taxonomy is created using the parameters and macro-parameters discovered from the Guardian newspaper. The first level branches show the macro-parameters, the second level branches show the discovered parameters,

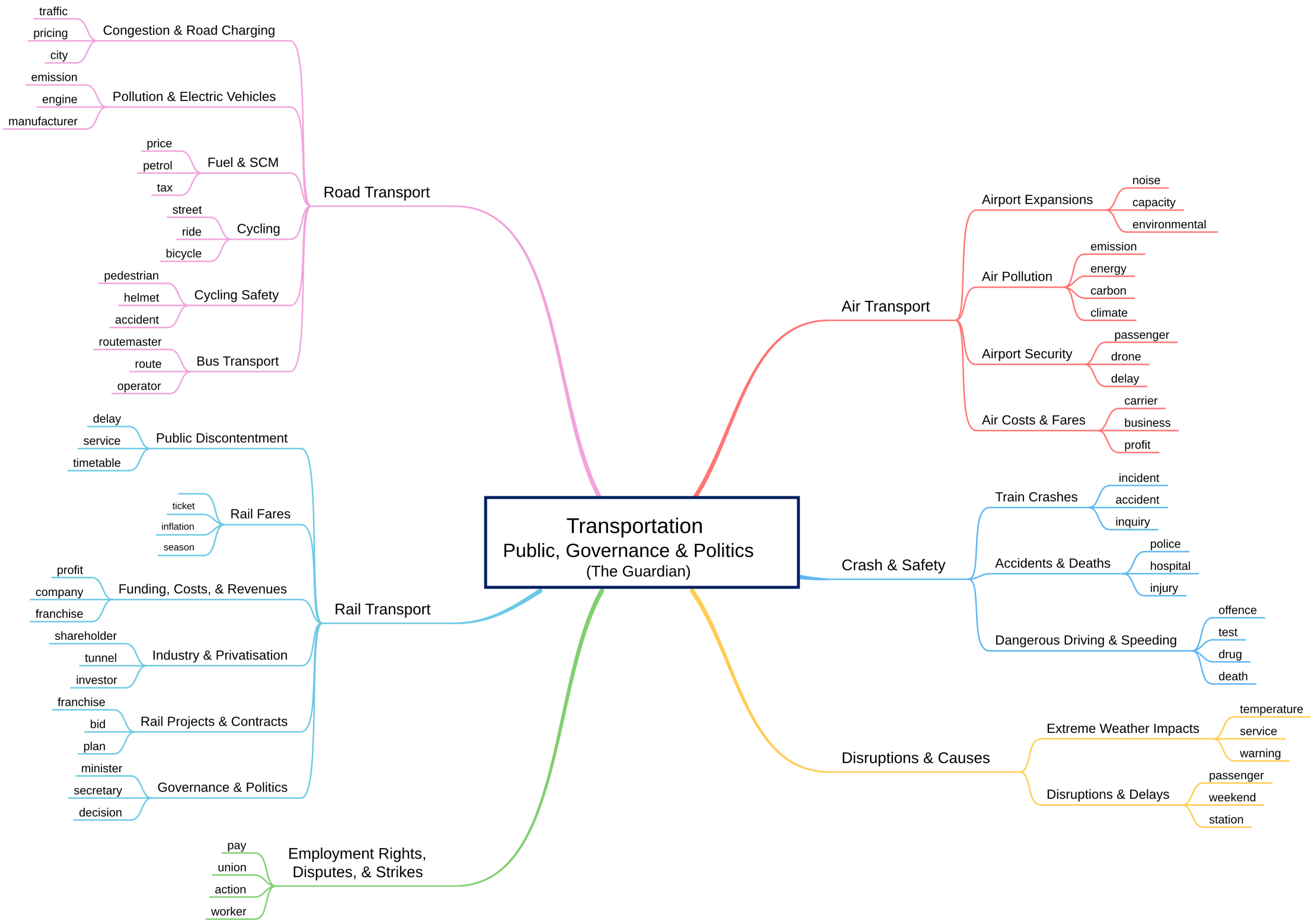

Figure 6. A Taxonomy of Transportation Extracted from The Guardian Dataset

4.2. Quantitative Analysis (The Guardian)

This Section discuss the term score, word score, intertopic distance map, hierarchical clustering and similarity matrix.

Each parameter is represented by a group of keywords, although not all of these words describe the parameter equally. The term probability declined representation depicts how many keywords are required to describe a parameter and when the benefit of adding more keywords begins to diminish (see Section 3.8). When we assess the keywords, only the top seven to ten terms in each parameter accurately describe the parameter, as shown in Figure 7. Because all of the other probabilities are so close to one another, ranking them becomes more or less useless. When we analysed the top keywords per parameter to discover the parameter, we used this information to focus on the top seven or so keywords in each parameter.

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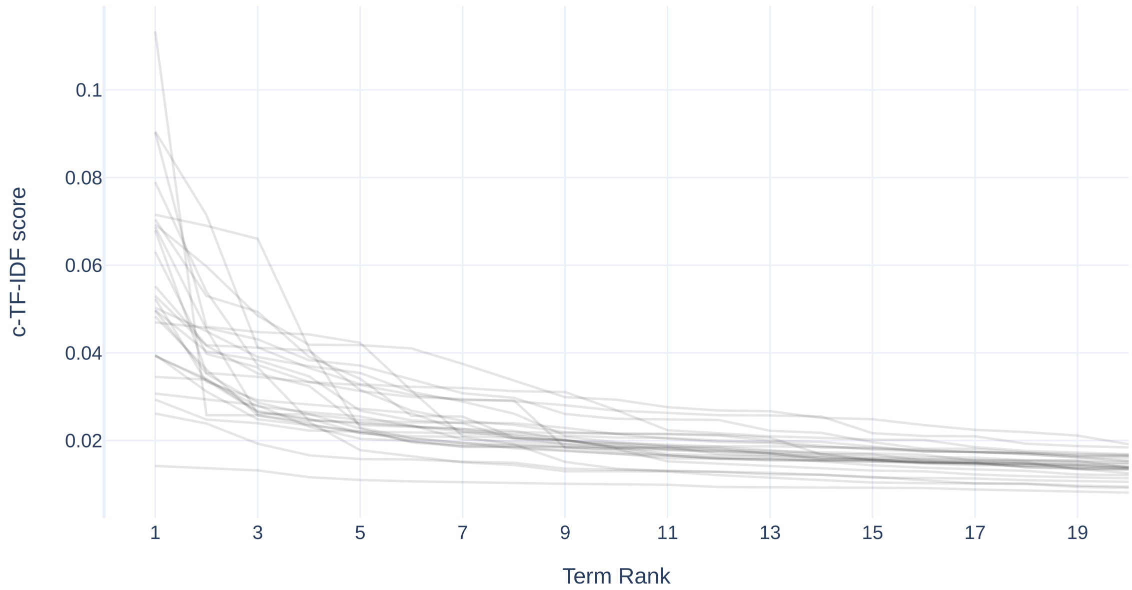

Figure 7. Term Score (The Guardian)

Figure 8 depicts the top 5 keywords for each parameter. The keywords are sorted based on the importance score, or c-TF-IDF score (see Section 3.8). There are 25 sub-figures and in each sub-figure, the horizontal line indicates the c-TF-IDF scores and the vertical line indicates the keywords. For example, the first sub-figure is the Airport Expansion parameter, which is represented by the 5 keywords such as runway, airport, heathrow, expansion, and government, having 0.07, 0.05, 0.49, 0.39, and 0.26 scores, respectively.

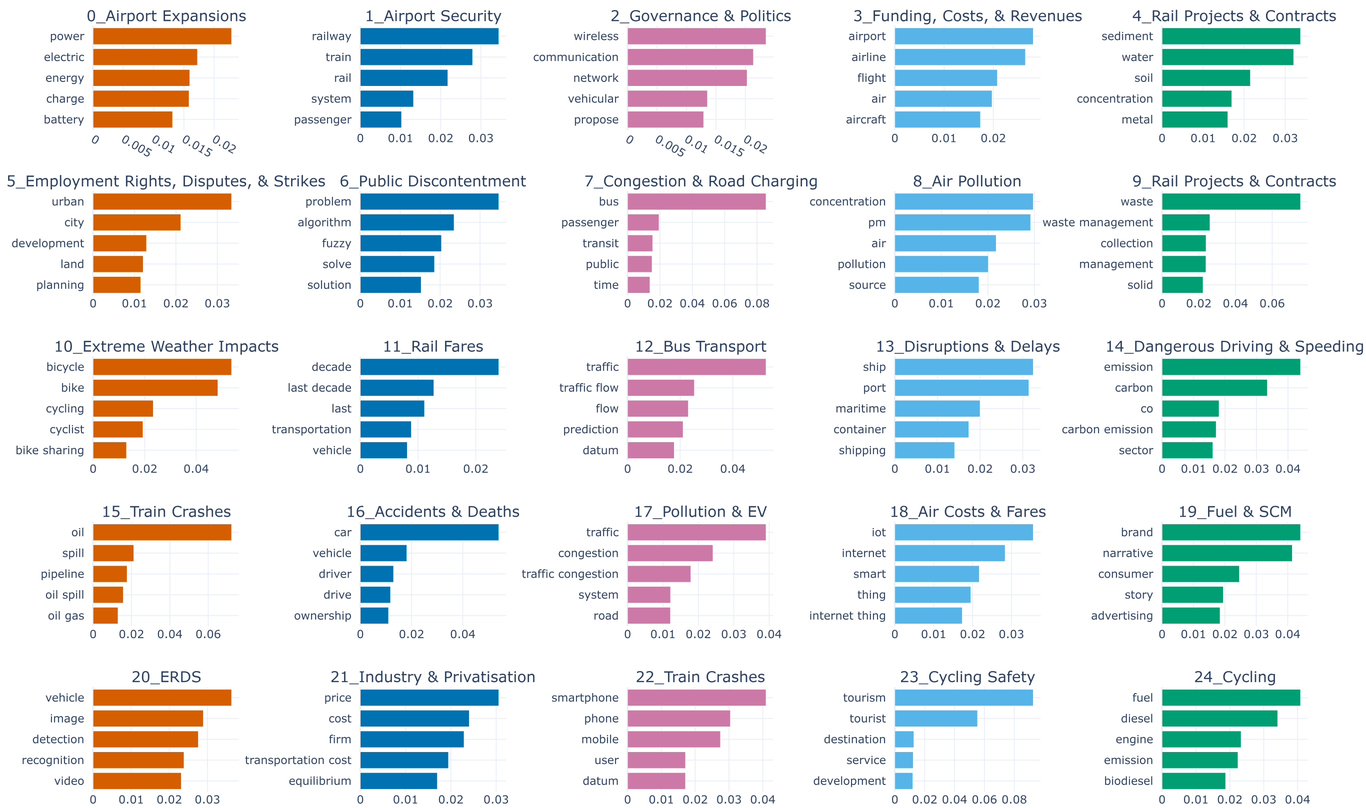

Figure 8. Newspaper Article Parameter with Keywords c-TF-IDF Score

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Figure 9 shows the intertopic distance map (see Section 3.8), where six macro-clusters are separately identified.

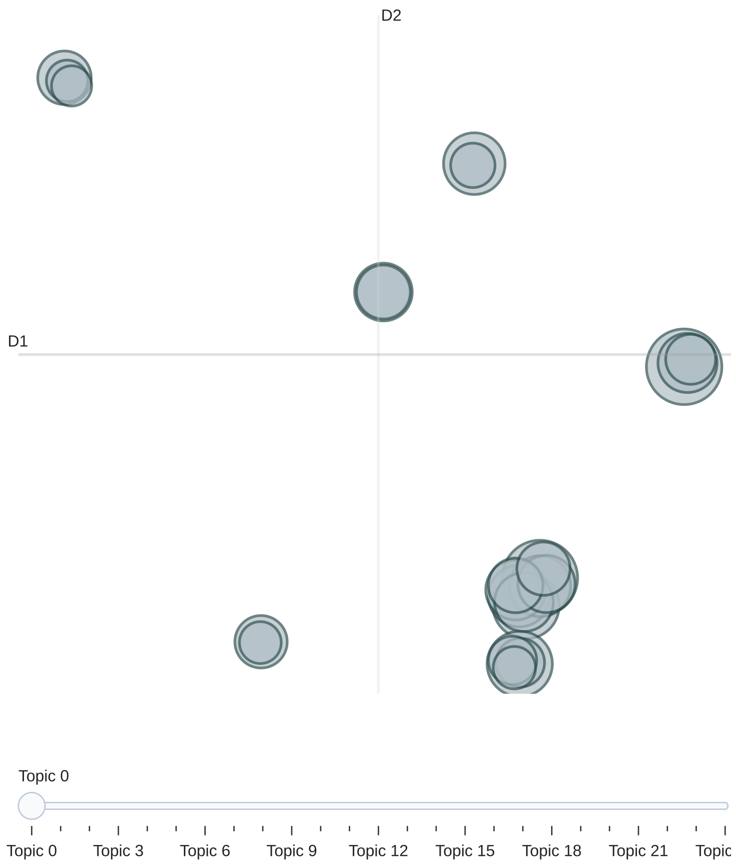

Figure 9. Intertopic Distance Map (The Guardian)

Figure 10 describes the hierarchical clustering of the 25 clusters and systematically pairs the clusters based on the similarity matrix (see Section 3.8). We noticed that cluster No. 6, 3, 9, 2, and 4 created a unique clusters that we labelled as the Rail Transport parameter.

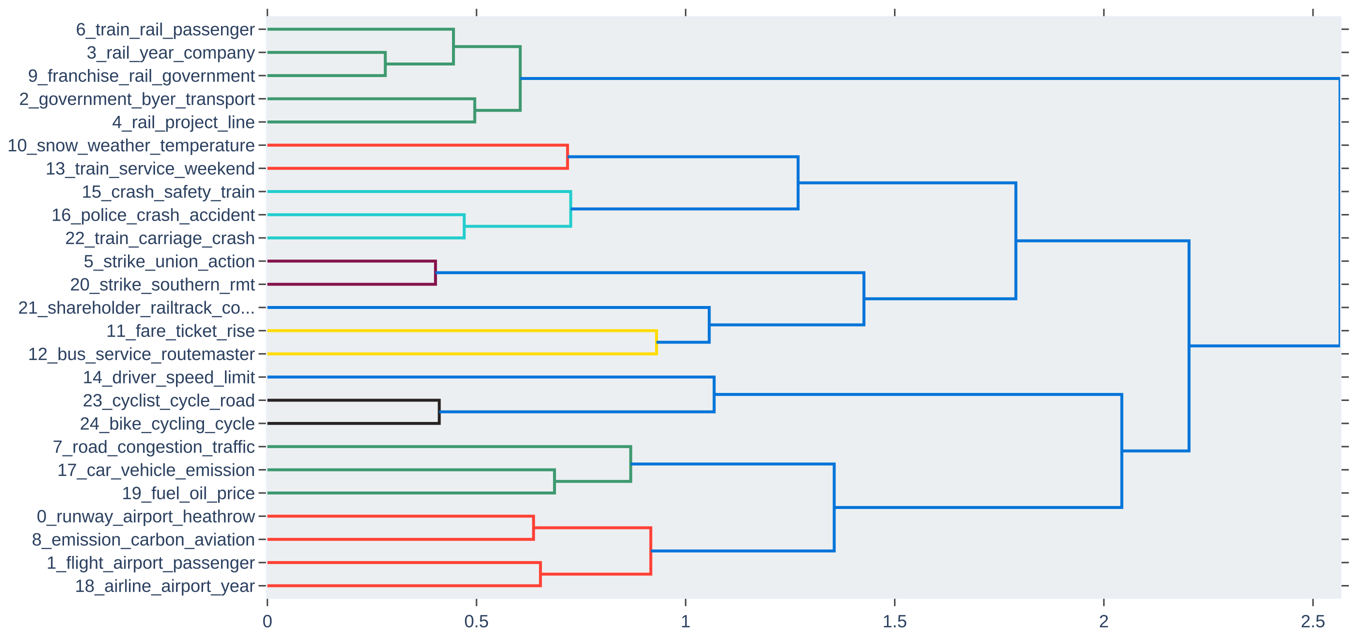

Figure 10. Hierarchical Clustering (The Guardian)

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Figure 11 visualizes the similarity matrix among the parameters (see Section 3.8). Note the dark blue colour between clusters 22 and 16, which showed a high similarity score because both clusters 22 (train, carriage, and crash) and 16 (police, crash, and accidents) have high resemblance. For example, whenever a train or carriage crash happens, at that time there is a high possibility of an accident, and police might react at that time.

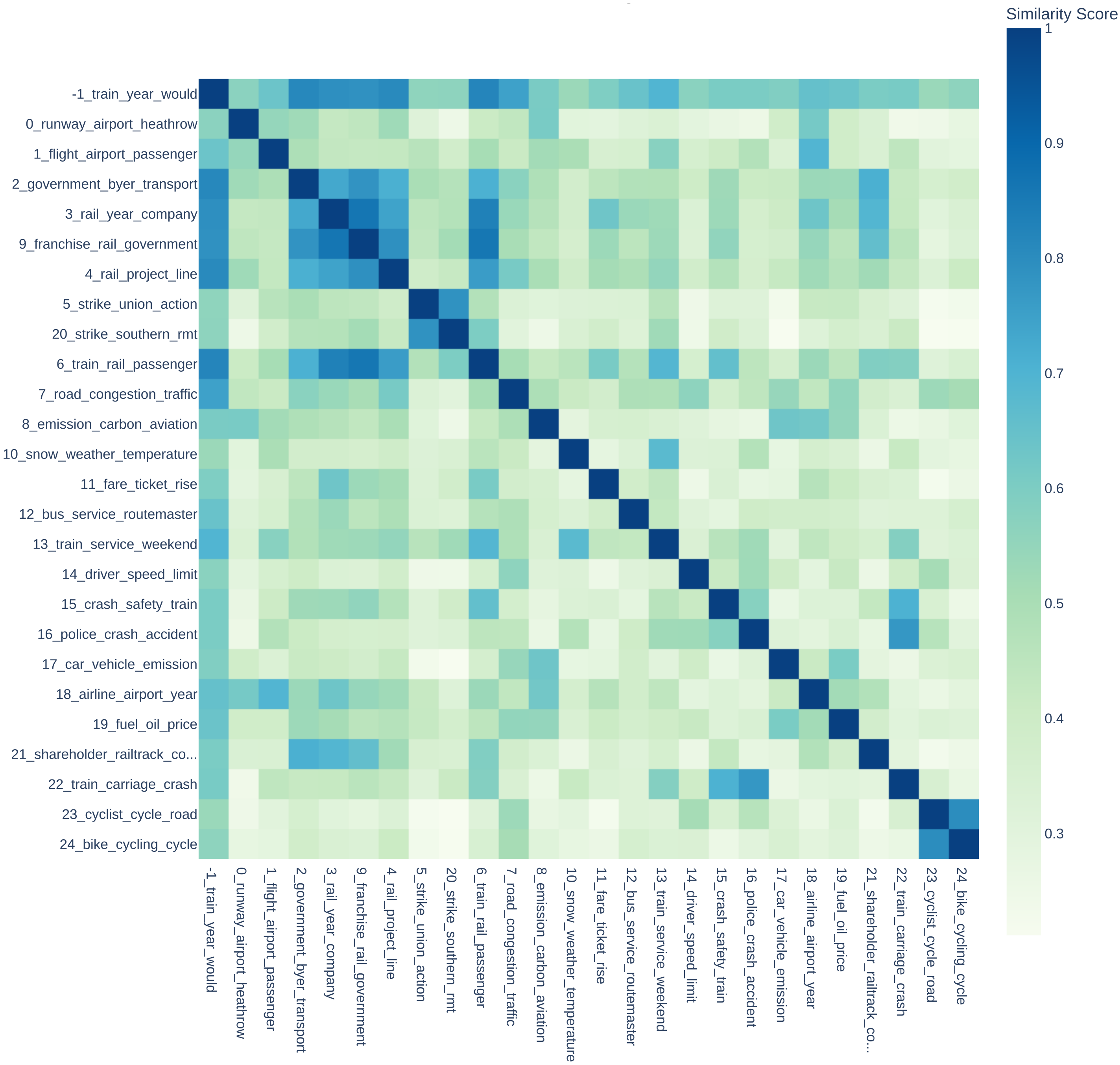

Figure 11. Similarity Matrix (The Guardian)

4.3. Road Transport

The macro-parameter Road Transport includes the following parameters: Congestion & Road Charging; Pollution & Electric Vehicles, Fuel & SCM (Supply Chain Management), Cycling, Cycling Safety, and Bus Transport.

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4.3.1. Congestion & Road Charging

The Congestion & Road Charging parameter is regarding road congestion and the imposed congestion charging to address the congestion. It is represented by keywords (detected by our model) such as road, congestion, traffic, charge, scheme, car, and city. Looking at the news articles that belong to this parameter we were able to find a number of topics that capture various dimensions of this parameter. These include congestion charging [91], traffic reduction and management [92], smart roads [93], parking [94], walking [95], cycling [96], congestion charge for non-residents [97], e-scooters [98], etc. For example, Harvey reports in a Guardian article [99] that the traffic congestion levels in September 2020 in outer London have increased above the pre-pandemic (COVID-19) lockdown levels in 2019. The article also shows the impact of congestion charging on outside central London and central London traffic between pre-pandemic, 2019, traffic and 2020.

4.3.2. Pollution & Electric Vehicles

The Pollution & Electric Vehicles parameter captures various dimensions of transportation from Guardian newspaper. These dimensions and related news include high air pollution and fears of high risks for COVID-19 infection [100], London being the worst city in Europe in terms of the damages to health due to air pollution [101], inadequacy of electric vehicle reforms alone in solving the pollution problem and the need for holistic solutions [102], proposed increase in diesel and petrol vehicle prices to curb pollution [103], UK cities delaying creating clean air zones supposedly for COVID-19 excuses [104], fall in air pollution levels in London by fifty percent by anti-pollution measures reported in April 2020 [105], UK to introduce E10, a high-ethanol fuel, to cut pollution [106], UK's plans to ban diesel and petrol vehicles by 2035 or even earlier [107], Bristol's plan (late 2019) to ban diesel vehicles [108], Oxford's plan (late 2017) to become first zero emissions area in the world [109], charging station deserts and monopoly [110], opening of first all-electric vehicle charging station [111], Tesla struggling in the US, asking funds from government [112], a 2008 article on myths about renewable energy [113], the concerns that despite electric and hybrid car sales the emission gains are only 1% between 2011 and 2021 [114], and many more news and topics. The parameter includes the following keywords detected by our model: car, vehicle, emission, diesel, pollution, fuel, electric, petrol, carbon, and hydrogen.

4.3.3. Fuel & SCM (Supply Chain Management)

The Fuel & SCM (Supply Chain Management) parameter contains keywords, fuel, oil, price, petrol, driver, duty, tax, government, shortage, car, and rise. Many news articles in this parameter are about fuel prices, shortage, and crisis [31,115], and costs of supply chains [116–118]. For example, a Guardian article [119] dated 17 November 2021 discusses the rising costs affecting all streams of businesses featuring case studies on agriculture, farming, hospitality, transport (individuals, small and large businesses), manufacturing, and retail. We found in this parameter a fascinating article on just-in-time supply chains by Kim Moody [120], Moody writes, "*Decades of deregulation, privatisation and market worship have left society vulnerable to the unbidden force of "just-in-time" supply chains. No amount of government subsidies, ... will be enough to address the crises we face, from the pandemic to climate breakdown, ... Now is the time to think about not just how we make and consume things, but also how we move them*". Moody discusses how we got used to of 'just-in-time world' while not appreciating the complexity of it including cross-continent shipping, fuel price variations, floods, closed roads, last-mile delivery people and their well-being, and the most important, the triple bottom line effects of all of it.

4.3.4. Cycling

The Cycling parameter captures the transportation issues associated with cycling and bikes, an issue that has become important due to climate and health. It includes the following keywords: bike, cycling, cycle, cyclist, city, ride, road, bicycle, route, lane, scheme, year, car, traffic, transport, way, safe, work, street, day. The parameter discloses several

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important dimensions of cycling through the Guardian news articles including the planned five thousand miles of dedicated cycle routes in UK announced June 2000 supported by the charity Sustrans [121], barring of charity cyclists from using new trains [122], increase in the number of bikes and rise of the 'born-again bikers' in the UK, covered in February 2004 [123], Minister setting examples for bike usage in 2004 [124] a major rise of weekend cycling in the UK [125], loss of a legal case made by cycling and rambling campaigners to prohibit vehicle driving in Lake District [126], funding to nurture increased walking and cycling in UK [127], cycle thefts [128], the rise of cycling holidays [129], new five-hundred mile cycle route network in West Midlands, UK [130], cycling with young children [131], Uber launching electric bikes for hire in Islington borough [132], and more.

4.3.5. Cycling Safety

The parameter Cycling Safety is about the risks and safety of cycling due to vehicles and other hazards on the road. Our model detected the following keywords for the parameter: cyclist, cycle, road, bike, cycling, death, kill, pedestrian, traffic, ride, safety, accident, driver, year, lorry, safe, helmet, injury, lane, and number. This parameter captured some issues related to road accidents in general, from early 2000s, such as higher accident risks for the children from deprived areas [133], the use of explicit graphic accident images in ads to nurture road safety [134], but the parameter was dominated by road risks and safety for cyclists. Examples include increase in cyclist death in UK in 2020 [135], advices on keeping safe while cycling [136], cheaper insurance for drivers who take cycle training to improve cyclists safety [137], concerns that pavements are being used for cycles stands and other purposes causing problems for pedestrians [138], the possibility of Great Britain to become a great cycling nation but road safety is a hurdle [39], and more.

4.3.6. Bus Transport

The parameter Bus Transport is represented by keywords including bus, service, route, local, public, passenger, and operator. The parameter capture bus transport issues in UK, though most of these are applicable to other countries in one or another way. The dimensions and issues of bus transport include schemes from the government to provide cheaper bus fares for pensioners introduced in August 2000 [139], government-hired pensioners in 2000 to go undercover and check bus service quality [140] the proposals in late 2002 to scrap cheaper fares for pensioners' and instead provide for jobless and students [141], better employment conditions for bus drivers [142] a bus strike in London in January 2015 and its effects on commuters [143], an article from year 2019 discussing the importance for an integrated public transport across the UK while allowing city mayors to have freedom for local transport operations [144], the launch of buses in UK in 2020 that filter air ("air-filtering buses") while in operation around a city [145], the need for security for bus drivers against coronavirus infection [146], a boost in electric buses in UK with twenty million GBP contract [147], the behaviour of passenger towards physical distancing measures deteriorating as people getting vaccinated [148], a 2021 news discussing the government plans to introduce a major redesign of public transport with new bus lanes, new fare plans, and richer bus schedules [149], changes in commuting patterns due to COVID-19 [150], compulsory masks on Tranport for London [151], severely negative effects of privatisation of bus services outside London [152], the affect of the COVID-19 pandemic on setting back public attitudes by two decades regarding giving preference to private cars over public transport for safety reasons [153], an article discussing the downfall of British public transport services by bus privatisation [154], and more.

4.4. Rail Transport

The macro-parameter Rail Transport defines the characteristics of the transportation sector that relate to trains and railways, as captured by the topic modelling of the Guardian dataset. Rail Transport includes the parameters, Public Discontentment; Rail Fairs; Funding, Costs, & Fares; Industry & Privatisation; Rail Projects & Contracts; and Governance & Politics.

4.4.1. Public Discontentment

The Public Discontentment parameter is represented by keywords, train, rail, passenger, service, company, network, year, railtrack, timetable, and railway. The overarching theme of the news articles in this parameter is the state of public discontentment with the rail services in the UK. The range of issues that public finds discontent with include, for instance, train delays particularly due to ineffective train schedules. For example, Guardian reported on 18 May 2019 that a new rail timetable was announced by the Rail Chief, UK, to improve the chaotic situation with the rail services in the UK due to many cancellations and delays in train services evidenced by people during the last year, 2018-2019 [19]. A couple of months later people again encountered severe delays and cancellation affecting the trains schedule due to overhead wire damage in July 2019 on the mainlines connecting London with Scotland, north-east England and other regions [155]. A revised rail timetable was developed and put in place in late 2019 to enhance the rail services promised to be the biggest change in the UK train schedule but the plans were ruined reportedly due to staff shortages [156]. These and similar incidents caused public upheaval and discussions on train delays schedules around the UK.

Other issues of discontent include, poor train accessibility [157], Delay in project completions [158,159], dissatisfaction with specific train service providers [160,161], discontent of company staff with their management [162], companies trying to win back customer satisfaction [163], Change of management due to discontentment with services [164], and more.

4.4.2. Rail Fares

The Rail Fares parameter is depicted by keywords, for example, fare, ticket, rail, season, price, commuter, cheap, peak. The parameter include issues such as EasyJet into fair wars with Virgin trains [165], the withdrawal of cheaper fairs amid train delays and cancellations [166], denying of compensation subsequent to Hatfield crash in 2000 for those who did not keep their tickets [167], planned increase of rail fares in England reported in 2020 [168], rail fares to increase by 3.8% in March 2022 reported in December 2021 [169], the launch of budget rail London-Edinburgh announced in September 2021 [170], post-pandemic flexible rail season tickets [171], and more.

4.4.3. Funding, Costs, & Revenues

The train Funding, Costs, & Fares parameter includes the keywords rail, company, network, profit, government, cost, fare, rise, revenue, public, and others. One of the news articles in this parameter, dated 5 December 2021, discusses the hefty budget cuts required by the UK government from train operators who are contracted to deliver train services for a fixed price while the revenues and risks are born by the government [172]. While the consequences of the pandemic on train travel patterns are obvious and being explored, some groups argue that it is critical to maintain services and cut costs in order to attract passengers and save taxpayer money. There are other political and public issues too including related to job cuts that on one hand harm some segments of the public while it is necessary to reduce costs and improve public services. Other articles touch on a range of dimensions and issues of this parameter including, penalties and cutting bonuses [173], bailouts [174], increase in demands and revenues [175–177], funding and funding gaps [178], and more.

4.4.4. Industry & Privatisation

The Industry & Privatisation parameter is characterized by keywords such as shareholder, railtrack, company, eurotunnel, buyer, debt, government, tunnel, share, and investor. The parameter captures transportation dimensions surrounding governance, privatisation,

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and industry, mainly for rail transportation. The earliest article [179] in this parameter dates back to 7 February 1964 about the agreement on Channel Tunnel between the French and British governments, seen as “a sound investment”. The Channel Tunnel as we know was opened in 1994. We then witness a news article [180] from 1999 opposing the cabinet view on partly privatisation the public transport system in UK due to its feebleness. We also see an article [181] from December 2000 deliberating comments from a chief executive officer of Atkins who was a major stakeholder in two London Underground bids that "the public does not appreciate the benefits brought to the railways by the private sector". These and similar issues [182] show the debates around and pros and cons of privatisation versus government-owned services. Another issue or dimensions that we can learn from our BERT model is the legal battles between companies such as reported in a Guardian article [183] from 2001 about the company Virgin planning to sue the company Railtrack for their losses due to the Hatfield train crash [184]. The legal battles between companies also extend to the leadership of a company being offered a job by another company such as reported in December 2009 by Dan Milmo that the chief of Tube Lines is offered at National Express [185]. There is also an article from September 2020 reporting the former transport secretary being offered a lucrative contract by Hutchison Ports [186,187]. Other news and dimensions of this parameter include Stagecoach offer in 2009 to its rival National express for merger [188], the Channel tunnel operator Eurotunnel’s hope in 2007 for "investors to back a debt-for-equity swap" to save its from bankruptcy [189], the problems with public and private sector working together such as London Underground public-private partnership (PPP) and East coast rail [190], FirstGroup, the rail and bus company, rejection for takeover the American company Apollo [191], the post-Brexit rebranding of Eurotunnel to Getlink [192], and more.

4.4.5. Rail Projects & Contracts

The Rail Projects & Contracts parameter was created by merging two clusters (number 9 and 4) because the two clusters contained keywords pointing to similar subjects. The parameter is represented by keywords franchise, rail, government, train, contract, railway, company, service, bid, plan, rail, project, line, transport, north, high, speed, government, plan, and route. Guardian confirmed on 18 November 2021 [193] that the eastern link of HS2 connecting Leeds was abandoned by the government and this caused fury among the affected segments of the public.

4.4.6. Governance & Politics

The Governance & Politics parameter represents the government’s decision or plan-related keywords including government, buyer, transport, labour, public, minister, private, decision, political, privatization, secretary. For example, Guardian reported on 14 November 2021 [23] that the government dropped the plan for HS2 and instead decided to support projects that benefit the ruling party. HS2 was reportedly promised by the Prime Minister during the very early days of his job. It was expected to provide a new high-speed railway link serving as the foundation of Britain’s transportation network.

4.5. Air Transport

The macro-parameter Air Transport includes the parameters Airport Expansions, Air Pollution, Airport Security, and Air Costs & Fares.

4.5.1. Airport Expansions

The Airport Expansions parameter is about expansions planned for airports and related facilities that are needed to meet the increasing demands for air travel [194] as well as about the oppositions to expansions due to their negative impacts on climate [195,196]. This parameter includes the keywords, runway, airport, heathrow, expansion, government, aviation, decision, flight, build, and plan. For example, The matter of London Heathrow Airport expansion and building its third runway has remained a matter of discussion

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for many years, it being given green signal to go ahead, climate activists challenging it, courts making decisions, and so on [197]. Asthana, Laville, and Kale in a Guardian news item [198] discussed the Court of Appeal decision announced in March 2020 to deem the expansion unlawful due to the UK government's failure of not considering the climate impacts of the expansion. This topic has continued to remain in the news to this time due to the airport trying to challenges the court decision [199] and Tim Crosland, the lawyer and a campaigner for environment protection who was found guilty (May 2021) by the supreme court and lost his appeal (December 2021) for disclosing the court decision before its official announcement to the public [200].

4.5.2. Air Pollution

The Air Pollution parameter contains the following keywords, emission, carbon, aviation, climate, airline, fuel, environmental, biofuel, and others. The parameter relates to air pollution caused by air transport. For example, Ungoed-Thomas from The Guardian wrote in a news item [201] about the high number of flights being taken by UK government staff (293 every day according to a report) despite the UK government's promises to climate protection and greening the government.

4.5.3. Airport Security

The Airport Security parameter is represented by keywords such as flight, airport, passenger, drone, and security. This parameter is exemplified in a news March 2008 article by Dodd and Milmo [30] reporting an incident of a breach, second within three weeks period, where a man succeeded in reaching a runway on of the Heathrow airport.

4.5.4. Air Costs & Fares

The Air Costs & Fares parameter represents the transportation characteristics connected to the costs and fees incurred by the air transportation providers and consumers. The keywords include airline, airport, flight, passenger, carrier, cost, price, business, market, and profit. An example of various issues that come under this parameter is a Guardian news reported by Topham and Kollewe [26] on 19 October 2021. The news is about Heathrow airport that could potentially increase charges for passengers by fifty-six percent by 2023. Topham and Kollewe explain in the news that Heathrow airport will be permitted by CAA, the Civil Aviation Authority, to raise the landing charges considerably from the summer of 2022. This was in response to the airport organisation that asked for doubling the charges due to the massive business losses caused by the dearth of airport activity during the COVID-19 pandemic. CAA explained that the permission to increase charges was necessary for keeping the airport competitive and safe. The airlines are affected by the decision as the costs for their operations will increase. The news shows the complexity of the parameter in terms of the different stakeholders (airport management, airline operators, CAA, and consumers), changing times and situations.

4.6. Crash & Safety

The macro-parameter Crash & Safety includes three parameters: Train Crashes, Accidents & Deaths, and Dangerous Driving & Speeding.

4.6.1. Train Crashes

The keywords that represent the parameter Train Crashes are crash, safety, train, railtrack, rail, signal, and accident. The earliest Guardian article we find in this parameter dates back to 6 October 1999 about the worst crash of the decade between Great Western and Thames trains near Paddington in London [202] making safety of rail transport a major political issue [203], making the two train operators, Railtrack, and the government to begin an inquiry into the crash [204], and government pledging one billion GBP for safety of rails [205]. This has further led to the possibility of manslaughter charges against Thames Trains and Railtrack [206]. Railtrack, a group of companies, owned a major part of the

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rail infrastructure in the UK from 1994. It was renationalised in 2002. Many other news items were found related to train accidents such as the rail accident between two trains at Salisbury in November 2021 caused potentially due to low adhesion between rail tracks and train wheels [207].

There have also been many news items from Guardian in this parameter about losses to rail companies due to accidents, compensations, penalties, etc. [208]. The parameter also contained some articles related to rail suicides such as this article from November 2017 about urging commuters to indulge in small talk with people potentially attempting suicides [209]. it was reported in this article that about 273 people committed suicides on the railways in the UK during 2016-17. The parameter and the contained news articles show the richness of information that can be extracted from our BERT-based modelling approach.

4.6.2. Accidents & Deaths

The Accidents & Deaths parameter is represented by keywords such as police, crash, accident, incident, scene, woman, injure, die, man, injury. This parameter contains news articles about deaths and road accidents as opposed to the parameter Train Crashes where the focus of the contained articles is on train crashes and the various issues surrounding them such as financial, political, investigative, and industrial issues. Moreover, while this parameter mainly contains articles about roads, we also found some articles that involved trains, such as a death (potentially a murder) by a woman pushing another person in front of a train [20]. Another example in this parameter showing the focus on deaths rather than the mode of transportation is a news from October 2000 about the history of train accidents in the UK [210]. The article focuses on injuries and deaths rather than other details and this is the reason we believe this article though also related to train crashes is mainly associated by our BERT model to the Accidents & Deaths parameter. Another example is a news about the death of a woman who was a staff in a railway ticket office. She died because of COVID-19 infection that she may have caught due to a man who claimed he had COVID-19 and spat and cough on her while she was on duty [211]. The news is related to rail transport but is about the death of a person. other examples of articles in this parameter that involve railways and trains (or even air transport) but are mainly about deaths, road transport, and vehicles include [212–219].

The dimensions and issues connected to this parameter as seen through the news articles include the UK government strategy for road safety highlighting the gravity of matter due to over 0.3 million road casualties in UK every year (1 March 2000, [220]), the release of the driver of the bus that crashed and killed two and injured dozens of people (5 January 2007, [221]) death and injuries of various people in different incidents due to cold, black ice, road death traps, etc. (8 February 2009, [222], 31 March 2010, [223]), the M5 crash in November 2011 [224], March 2012 [225], M1 crash in December 2012 and its investigations [226], death of a man due to collision with Nottingham tram (16 August 2016, [227]), the rescue of 60 children from bus operated by Stagecoach after its crash (11 November 2021, [228]), a woman killed due to collision of two buses near Victorial station, London (10 August 2021, [229]), and many more.

One of the issue discovered from this parameter is deaths on and safety concerns of smart motorways in the UK [230,231]. This topic of smart motorways was also detected in Parameters 7 and 14 in relation to congestion reduction and speeding, respectively.

The discussions in this article are supported by a large number of articles for the discovered parameters. These may be seen unnecessary or of little or no benefit. We discuss a large number and range of articles to show the complexity and breadth of the parameter topics. The knowledge gained through the parameter discovery and analysis process (that is currently partly automatic and partly manual and will become increasingly automatic and autonomous) will allow autonomous modelling, (exploratory, dynamic, and real-time) analysis, and optimisation of transportation of other sectors. The discussions presented in

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this article are also helpful in understanding the working and performance of BERT and other clustering algorithms.

4.6.3. Dangerous Driving & Speeding

The Dangerous Driving & Speeding parameter is characterised by drunk, dozing, and other dangerous driving, speeding, speed limits, methods to measure and curb dangerous driving and their devastating effects, and penalties and legal punishments. The first article in this parameter is dated 1 March 2000 and is about government pledging to introduce tougher measures for drink-driving and speeding to reduce child pedestrian deaths and other harms; while road safety and environment protection groups showing dismay and criticising the government to give in to the motoring lobby [232].

The dimensions and issues related to this parameter include, among others, efforts from the government to intervene and improve dangerous driving behaviour [233], government caving in to different lobbies including motoring and alcohol lobbies [234], dozing drivers causing deaths and their legal punishments [235], the use of virtual reality in driving test [236], dangerous and drunk drivers and their legal punishments [237], device that would not let drunk driver start the vehicle [238], drunk police officera [239], uninsured drivers [240], speed cameras and privacy [241], law being soft on dangerous and drunk drivers [242], the benefits of lower speed limits to air quality and environment [243], penalties and jails for drivers using mobile phones [244], illegal use of devices to deceive speed measuring equipment [245], improvements to driving tests to improve driving behaviour of young people [246], the benefits of autonomous cars to free us from dangerous drivers [247], shocking driving speed violations during the COVID-19 lockdown [248], and more.

4.7. Disruptions & Causes

The macro-parameter Disruptions & Causes comprises two parameters Extreme Weather Impacts, and Disruptions & Delays.

4.7.1. Extreme Weather Impacts

The Extreme Weather Impacts parameter captures the various impact on transportation of extreme weathers such as snow, rain, floods, heat, and wind-storms. The keywords detected by our BERT model for this parameter include snow, weather, temperature, flood, road, cold, rain, heavy, condition, and wind. The issues and dimensions for this parameter as evidenced through Guardian news articles include, among others, Ice bombs (“frozen effluent falling from aeroplanes") [249], impact on rail transport causing delays, cancellations, accidents, deaths, injuries, financial losses, and more [250], magic de-icer to help railways in applying timely breaks [251], effects of snow on roads [252], heaviest snow in 18 years and its effects [253], government rejecting criticism over transport management during extreme weathers [254], resignation of tranport minister over snow chaos [255], strong winds, snow, and floods beat up the country and bring to halt [256] extreme weather effects on air travel [257], weather impact on schooling [258], travel chaos in the country [259], storm Darcy, cold and snow to cause disruptions [260], weather impacts on Christmas and its arrangements [261], deaths due to storms [262], weather impacts on rail repairs [263] derailing of a train due to rain and landslide [17], village evacuation due to extreme weather [264], government advice to businesses not to penalize staff for following government snow advice [265], travel chaos due to rain and high temperatures [266], the inability of UK rail transport in dealing with extreme climates and a call for investments [267], damages to bridges due to flooding [268], and more.

4.7.2. Disruptions & Delays

The Disruptions & Delays parameter contains the following keywords detected by our BERT model: train, service, weekend, holiday, passenger, expect, delay, busy, work, station, line, travel, day, fire, weather, rail, disruption, run, and traffic.

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The earliest article in this parameter is from 19 November 1987 about a fire at King's Cross underground train station in London. This shows travel and other disruptions caused by the fire. The dimensions and issues related to travel disruptions include, among others, closure of many stations in London underground due to coronavirus [269], disruptions due to peak-hour services cancellations [18], a warning for people to plan their travel due to expected heavy traffic from bank holiday getaway travellers amid expected fine weather [270] Bridge failure causing disruptions [271], advice to avoid travel due to rail works [272], rail services disrupted by lightening strikes [273], fire arson at a train station [274], getaways for Easter expect to cause traffic at motorways [275], a leaf clearing operation by Network Rail to reduce rail accident risks [276], disruptions in Christmas Eve travels due to engineering problems and weather [277], disruptions due to Notting Hill carnival [278], heavy road traffic and delays due to rail closures [279], disruptions and delays due to London 2012 Olympics [280], disruptions due to tunnel falls in London Underground [281], crowded airports and rail stations and congested roads due to school holidays and good weather [282], and many more.

Considering the keywords and news articles in this parameter, we can say that this parameter is about travel disruptions, delays and their causes. The causes include accidents, fires, both bad and good weather, faults, repairs and new installations in transport infrastructures, and holidays including bank holidays, Easter, and Christmas.

4.8. Employment Rights, Disputes, & Strikes

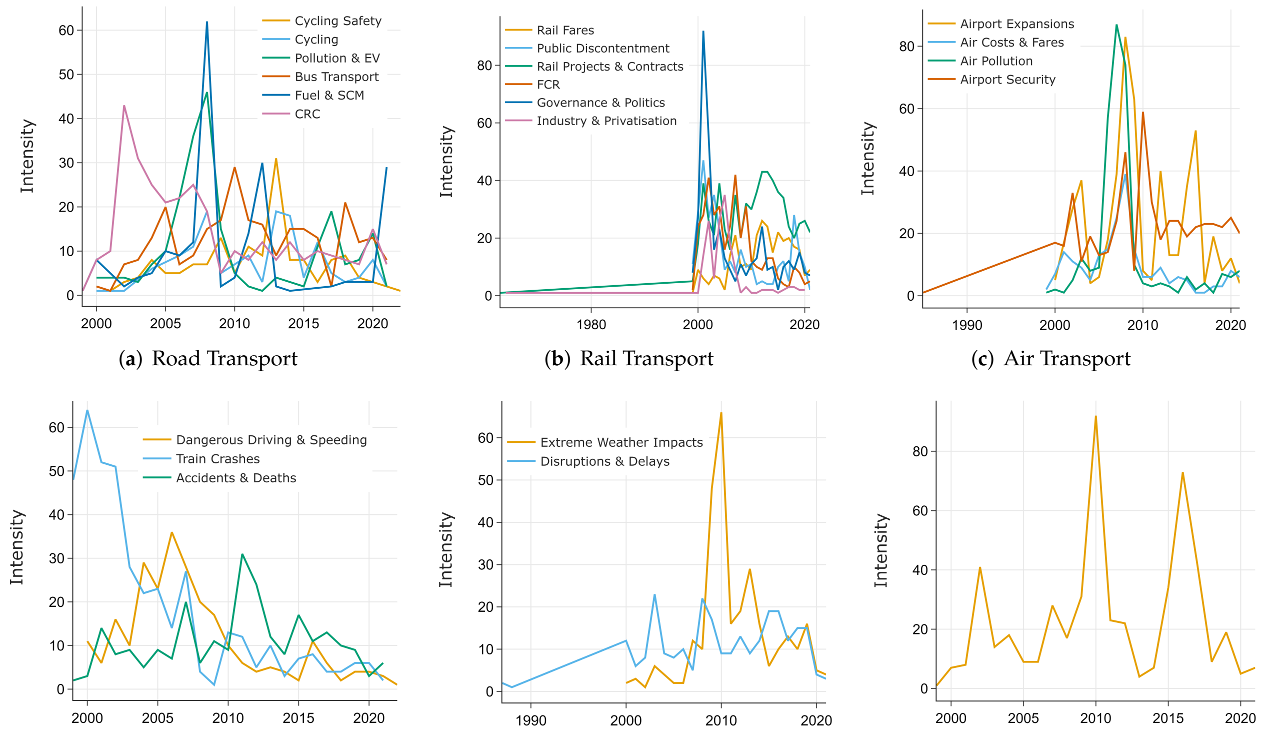
This macro-parameter has only one parameter which created from merging two clusters, number 5 and 20. The parameter Employment Rights, Disputes, & Strikes captures information about employees, their rights, job cuts, employment conditions, disputes with the management, and union strikes and their impact on people and economy. Two document clusters were detected with similar keywords and articles, the cluster numbers 5 and 20, and therefore we merged them into a single parameter. We noted some difference in the two cluster with cluster number 5 containing more articles related to rail transport and cluster number 20 a bit inclined towards air transport. We consider also this parameter as a macro-parameter because of its vast impact on social, economic, and environmental sustainability. There are always apparent exceptions in the cluster documents such as this article [283] is about cancellation of trains due to Covid but primarily belongs to the parameter Employment Rights, Disputes, & Strikes; however, on a close inspection one can find the connection such as the mention of strikes in the aforementioned article.

The earlier article reported by Guardian related to this parameter is on 14th October 1999 about rail guards voting to go for a strike over safety matters [284]. We see matters related to job cuts such as British Airways announcing on 7 December 2000 to cut 1000 jobs at the Gatwick airport [285]. Among the news related to employment rights, union disputes and strikes we find articles including about a dispute between Amalgamated Engineering and Electrical Union (AEEU) and Virgin Atlantic reported on on 29 December 2000 [286], the dispute between RMT (National Union of Rail, Maritime, and Transport Workers) and the government (precisely, TfL, Transport for London) over the work rosters threatening to go for a strike from 26 November 2021 [287], Train drivers threatening a major rail strike in London rail in January 2000 subsequent to rail privatisation [288], British Airways employees' strike for disputes regarding salaries reported in June 2017 [289], a strike stretching multiple weeks during March 2019 by French customs over poor working conditions causing havoc to Eurostar trains [290], Yodel employees threaten to strike in September 2021 due to poor salaries and conditions causing potential disruptions to deliveries for major supermarkets and others [291], Stagecoach under threat of strike by drivers'low wages [292], a recent news (October 2021) on post-COVID-19 abuse of staff working at transport stations and other customer-facing staff by customers [293], and more.

These examples of different types of employment disputes and strikes reveal insights into a range of issues surrounding stakeholders, causes and impacts of disputes and strikes.

4.9. Temporal Analysis (The Guardian)

In this section, we will analyse how the parameters have grown over time. Figure 12 displays the temporal progression of the parameters, which are distributed into six sub-figures. The vertical line of the graph indicates the number of articles, which is defined as the intensity, and the horizontal line indicates the years. Figure 12(**a**) depicted the temporal progression of the macro-parameter Road Transport. Fuel & SCM has a higher intensity compared to the others. Figure 12(**b**) illustrates the temporal progression of macro-parameter Rail Transport, where the Rail Projects & contracts, and Industry & Privatisation parameter were started in 1960. After that, both parameters were highly discussed between 2000 and 2005. The intensity of articles for the macro-parameter Air Transport, which includes four parameters, is depicted in Figure 12(**c**). Air Pollution and Air Airport Expansions both had a peak value of around 80 between 2007 and 2008. The temporal progression of the macro-parameter Crash & Safety, which includes three parameters, is shown in Figure 12(**d**). We observed that there are more articles related to Train Crashes compared to others. Figure 12(**e**) displays the temporal progression of the macro-parameter Disruptions & Causes. The parameter Extreme Weather Impacts was highly discussed in 2010 and had the highest peak value of 60. The temporal progression of the macro-parameters Employment Rights, Disputes, & Strikes, is shown in Figure 12(**f**), where the highest peak value of intensity was more than 80 in 2010.



(**a**) Road Transport (**b**) Rail Transport (**c**) Air Transport

(**d**) Crash & Safety (**e**) Disruptions & Causes (**f**) Employment Rights, Disputes, & Strikes

Figure 12. Temporal Progression of Parameters (The Guardian)

The temporal progression of all macro-parameters is summarised in Figure 13. For the first time, Rail Transport was discussed in 1960. After 2000, the parameter was highly concerned topics for discussion and had the highest peak value of 225. In 2008, the macro-parameter Air Transport had the highest peak value. We also saw in 2020 that the macro-parameters Road Transport, Rail Transport and Air Transport were equally discussed. The macro-parameters Crash & Safety, Disruptions & Causes, and Employment Rights, Disputes, & Strikes also be equally concerned in 2020.

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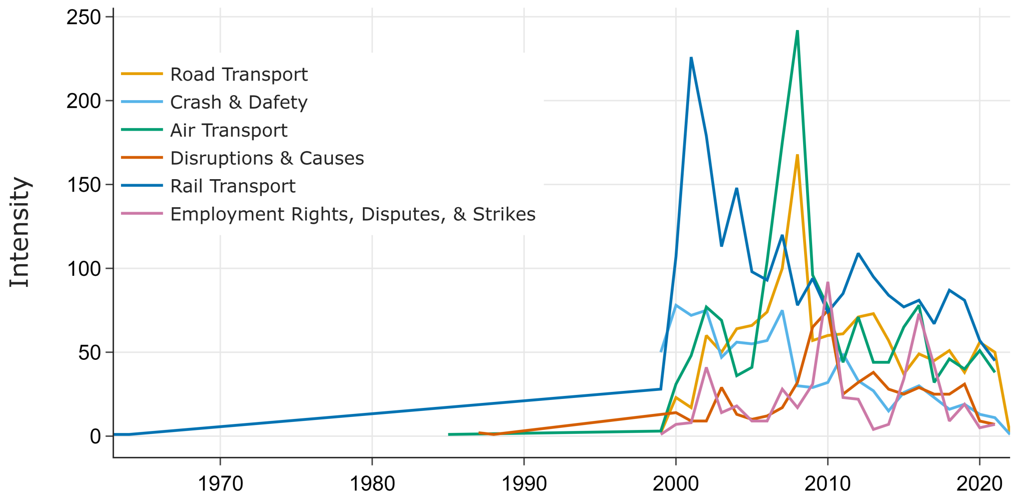

Figure 13. Aggregated Macro-Parameters (The Guardian)

5. Industry: Transportation Parameters Discovery

We discuss in this section the parameters detected by our BERT model from the dataset acquired from the Traffic Technology International (TTI) magazine. The parameters are grouped into five macro-parameters. We provide an overview of the parameters and macro-parameters in Section 5.1. The quantitative analysis is discussed in Section 5.2. Subsequently, we discuss each macro-parameters in separate sections, Sections 5.3 to 5.7. Section 5.8 discusses the temporal analysis of the parameters and macro-parameters.

5.1. Overview and Taxonomy (Traffic Technology International Magazine)

We detected a total of 15 parameters from the TTI dataset using BERT. These 15 parameters were grouped into five macro-parameters using the domain knowledge together with similarity matrix, hierarchical clustering, and other quantitative analysis methods. The methodology and process of the discovery of parameters and their groupings into macro-parameters have already been discussed in Section 3.

Table 2 lists the parameters and macro-parameters of the transportation magazine, TTI. The parameters are categorised into five macro-parameters, including Industry, Innovation, & Leadership, Autonomous & Connected Vehicles, Sustainability, Mobility Services, and Infrastructure (Column 1). The second and third columns list the parameters and the cluster number, respectively. The fourth column lists the proportion of the total number of articles. Our BERT model identified 58.16% of the articles as having outlier clusters. As a result of excluding this cluster, the remaining 41.84% of articles are listed in the fourth column. The top keywords related to each parameter are represented in the fifth column.

Table 2. Parameter and Macro-Parameters for Transportation (Source: Traffic Technology International)

Macro-Parameters	Parameters	No.	%	Keywords
Industry, Innovation & Leadership	Leadership	0	8.05	technology, mobility, vehicle, transportation, event, transport, traffic, city, system, service, work, future, world, infrastructure, road, public, time, datum, smart, industry
	Innovation	4	2.60	award, project, winner, competition, transportation, traffic, win, system, tsmo, technology, road, team, category, solution, work, vehicle, industry, transport, safety, innovation
Autonomous & Connected Vehicles	AV Systems	1	4.41	vehicle, car, autonomous, system, drive, technology, datum, map, driving, driver, road, sensor, automate, company, software, autonomous vehicle, automotive, platform, self, time
	AV Trials	8	2.18	vehicle, autonomous, technology, test, drive, trial, first, driverless, autonomous vehicle, driving, testing, self, driver, road, car, system, public, company, automate, shuttle
	V2X Trials	9	1.97	australian, transport, vehicle, technology, road, government, trial, system, industry, project, infrastructure, world, safety, cohda, first, future, provide, state, automate, city
	Platooning	12	1.69	truck, driver, vehicle, platoone, technology, system, parking, drive, freight, commercial, road, truck parking, project, truck driver, trucking, company, fuel, highway, autonomous, safety
Infrastructure	Road Infrast.	2	4.10	project, lane, road, motorway, traffic, construction, bridge, improve, scheme, work, design, tunnel, junction, improvement, highway, route, mile, time, provide, reduce
	Crash & Safety	13	1.58	road, death, pedestrian, crash, safety, fatality, injury, speed, increase, report, vehicle, reduce, number, traffic, safe, kill, serious, driver, high, state
	Tolling	10	1.95	toll, system, tolling, lane, toll collection, collection, electronic, bridge, tolling system, project, transponder, contract, customer, transcore, express, road, vehicle, company, state, collection system
	ALPR	14	1.50	camera, video, system, traffic, surveillance, high, vehicle, application, technology, provide, solution, detection, plate, analytic, enforcement, range, datum, feature, capture, view
Mobility Services	Transport Services	3	3.01	system, traffic, vehicle, german, service, datum, software, mobility, company, technology, city, road, base, time, speed, transport, parking, project, driver, solution
	Parking Services	6	2.31	parking, app, system, driver, space, car, time, service, city, payment, parking space, park, available, information, smartphone, user, street, vehicle, provide, traffic
Sustainability	Air Quality & Pollution	5	2.35	air, emission, pollution, air quality, quality, vehicle, reduce, air pollution, transport, clean, city, government, local, earthsense, charge, work, help, electric, road, public
	Street Lighting	7	2.27	city, smart, smart city, energy, datum, lighting, technology, traffic, system, project, street, urban, provide, solution, sensor, light, time, help, streetlight, network
	Electric Vehicles	11	1.89	bus, passenger, system, electric, vehicle, technology, transport, public, emission, service, city, electric bus, operator, stop, route, school, help, time, bus lane, first

Figure 14 provides a taxonomy of the transportation domain extracted from a trans- portation industry-focussed technical magazine. The taxonomy is created using the param- eters and macro-parameters discovered from the TTI magazine. The first level branches show the macro-parameters, the second level branches show the discovered parameters, and the third level branches show the most representative keywords.

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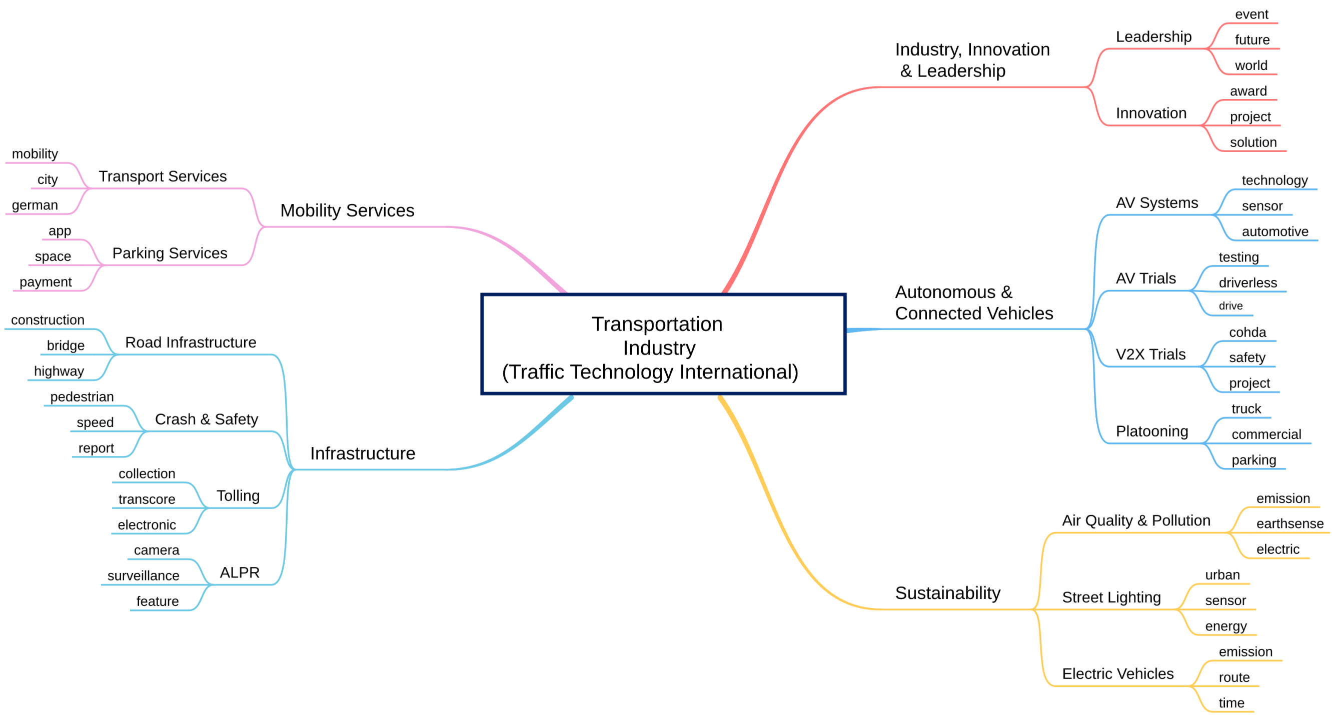

Figure 14. Taxonomy extracted from Traffic Technology International Magazine Dataset

5.2. Quantitative Analysis (Traffic Technology International Magazine)

This Section discuss the term score, word score, intertopic distance map, hierarchical clustering and similarity matrix.

Figure 15 shows that only the top seven to ten keywords in each parameter actually represent the parameter when we evaluate the keywords (see Section 3.8). Because the probabilities of all the other possibilities are so close to one another, their ranking becomes more or less meaningless. When we analysed the top keywords per parameter to discover the parameter, we used this information to focus on the top seven or so keywords in each parameter.

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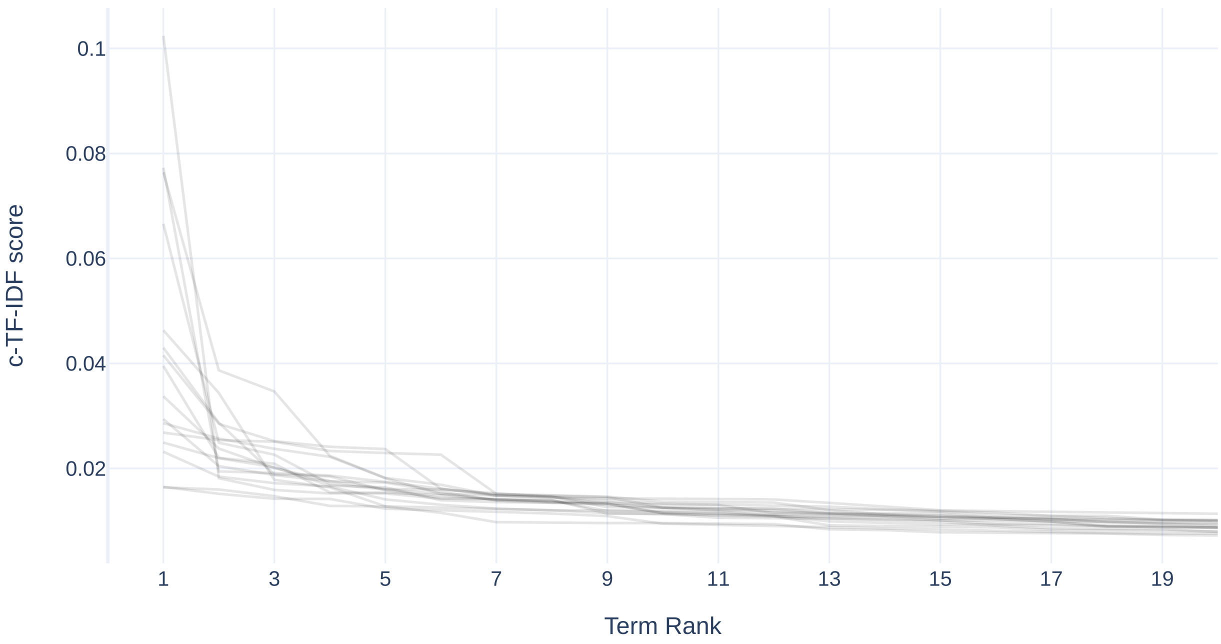

Figure 15. Term Score (Traffic Technology International Magazine)

Figure 16 depicts the top 5 keywords for each parameter. The importance score, or c-TF-IDF score, is used to order the keywords (see Section 3.8). There are 15 sub-figures and in each sub-figure, the horizontal line shows the importance score and the vertical line shows the parameter keywords.

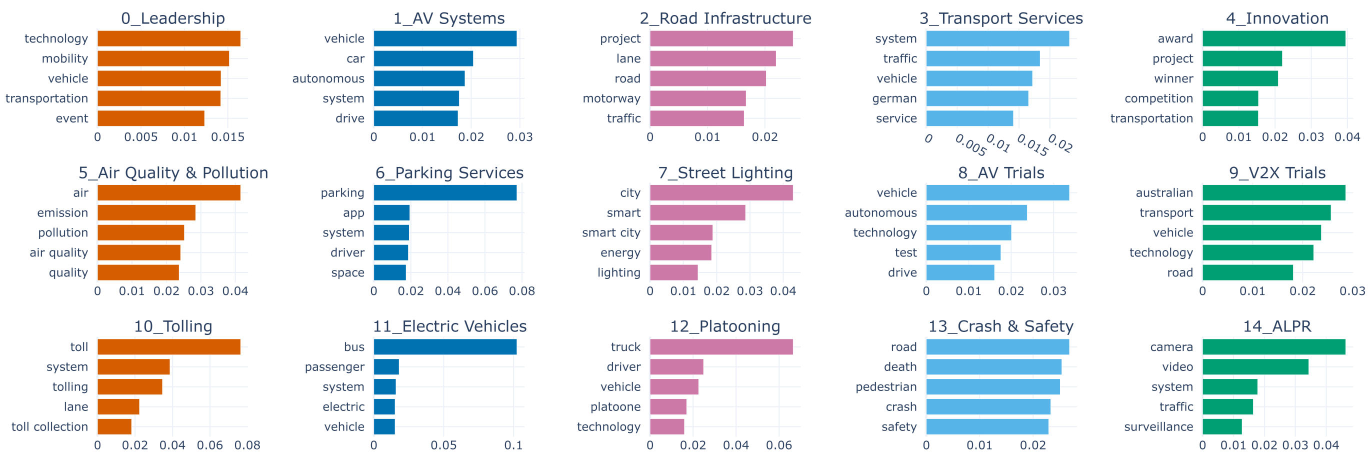

Figure 16. Magazine Article Parameter with Keywords c-TF-IDF Score

Figure 17 shows the intertopic distance map (see Section 3.8), where two clusters are clearly identified on the left-below corner side, and the right-upper side represents the three clusters. However, we manually tagged the parameters into five macro-parameters.

Figure 18 represents the hierarchical clustering of the 15 clusters and systematically pairs the clusters based on the similarity matrix (see Section 3.8). We noticed that initially, the clusters are grouped into five clusters: (1, 8, 9, 0, 3), (13, 2, 4), (11, 5, 7), (10), and (14, 6, 12). This automated hierarchical clustering grouped the clusters correctly, with some exceptions. Furthermore, based on our knowledge and magazine articles, we manually group the clusters that are discussed in Table 2.

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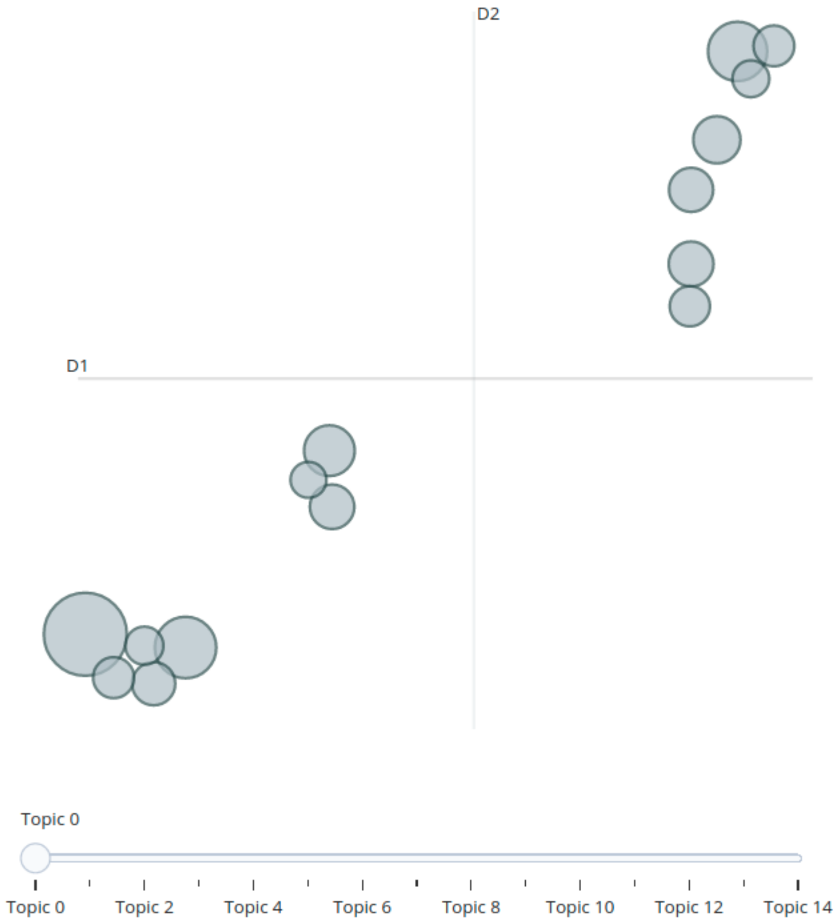

Figure 17. Intertopic Distance Map (Traffic Technology International Magazine)

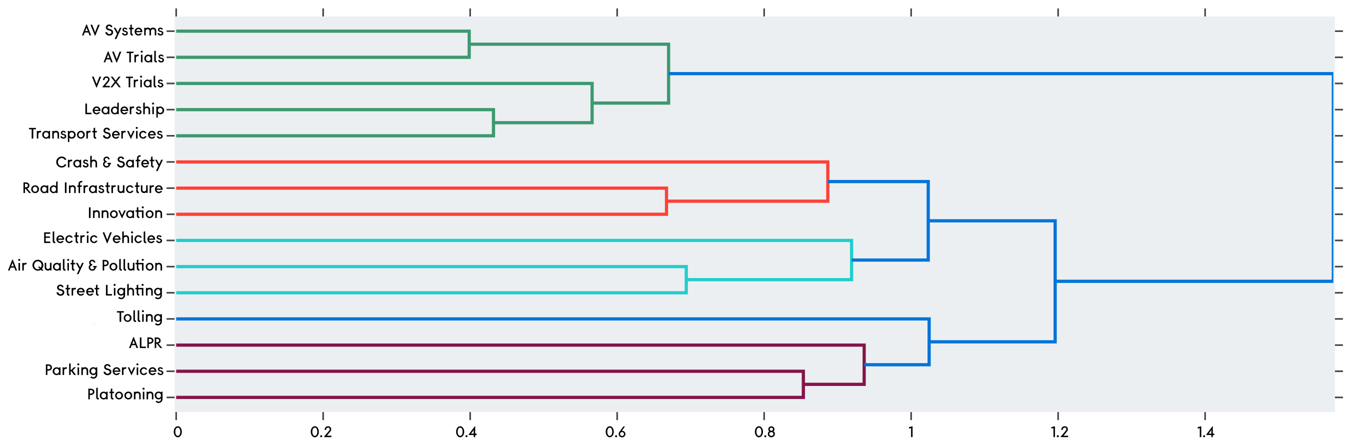

Figure 18. Hierarchical Clustering (Traffic Technology International Magazine)

Figure 19 visualises the similarity matrix among the parameters (see Section 3.8). We use the same configuration as discussed in Figure 11. The dark blue colour represents the highest similarity relationship between parameters, while the light green represents the lowest similarity. For example, cluster 3, labelled as Transport Services, and cluster 1, labelled as AV Systems, have high similarity scores as the main intention of AV systems is to improve transport services and make them more smooth and flexible. There is another high similarity between clusters 8 and 9, which are labelled as AV Trials and V2X Trials, respectively.

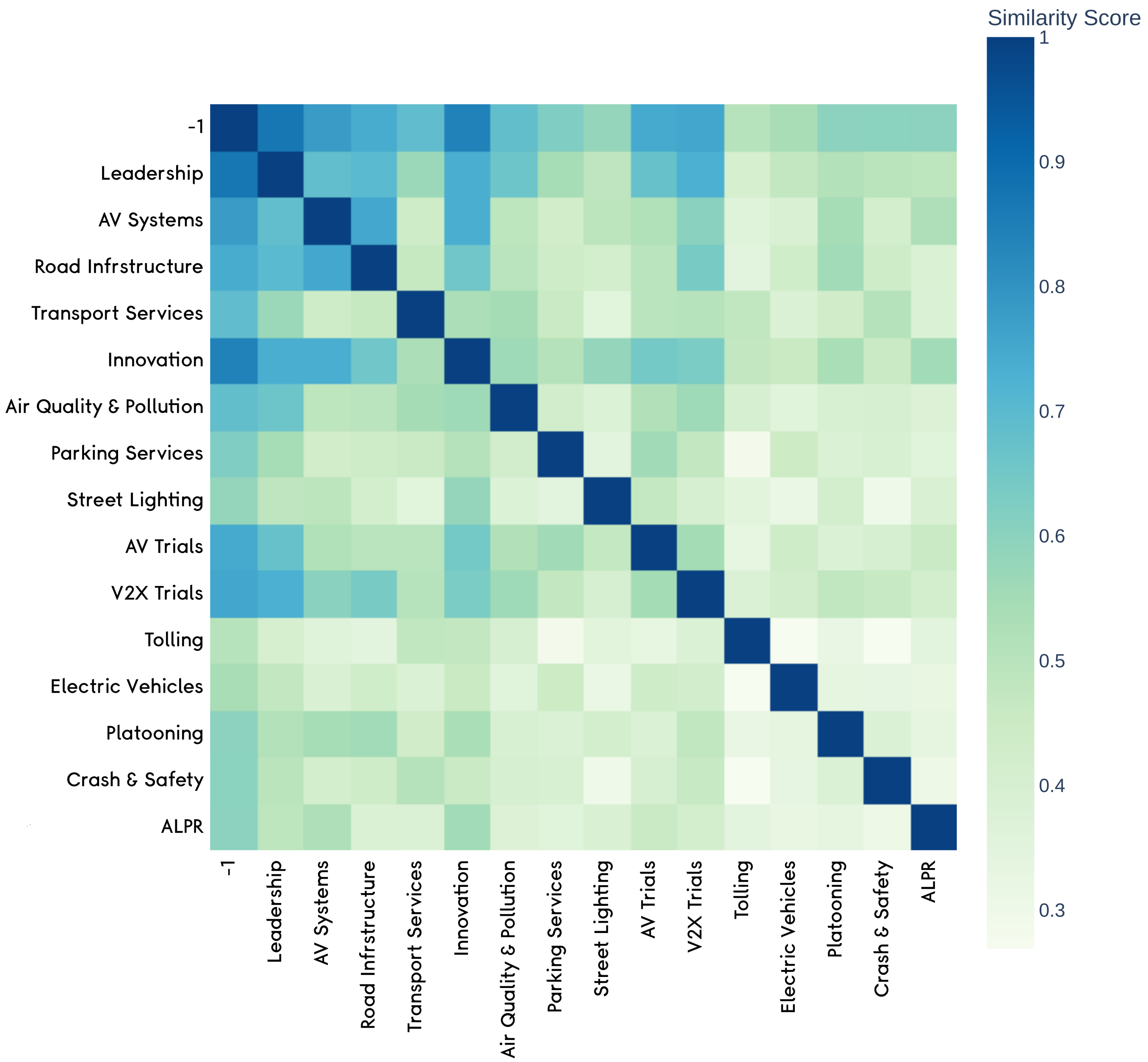

Figure 19. Similarity Matrix (Traffic Technology International Magazine)

5.3. Industry, Innovation, & Leadership

The macro-parameter Industry, Innovation, & Leadership includes two parameters: Leadership, and Competitive Innovation, which reveals events, appointments, innovations, and awards related information and topics. The Leadership parameter captures the transportation events and leadership news that have a high impact on transportation development. For example, the appointment of Angelos Amditis as ITS Europe chairman in 2018 [294], Laura Chace as CEO & president of ITS America in 2021 [295], and Laura Shoaf as the chair of the UK's transport group in 2021 [296], and much more news and topics. The Competitive Innovation parameter is about new innovations and projects related to transportation. It includes the following keywords: award, project, winner, competition, solution, and so on.We discovered an award-related announcement that occurred in Florida, and the Woolpert was awarded for operating district-wide aerial photogrammetry and various surveys [297].

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5.4. Autonomous & Connected Vehicles Systems

The macro-parameter Autonomous & Connected Vehicles Systems includes Au- tonomous Vehicles (AV) Systems, AV Trials, Vehicle-to-everything (V2X) Trials, Platooning / Truck Platooning. The AV system is designed to develop an autonomous driving vehicle by using several technologies, sensors, GPS, etc. This parameter reveals several significant innovations and projects through traffic technology international magazine articles, includ- ing the first thermal sensor-equipped production for AV [298], the first use of blockchain to provide connected vehicle data by CyberCar [299], a thermal sensor technology for the AV system was announced on November 5, 2019, by the Veoneer system [300], the first vehicle-to-cloud infrastructure for automated connected vehicles by SENSORIS [301], and so on. We found AV trials related news that illustrates the AV trials by Singapore's Land Transport Authority [302].

Communication between a car and any component that can be affected by the car is referred to as V2X communication. Platooning is a technology that helps vehicles drive together and boosts road capacity by applying the automated highway system to reduce the distance between automobiles or trucks.

5.5. Infrastructure

The macro-parameter Infrastructure includes Road Infrastructure, Crash & Safety, Tolling, and ALPR (automatic licence plate recognition). The Road Infrastructure is represented by the following keywords: project, lane, road, motorway, traffic, construction, bridge, improvement, scheme, work, design, tunnel, junction, etc. We uncovered the following example related to this parameter: Highways England (HE) marked a turning point in road construction, encouraging better-planned roadworks and more consistent travel on motorways and key trunk routes [303]. The Crash & Safety is presented by road, death, pedestrian, crash, safety, fatality, injury, speed, etc. We noted that UK road death was increased in 2016 [304]. Tolling is illustrated by toll, system, tolling, lane, toll collection, electronic, etc. We noticed that Canadas's A25 highway electronic tolling system was upgraded on October 24, 2017 [305]. ALPR is defined by the camera, video, system, traffic, surveillance, detection, plate, etc. The enforcement system employs over 120 Sicore ALPR cameras located at 80 locations along major arterial routes around the UK capital [306].

5.6. Mobility Services

The macro-parameter Mobility Services retains Transport Services and Parking Services. By applying our model, we found that the traffic enforcement system is one of the transport services [307]. The parking system is another solution to make transportation services more convenient. We found news that merged the parking payment solution and electric vehicle charging system in the UK [308].

5.7. Sustainability / Sustainable Infrastructure

The macro-parameter Sustainability includes Air Pollution & Quality, Street Lighting, and Electric Vehicles. Diminishing transport-sourced air pollution is one of the major concerns as the number of vehicles is dramatically increasing every day. We found the Wolverhampton project focused on diminishing air pollution and improving the air quality monitoring system [309].

Street lighting is one of the solutions for smart cities' public safety and traffic optimization. For example, CityIQ Edge collects and processes street-level video and audio information that will enable urban areas to handle day-to-day problems [310]. To reduce best solutions. The following news is an example of this parameter: The Department for Transport had contracted the UK's Transport Research Laboratory (TRL) to observe and evaluate the effectiveness and implications of low emission buses at 13 sites around the country [311].

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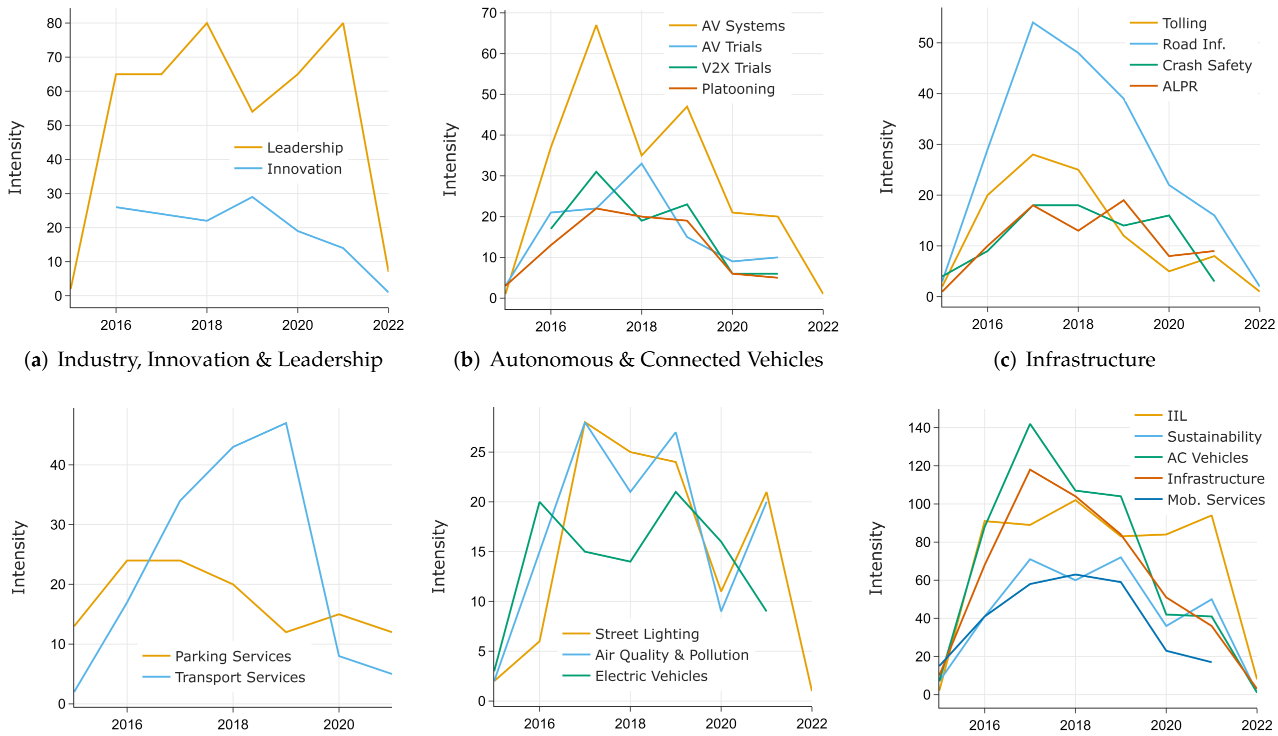
5.8. Temporal Analysis (Traffic Technology International Magazine)

In this section, we will analyze how the parameters have evolved over time. Figure 20 shows the temporal progression of the parameter, which is distributed into six sub-figures. The first five sub-figures represent the temporal progression of five macro-parameters, whereas the last sub-figure depicts the temporal progression of all macro-parameters. The vertical line of the graph indicates the number of articles, which is defined as the intensity. The temporal progression of the macro-parameter Industry, Innovation, & Leadership is depicted in Figure 20(**a**). Leadership has a higher intensity compared to the Innovation parameter. Figure 20(**b**) shows that the AV Systems intensity was increasing over time until 2017, but after that, the intensity declined. Figure 20(**c**) shows that the intensity of the Road Infrastructure parameter, which is one of the components of the macro-parameter Infrastructure, was high in 2017 and then gradually decreased. The temporal progression of macro-parameter Mobility Services, which includes two parameters, Parking Services and Transport Services, is shown in Figure 20(**d**). We observed that there are more articles related to Transport Services compared to Parking Services. The intensity of articles for the macro-parameter Sustainability, which includes three parameters: Street Lighting, Air Quality and Pollution, and Electric Vehicles, is depicted in Figure 20(**e**). Street Lighting and Air Quality & Pollution have both had the same peak value of 25 in 2017.

The temporal progression of all macro-parameters is summarized in Figure 20(**f**). In 2017, macro-parameters Autonomous & Connected Vehicles, Infrastructure, and Sustainability have the highest peak values of 140, 120, and 60, respectively.



(**a**) Industry, Innovation & Leadership (**b**) Autonomous & Connected Vehicles (**c**) Infrastructure

(**d**) Mobility Services (**e**) Sustainability (**f**) Macro-Parameters

Figure 20. Temporal Progression of Parameters (Traffic Technology International Magazine)

6. Academia: Transportation Parameters Discovery

We discuss in this section the parameters detected by our BERT model from the Web of Science. We provide an overview of the parameters and macro-parameters in Section 6.1. The quantitative analysis is discussed in Section 6.2. Subsequently, we discuss each macro- parameters in separate sections, Sections 6.3, to 6.8. Section 6.9 discusses the temporal analysis of the parameters and macro-parameters.

6.1. Overview and Taxonomy (Web of Science)

We detected a total of 50 parameters from the Guardian dataset using BERT. We skip cluster number 19 as it is related to Narrative Transportation [312–314], not relates to general transportation. These 49 parameters were grouped into six macro-parameters using the domain knowledge along with similarity matrix, hierarchical clustering, and other quantitative analysis methods. The methodology and process of the discovery of parameters and their groupings into macro-parameters have already been discussed in Section 3.

Table 3 and 4 list the parameters and macro-parameters of the academic dataset. The macro-parameters Policy, Planning & Sustainability; Transportation Modes; Logistics & SCM; Pollution; Technologies; and Modelling, are listed in Column 1 with the associated parameters (Column 2). Some parameters are merged, for example, the cluster No. 33 & 38, and 44 & 45 are merged as Road Safety and Freight & Logistics, respectively, in Table 3. The third column indicates the cluster number. The percentage of the number of articles is recorded in the fourth column. Our BERT model labelled 56.42% of articles as the outlier clusters. Consequently, we ignored this outlier clusters, and the rest of the 43.58% of articles are listed in the fourth column. The fifth column represents the top keywords associated with each parameter.

Table 3. Parameter and Macro-Parameters for Transportation (Source: Web of Science)

Macro-Parameters	Parameters	No.	%	Keywords
Policy, Planning & Sustainability	Land-Use Planning	5	1.47	urban, city, development, land, planning, transportation, public, sustainable, model, area, transport, spatial, system, transit, policy, economic, infrastructure, accessibility, regional, sustainability
	Smart Cities	31	0.43	smart, city, smart city, urban, system, datum, technology, citizen, transportation, service, public, concept, management, transport, energy, framework, transportation system, privacy, information, iot
	Low-Income Neighborhoods	39	0.36	job, worker, housing, commute, income, low income, low, transit, accessibility, employment, work, access, wage, job accessibility, poor, job seeker, seeker, live, area, household
	Urban Mobility	26	0.47	urban, city, growth, population, development, area, model, transportation, increase, transport, transit, demand, urban growth, network, new, land, agglomeration, spatial, build, urbanization
	Road Safety	33	0.41	accident, road, crash, driver, safety, vehicle, collision, traffic, fatality, weather, speed, risk, traffic accident, truck, cause, system, injury, drive, road accident, death
		38	0.36	pedestrian, walk, sidewalk, walking, neighborhood, environment, walk trip, trip, build environment, household, build, walkability, walkable, behavior, model, residential, pedestrian detection, safety, crossing, street
	Traffic Congestion	17	0.89	traffic, congestion, traffic congestion, system, road, urban, time, vehicle, city, transportation, problem, propose, network, datum, base, transportation system, control, model, travel, become
	Subways	41	0.34	subway, station, subway station, underground, passenger, subway system, line, subway line, system, pm, public, passenger flow, flow, transportation, network, public transportation, platform, urban, time, city
	Vehicle Ownership	16	0.95	car, vehicle, driver, drive, ownership, model, car ownership, car follow, datum, system, transportation, base, travel, consumer, traffic, follow, household, mode, driving, information
	EV & Charging	0	5.88	power, electric, energy, charge, battery, system, electric vehicle, vehicle, voltage, grid, control, fuel, propose, high, transportation, load, motor, current, model, converter
	Bike Sharing & Ridesourcing	10	1.17	bicycle, bike, cycling, cyclist, bike sharing, sharing, share, mode, public, trip, motorcycle, city, user, station, cycle, system, travel, public bicycle, transportation, sharing system
	Children & Schools	49	0.32	school, child, student, parent, travel, active, walk, parental, school travel, travel school, mode, active travel, youth, high school, distance, walk school, choice, influence, activity, factor
	Gender & Race Equality	48	0.32	woman, gender, health, homeless, black, care, man, barrier, need, transportation, service, social, treatment, segregation, individual, community, female, child, racial, lack
	Parking	46	0.33	parking, parking lot, parking space, lot, space, parking policy, congestion, driver, policy, traffic, time, cost, car, pricing, occupancy, system, parking system, model, area, park
	Tolling	47	0.32	toll, problem, network, travel, model, travel time, time, congestion, optimal, propose, traveler, method, objective, cost, transportation, approach, path, mode, uncertainty, base
	Tourism	23	0.50	tourism, tourist, destination, service, development, travel, tourism industry, accommodation, transportation, industry, tourism development, visitor, attraction, activity, village, economic, information, tour, resource, country
Transportation Modes	Road Transport	7	1.26	bus, passenger, transit, public, time, service, stop, public transportation, route, system, model, bus stop, travel, transportation, bus service, base, transport, vehicle, datum, bus route
	Rail Transport	1	2.85	railway, train, rail, system, passenger, hsr, speed, line, high speed, transportation, operation, model, high, transport, track, traction, method, freight, propose, base
	Air Transport	3	2.19	airport, airline, flight, air, aircraft, passenger, aviation, air transportation, drone, service, model, system, market, transportation, network, air traffic, operation, datum, cost, time
	Marine Transport	13	1.08	ship, port, maritime, container, shipping, sea, vessel, ferry, model, cargo, risk, transportation, inland, system, seaport, terminal, operation, analysis, transport, base
Logistics & SCM	Freight & Logistics	44	0.33	business, logistic, company, industry, service, market, international, transportation, customer, growth, factor, sector, important, port, datum, transport, economic, investment, process, development
		45	0.33	cost, carrier, model, transportation, activity, freight, service, ltl, reduce, approach, less, analysis, transportation cost, inventory, base, process, customer, total, supply chain, implication
	Food Supply Chain	36	0.36	food, chain, product, meal, supply, supply chain, food supply, waste, food waste, temperature, production, fresh, environmental, perishable, consumer, impact, food production, store, transportation, fresh food
	Cost & Pricing	21	0.59	price, cost, firm, transportation cost, equilibrium, consumer, market, profit, auction, product, transportation, model, competition, location, valuation, segment, good, game, low, shipper

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Table 4. Parameter and Macro-Parameters for Transportation (Source: Web of Science)

Macro-Parameters	Parameters	No.	%	Keywords
Pollution	Air Quality & Pollution	8	1.20	concentration, pm, air, pollution, source, emission, high, particle, pollutant, dust, winter, exposure, air pollution, contribution, summer, ozone, period, particulate, level, atmospheric
		14	1.01	emission, carbon, co, carbon emission, sector, energy, reduction, co emission, reduce, policy, transportation, climate, emission reduction, transport, low carbon, gas, greenhouse, greenhouse gas, industry, change
		25	0.47	emission, climate, climate change, change, carbon, co, sector, global, energy, environmental, co emission, warming, adaptation, global warming, carbon dioxide, dioxide, impact, transportation, policy, mitigation
		42	0.34	chinese, policy, development, city, chinese city, transportation, government, port, industry, quality, chinese government, economic, urban, air, air quality, level, emission, factor, market, pollution
	Soil Pollution	29	0.44	root, cd, plant, soil, rice, concentration, accumulation, shoot, metal, content, stress, gene, uptake, seedling, treatment, cadmium, high, decrease, increase, leave
		32	0.41	soil, metal, heavy metal, heavy, concentration, sample, plant, pollution, risk, cd, high, contamination, mining, area, water, source, environmental, dust, health, human
		4	1.59	sediment, water, soil, concentration, metal, river, high, surface, heavy metal, sample, heavy, source, pah, lake, distribution, organic, fish, erosion, area, process
	Noise Pollution	43	0.33	noise, pollution, traffic noise, noise pollution, sleep, noise level, exposure, annoyance, level, traffic, night, transportation noise, road traffic, air, health, air pollution, hour, road, cancer, noise exposure
	Fuel Types & Effects	24	0.49	fuel, diesel, engine, emission, biodiesel, production, biomass, energy, gasoline, oil, ethanol, biofuel, gas, renewable, blend, produce, cycle, diesel engine, life cycle, feedstock
	Coal Transport & Consumption	40	0.35	coal, plant, power plant, power, emission, electricity, gas, mine, mining, energy, production, fire power, coal fire, coal transportation, co, fire, transportation, fuel, thermal, natural gas
	Waste Management	9	1.19	waste, waste management, collection, management, solid, solid waste, disposal, landfill, recycling, municipal, environmental, treatment, cost, municipal solid, waste collection, collection transportation, impact, facility, material, hospital
	Waste Water Treatment	35	0.36	water, sludge, wastewater, treatment, sewer, sewage, removal, microplastic, process, pipe, environmental, wastewater treatment, desalination, concentration, environmental load, sample, reduce, high, effluent, oxygen
	Incident & Risk Management	15	0.97	oil, spill, pipeline, oil spill, oil gas, crude, crude oil, gas, petroleum, price, oil price, accident, hydrocarbon, corrosion, water, refinery, leakage, process, risk, transportation
Technologies	ITS	11	1.14	decade, last decade, last, transportation, vehicle, system, datum, past, past decade, base, technology, application, traffic, network, new, model, review, development, logistic, impact
	Computer Vision	20	0.64	vehicle, image, detection, recognition, video, plate, system, license plate, license, method, propose, object, detect, traffic, color, tracking, feature, intelligent, algorithm, base
	Smartphone Sensing	22	0.53	smartphone, phone, mobile, user, datum, mobile phone, application, sensor, information, system, mode, device, transportation, gps, time, location, base, transportation mode, service, mobility
	VANET	2	2.42	wireless, communication, network, vehicular, propose, system, vehicle, node, scheme, base, application, vanet, intelligent, mobile, protocol, sensor, intelligent transportation, access, transmission, transportation system
		28	0.44	vehicular, vehicle, application, network, system, transportation, communication, transportation system, base, protocol, intelligent, attract, vanet, intelligent transportation, researcher, propose, route, vehicular network, performance, service
		30	0.43	security, attack, privacy, vehicle, authentication, protocol, communication, network, secure, scheme, internet, propose, vanet, base, vehicular, system, iot, node, user, intelligent
	Autonomous Vehicles & Taxis	27	0.46	taxi, driver, taxi driver, passenger, taxi service, service, time, travel, share, demand, datum, taxi demand, trip, ride, autonomous taxi, autonomous, model, system, base, vehicle
	IoT Security	18	0.85	iot, internet, smart, thing, internet thing, device, security, network, application, datum, cloud, system, technology, service, thing iot, propose, intelligent, information, base, communication
	Physical Layer Communication	34	0.38	antenna, radar, frequency, system, communication, band, signal, radio, range, design, intelligent, intelligent transportation, propose, bandwidth, target, application, propose antenna, light, modulation, gain
	Robot Mobility	37	0.36	robot, mobile robot, robotic, task, system, mobile, control, approach, object, environment, problem, propose, transportation, sensor, present, base, motion, swarm, obstacle, time
Modelling	Traffic Flow Modelling	12	1.14	traffic, traffic flow, flow, prediction, datum, model, time, method, propose, network, road, system, real, forecasting, speed, traffic datum, base, intelligent, vehicle, accuracy
	Transportation Modelling Algorithms	6	1.27	problem, algorithm, fuzzy, solve, solution, propose, optimization, method, model, objective, transportation problem, optimal, cost, genetic, programming, time, transportation, multi, network, base

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Figure 21 provides a taxonomy of the transportation domain extracted from academia. The taxonomy is created using the parameters and macro-parameters discovered from the Web of Science dataset. The macro-parameters are shown on the first level of branches, the discovered parameters are shown on the second level of branches, and the most representative keywords are shown on the third level of branches.

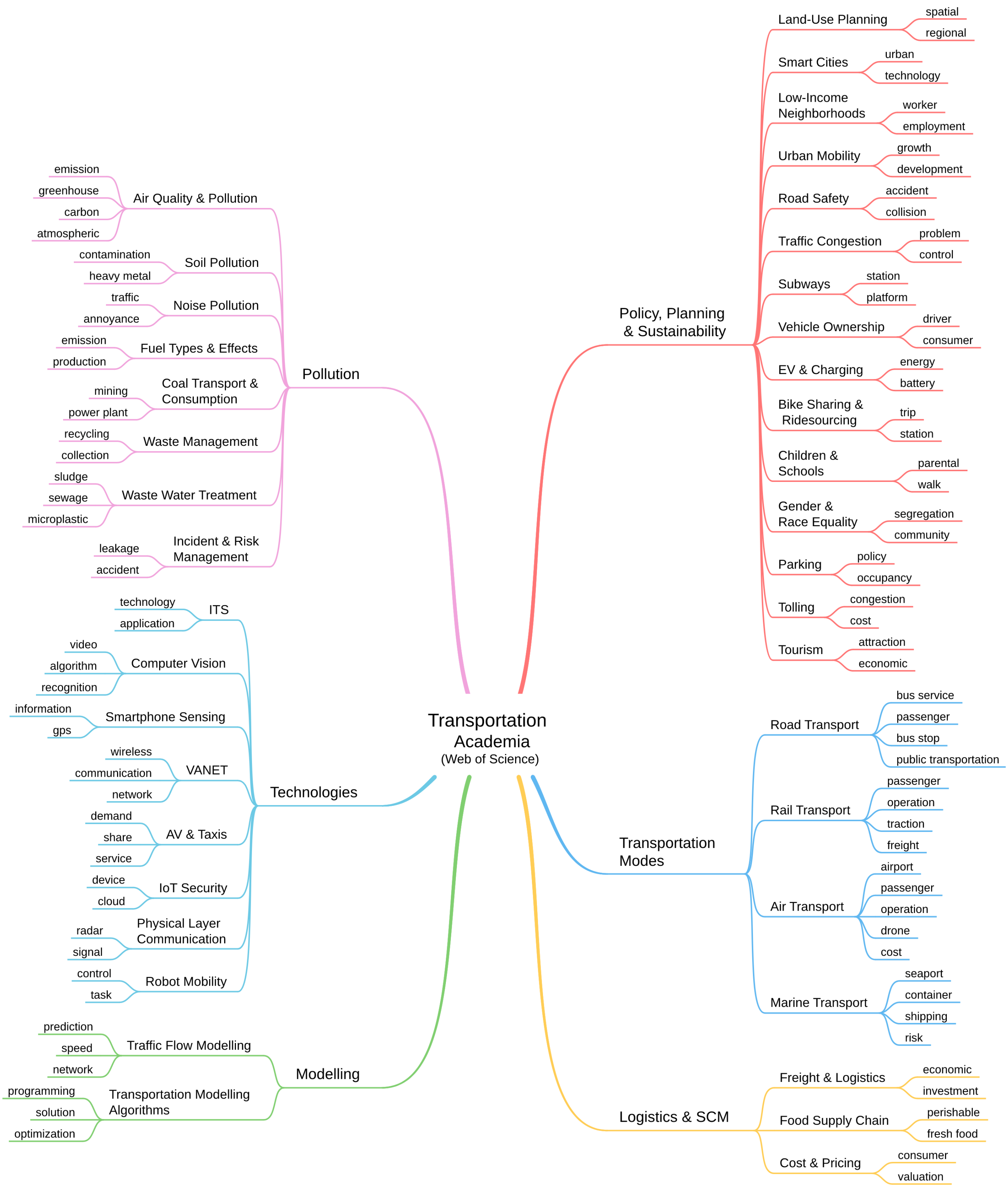

Figure 21. Taxonomy extracted from Web of Science dataset

6.2. Quantitative Analysis (Web of Science)

This Section discuss the term score, word score, intertopic distance map, hierarchical clustering and similarity matrix.

Figure 22 depicts that only top thirteen keywords in each parameter actually represent the parameter when we evaluate the keywords (see Section 3.8). Because the probabilities of all the other possibilities are so close to one another, their ranking becomes more or less pointless. When we investigated the top keywords per parameter to label the parameter, we used this information to focus on the top ten or so keywords in each parameter.

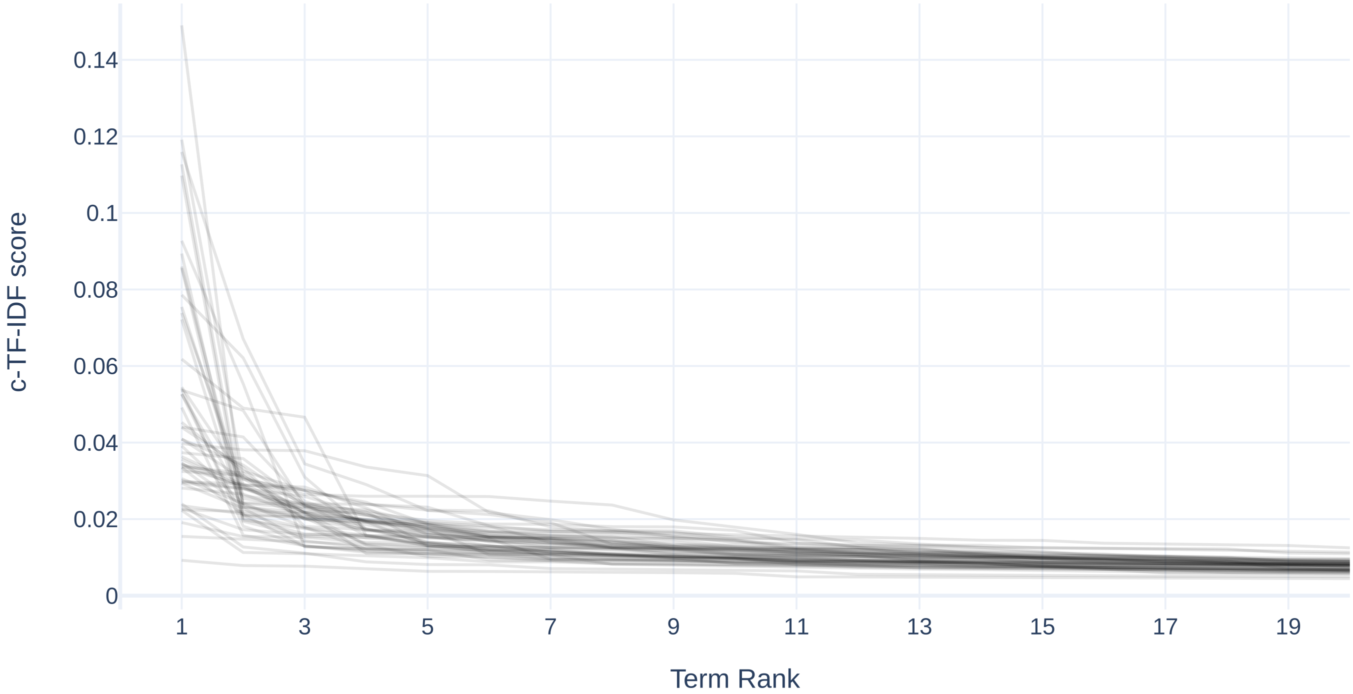

Figure 22. Term Score (Web of Science)

Figure 23 shows the top 5 keywords for each parameter. The importance score, or c-TF-IDF score, is used to order the keywords (see Section 3.8). There are 50 sub-figures and in each sub-figure, the horizontal line shows the importance score and the vertical line shows the parameter keywords.

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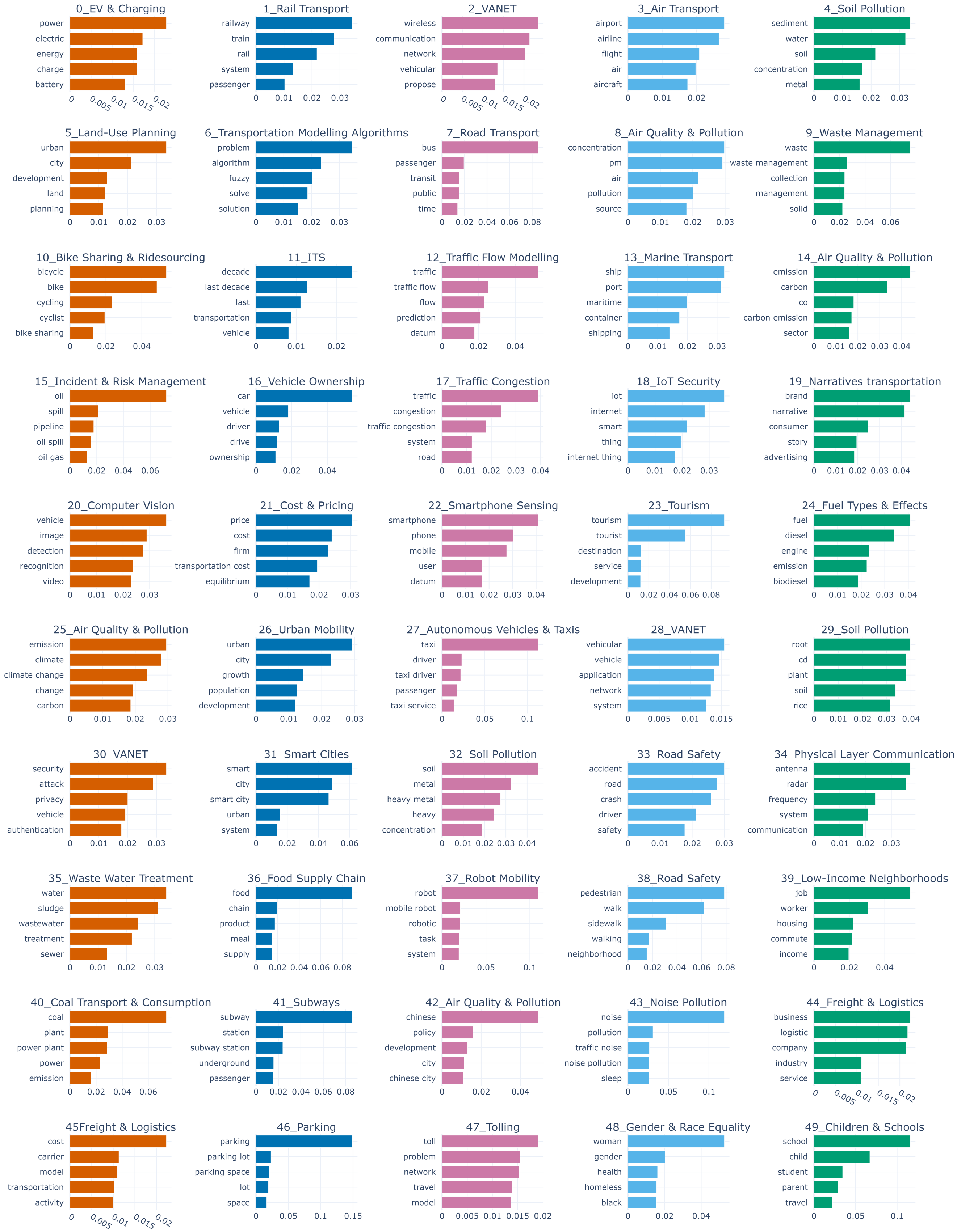

Figure 23. Academic Article Parameter with Keywords c-TF-IDF Score

Figure 24 shows the intertopic distance map (see Section 3.8), where nine groups of parameters are clearly identified. In the bottom left corner, one group of parameters contains more parameters than the others. There are two small-size parameters on the right side, which are comparatively small. However, we notice that the BERT model clusters are not very well clustered, so we used domain knowledge and other information to label them. Additionally, we manually labelled the parameters into six macro-parameters.

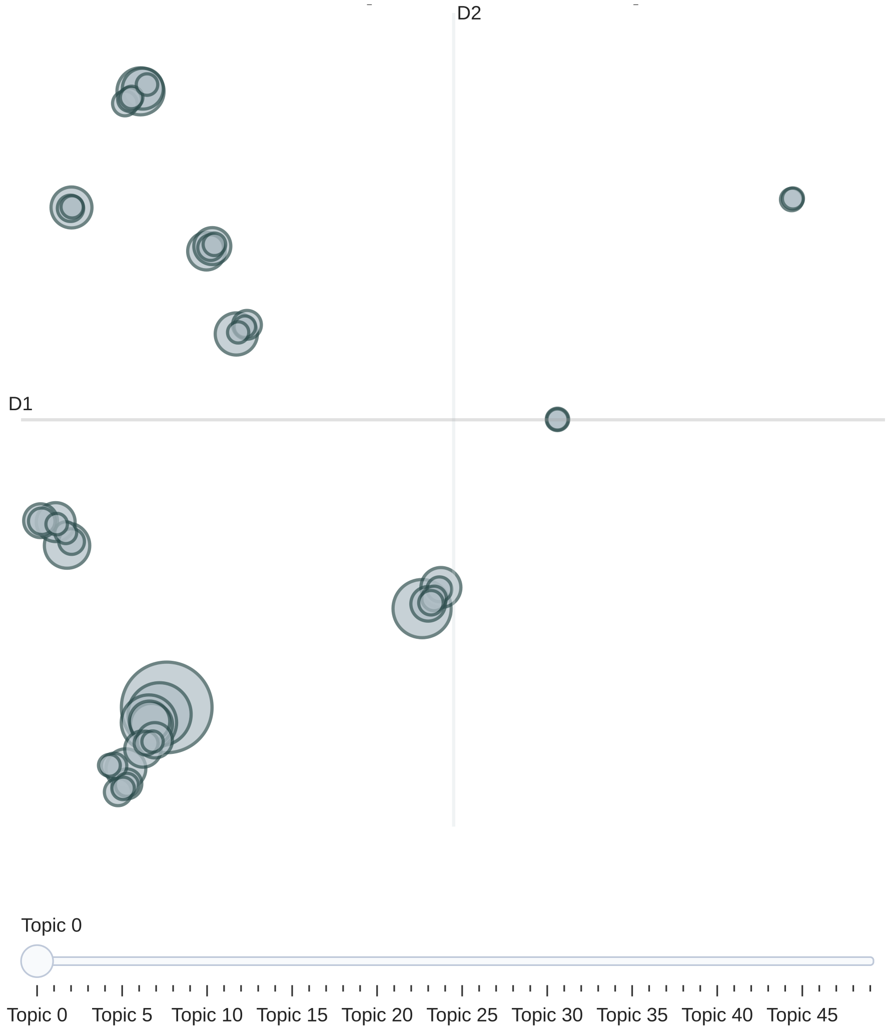

Figure 24. Intertopic Distance Map (Web of Science)

Figure 25 describes the hierarchical clustering of the 50 clusters and systematically pairs them based on the cosine similarity matrix (see Section 3.8). This automated hierarchical clustering grouped the clusters correctly, with some exceptions.

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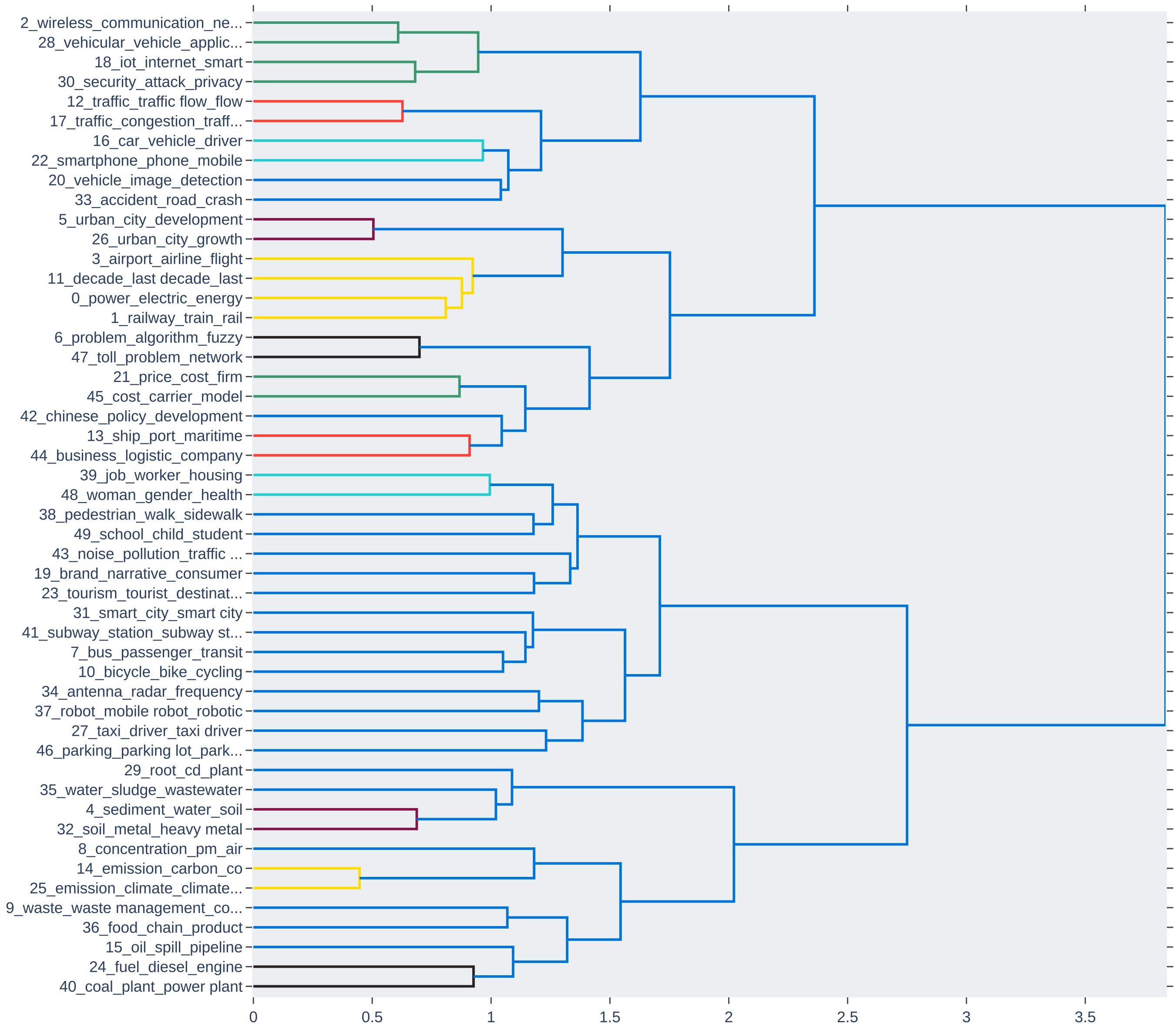

Figure 25. Hierarchical Clustering (Web of Science)

Figure 26 visualises the similarity matrix among the parameters (see Section 3.8). We use the same configuration as discussed in Figure 11. The dark blue colour represents the highest similarity relationship between parameters, while the light green represents the lowest similarity. For example, cluster 12, labelled as Traffic Flow Modelling, and cluster 17, labelled as Traffic Congestion, have high similarity scores as the main focus on traffic. There is another high similarity between clusters 2 and 30, and both are labelled as VANET.

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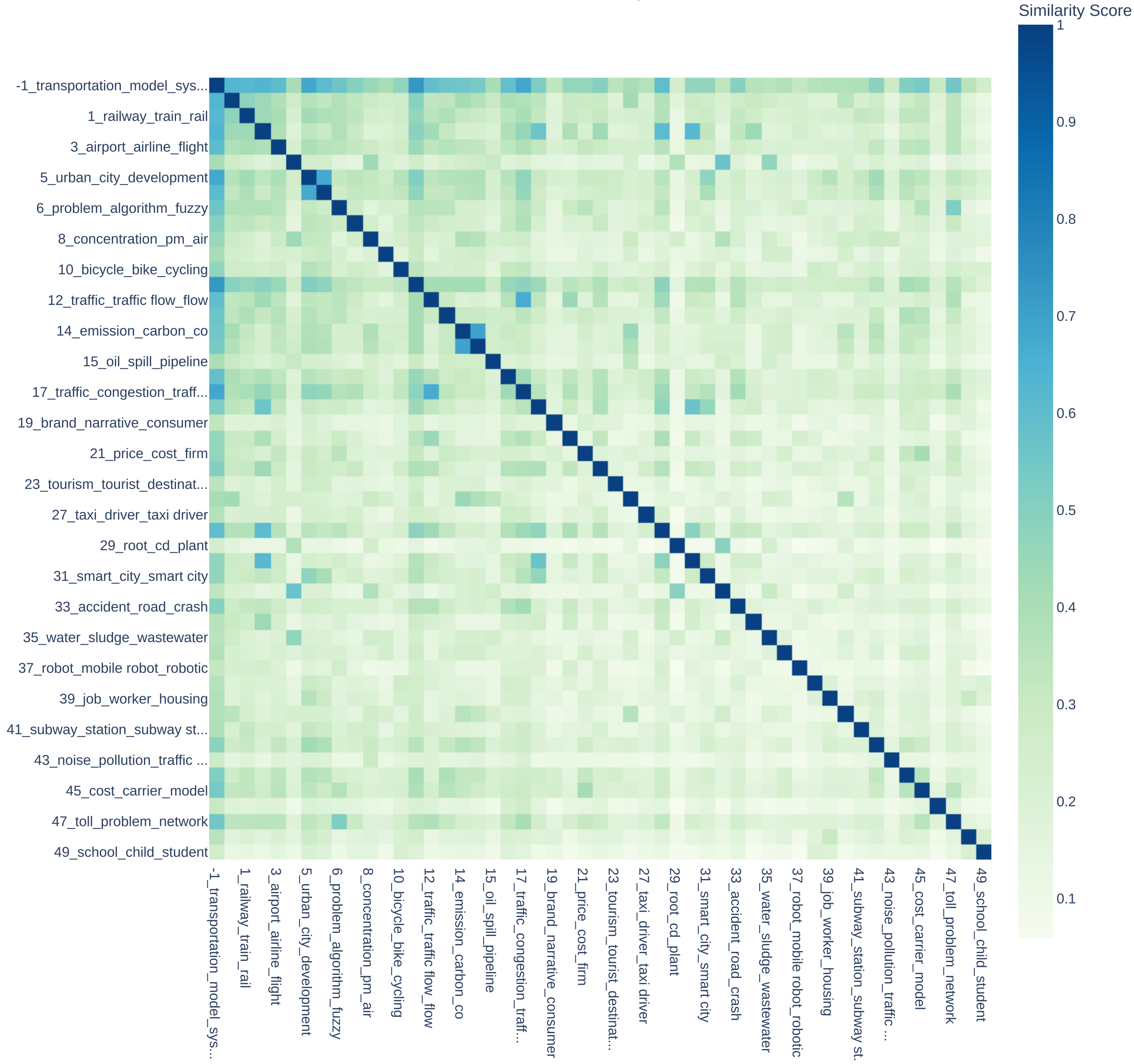

Figure 26. Similarity Matrix (Web of Science)

6.3. Policy, Planning & Sustainability

The macro-parameter Policy, Planning & Sustainability discuss the policy, services, planning, and development related to transportation. It includes fifteen parameters, includ- ing Land-Use Planning, Smart Cities, Low-Income Neighborhoods, Urban Mobility, Road Safety, Traffic Congestion, Subways, Vehicles Ownership, Electric Vehicles & Charging, Bike Sharing & Ridesourcing, Children & Schools, Gender & Race Equality, Parking, Tolling, and Tourism.

The Land-Use Planning parameter discussed how to manage and map the transporta- tion area based on several criteria. For example, analysing the usage of spatial metrics & population data to map the urban transportation areas [315] or the impact of walkability to the metro station on retail location choice [316], types of suburbanization [317], etc. The Smart Cities parameter refers to urban areas that have experienced rapid growth and are technologically sophisticated. Crowd management [318], green transportation [319], and improving the quality of transportation systems [320] are the important areas of Smart Cities. With the progress of civilization and rapid industrialization, urban mobility become

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one of the key research areas in transportation. The investigation of urban mobility is the key factor for the policy-makers, and transport planners. Road Safety Parameter is the combination of parameters numbers 33 and 38. This parameter is related to the research on road accidents & crashes, traffic collisions, pedestrian walking & safety [321], sidewalks, etc.

Transportation affordability is one of the major issues in low-income neighbourhoods. Extensive research work has been done to analyse the issue and co-relation between transportation and low-income households. [322] examination of transportation services and policies between 1960 and 2000 in order to determine the relationship between poverty and public transportation.In another study, the transportation affordability of low-income people in US cities was examined, and it was discovered that transit-rich neighbourhoods are more inexpensive than auto-oriented ones owing to reduced transportation costs [323]. With the advancement of civilization and fast industrialization, urban mobility has become one of the major research areas in transport research. For policymakers and transportation planners, investigating urban mobility is fundamental [324].

Hybrid Electric Vehicles (HEVs), Battery Electric Vehicles (BEVs), Plug-in Electric Vehicles (PEVs), and Plug-in Hybrid Electric Vehicles (PHEVs) are the most prevalent forms of electric vehicles. There are two types of charger systems: off-board and on-board, with uplink and downlink power transmission. A study of battery charger layouts, infrastructure for PHEVs, and charging voltage levels is provided by [325]. Zhang et al. [326] demonstrated efficient planning of PEVs fast-charging stations while taking into account interactions between transportation and electrical networks. In other research, Fernandez et al. [327] evaluated the impact of PEVs on distribution networks. The PHEVs batteries are charged at home from the outlet or corporate car park, which has an extra impact on the distribution grid (i.e., voltage deviations and power loss) [328].

Recently, research on Bike Sharing & Ridesourcing are dramatically increased after Covid-19. There is a lot of research work ongoing to improve the quality of resourcing and bike-sharing system. For example, the survey of ridesourcing research [329–331], shared autonomous vehicles [331–333], the survey of Bike Share [334], travellers experience after using the ride-sharing services, like Uber [335].

6.4. Transportation Modes

The macro-parameter Transportation Modes includes four parameters: Road Transport, Rail Transport, Air Transport, Marine Transport. Road Transport parameter is related to public transportation. Normally, there are three types of public transportation in rular areas, such as intercity buses, demand-responsive transit, and deviated fixed-route transit, which is discussed in this study. One of the keys to bringing sustainable growth and a higher quality of life to urban areas is better public transit planning, control, and management [336]. Public transit uses road space more effectively than private traffic and creates fewer accidents and pollutants. Furthermore, owing to the impractical nature of public transit in many places, many choose to use private transportation rather than public transportation [337]. Much research has been done to improve the quality of public transportation. For example, evaluation of road transportation in Brazil [338], analysing passenger satisfaction with public transportation in Romania [339], passenger flow prediction in public transport based on the timetable in India [340], effective system design for public transport in the USA [341], etc.

The Rail Transport parameter shows key research areas in rail transportation, such as high-speed railways [342], rail freight transportation [343], risk management [344], railway transit traffic [345], and train services [346]. The objective of high-speed rail (hsr) is to enhance mobility via inter-city conveyance and facilitate financial growth. In October 1964, Japan's first modern high-speed rail line opened, linking Tokyo and Osaka at a maximum speed of 210 km/h [347]. In 1976, British Railways established a high-speed train link between London and Bristol. Following that, France started its first high-speed rail service between Paris and Lyon in 1981. Since then, several European countries, including Spain,

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Germany, Italy, Belgium, and the Netherlands, have built HSR lines. South Korea built its first high-speed rail line between Daegu and Seoul in 2004, which was later extended to Busan in 2009, while Taiwan began service between Taipei and Kaohsiung in 2007. China declared HSR tracks in 2016, about 38,000 km by 2025 [348].

The Air Transport parameter is represented by keywords airport, airline, flight, air, aircraft, passenger, aviation, air transportation, and others. It discusses the environmental impact of air transportation with respect to air pollution, noise and climate change [349]. Marine transport parameter is defined by the keywords ship, port, maritime, container, shipping, sea, vessel, ferry, model, cargo, etc. Marine transportation accounts for 80–90% of worldwide trade, transporting about 10 billion tonnes of cartons and solid-liquid weighty cargo across the world's oceans each year [350]. Some research has been done on ma- rine transportation trade [351,352], waterway or marine transportation systems [33,34], waterway traffic flow modelling [353], and so on,

6.5. Logistics & SCM

The macro-parameter Logistics & SCM comprises three parameters, the cluster No. 44 and 45 are combined as Freight & Logistics, Food Supply Chain, and Cost & Pricing. The Logistics & SCM parameter contains the following keywords, business, company, industry, service, freight, and others. The parameter relates to freight transportation, where companies or industries are using technologies to evaluate and improve their business models, logistics services, and activities. For example, marine transportation contributes 75% of all international freight [36,354], and as international freight increases, seaports need to improve their infrastructure to maintain the services and market demand. Inter- national freight transportation should be expanded to promote the growth of the logistics industry [355,356].

The Food Supply Chain parameter is represented by keywords including food, chain, product, meal, supply, supply chain, food supply, waste, food waste, temperature, etc. This parameter is associated with research aimed at enhancing the quality and safety of industrial food supply chain management. [357] presented an architecture for goods supply chain management with three key elements: real-time surveillance of the goods to reduce lost and perishable goods; anticipating the heat of the package; and triggering an alarm if the goods are not reserved under the acceptance conditions. Fresh food transportation is another research area in the Food SCM parameter. A mathematical model was proposed by [358] to distribute the fresh food to the end customer. The distributed ledger and blockchain technologies are also used in the agri-food supply chain [359].

The Cost & Pricing parameter is an important research area in transportation. For example, the spatial price policy under transportation asymmetry [360], reducing transportation carrier cost [361], and analysis of the global transportation system [362].

6.6. Pollution

The macro-parameter Pollution contains eight parameters namely Air Quality & Pollution, Soil Pollution, Noise Pollution, Fuel Types & Effects, Coal Transport & Consumption, Waste Management, Waste Water Treatment, and Incident & Risk Management. The transportation industry is responsible for around 30% of the greenhouse emissions that contribute to global warming [363]. In recent times, air pollution in transportation has become a major public concern. Consequently, it is crucial to enhance transport efficiency to keep urban air quality [364]. A number of studies have examined the levels of exposure to presumed air pollutants such as VOCs (volatile organic compounds)[365]. Traffic congestion also has an impact on air pollution & quality [366].

Transportation is a major contributor to soil pollution. Railway transport, for example, pollutes nearby soils with heavy metals. Heavy metal contamination has a significant detrimental influence on the natural environment, including decreased enzyme activity in soil and ecosystem destruction [367]. Noise pollution, which is mostly caused by transportation and automobile traffic [368], is a significant environmental contaminant because of its physical and mental impacts on humans.

Fuel Types & Effects parameter includes several types of fuels keywords like diesel, biodiesel, gasoline, oil, biofuel, etc. Biofuel use has an impact on carbon dioxide emission in the United States transportation [369]. To determine more sustainable fuel is another area of research. [370] analyze the factors which help to choose between ethanol and gasoline for the flex-fuel vehicles. Bayramoğlu et al. [363] analyze the valve lift effects on the diesel engine.

6.7. Technologies

ITS, Computer Vision, Smartphone Sensing, VANET, Autonomous Vehicles & Taxis, IoT Security, Physical Layer Communication, and Robot Mobility are the eight parameters of macro-parameter Technologies.

Intelligent Transportation Systems (ITS), which have seen substantial advancement in the recent decade, have been recognized as viable solutions to improve the transportation system's safety and reliability [371].

Computer Vision parameter is the state-of-the-art research area including vehicle detection, vehicle type recognition, vehicle colour recognition [372], automatic license plate recognition [75], tracking moving vehicles, incident detection through the image processing task, vehicle counting system, traffic light detection, pedestrian detection, traffic sign recognition, etc.

Smartphone Sensing parameter is another research area in the transportation field. Transport organisations actively promote public transportation to alleviate the traffic congestion produced by private vehicles. To increase the number of passengers using public transport, transport authorities can evaluate their local & premium services and market policies by analysing the travel patterns and regularity. For example, Ma et al. [373] proposed a data-mining process to identify the travel patterns in China based on the temporal and spatial features of Chinese smart card transaction data.

VANET referred to as Vehicular ad-hoc networks, encloses V2V (vehicle-to-vehicle) and V2I (vehicle-to-infrastructure) communication architectures to enhance navigation, road safety, and other transport services. We noticed that VANET has been the most active research field for more than ten years. The top three survey papers for VANET are [74,374,375], which provide an overview of VANET.

The parameter Autonomous vehicles, also known as self-driving cars or driverless cars, have the ability to reduce travel time, increase road safety, improve fuel efficiency, and provide automatic parking facilities [376]. More research work is ongoing to improve the performance and quality of AV systems. For example, Haboucha et al. [377] discussed user preference concerning AV. In other research, a cost analysis of several types of AV was presented by [378].

6.8. Modelling

The macro-parameter Modelling includes two parameters Traffic Flow Modelling, and Transportation Modelling Algorithms. Traffic flow models are important for analysing the performance of ITS applications. Extensive research work has been done on traffic flow models. For example, traffic flow prediction [379], traffic speed prediction [380], traffic violation detection, traffic sign detection, traffic congestion prediction, traffic data collection methods and passenger flow prediction [381]. Traffic coordination and monitoring massively depend on the traffic flow model. To solve the transportation modelling problems, i.e. fuzzy transportation problem, where transportation source, destination, and time are represented as exponential fuzzy numbers, transportation scheduling problem, transport shipment problem, transport parameters (such as cost, capacity, speed) problem, and transportation network design problem, the researcher proposed several algorithms. For example, the genetic algorithm is used to solve the solid transportation problem [382].

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6.9. Temporal Analysis (Web of Science)

In this section, we will analyse how the parameters have developed over time. Figure 27 shows the temporal progression of the parameter, which is distributed into eight sub-figures. The first two sub-figures represent the temporal progression of Policy, Planning & Sustainability parameter by showing seven, and eight parameters, respectively. The next five macro-parameters show the temporal progression of Transportation Modes, Logistics & SCM, Pollution, Technologies, and Modelling, respectively. The last sub-figure depicts the temporal progression of all macro-parameters.

The vertical line of the graph indicates the number of articles, which is defined as the intensity. The temporal progression of the macro-parameter Policy, Planning & Sustainability is depicted in Figure 27(**a**), and Figure 27(**b**) for better visualisation. We EV & Charging has a higher intensity compared to the other parameters. Figure 27(**c**) shows that the Rail Transport intensity was increasing over time until 2017, and also more research was done on this parameter.

The intensity of articles for the macro-parameter Logistics & SCM, which includes three parameters: Cost & Pricing, Freight & Logistics and Food Supply Chain, is depicted in Figure 27(**d**). Freight & Logistics has the highest peak of about 14 in 2017. The temporal progression of macro-parameter Pollution, which includes eight parameters, is shown in Figure 27(**e**). We observed that there are more articles related to Air Quality & Pollution, and Coal Transport & Consumption, compared to others. Figure 27(**f**) shows the parameters of the Technologies macro-parameter, where we observed that there is more research was done on the VANET parameter. The intensity of articles for the macro-parameter Modelling, which includes two parameters: Traffic Flow Modelling, and Transportation Modelling Algorithms, is depicted in Figure 27(**g**). We noticed that more research work was done on the Transport Flow Modelling parameter. The temporal progression of all macro-parameters is summarised in Figure 27(**h**). In 2019, we discovered that the macro-parameter Policy, Planning, & Sustainability has the highest peak value of 350. Pollution has the highest peak in 2021, about 250. The macro-parameter Technologies and Transportation Modes intensity were about 150 between 2016 and 2020. There has been less research on macro-parameter Modelling, Logistics & SCM.

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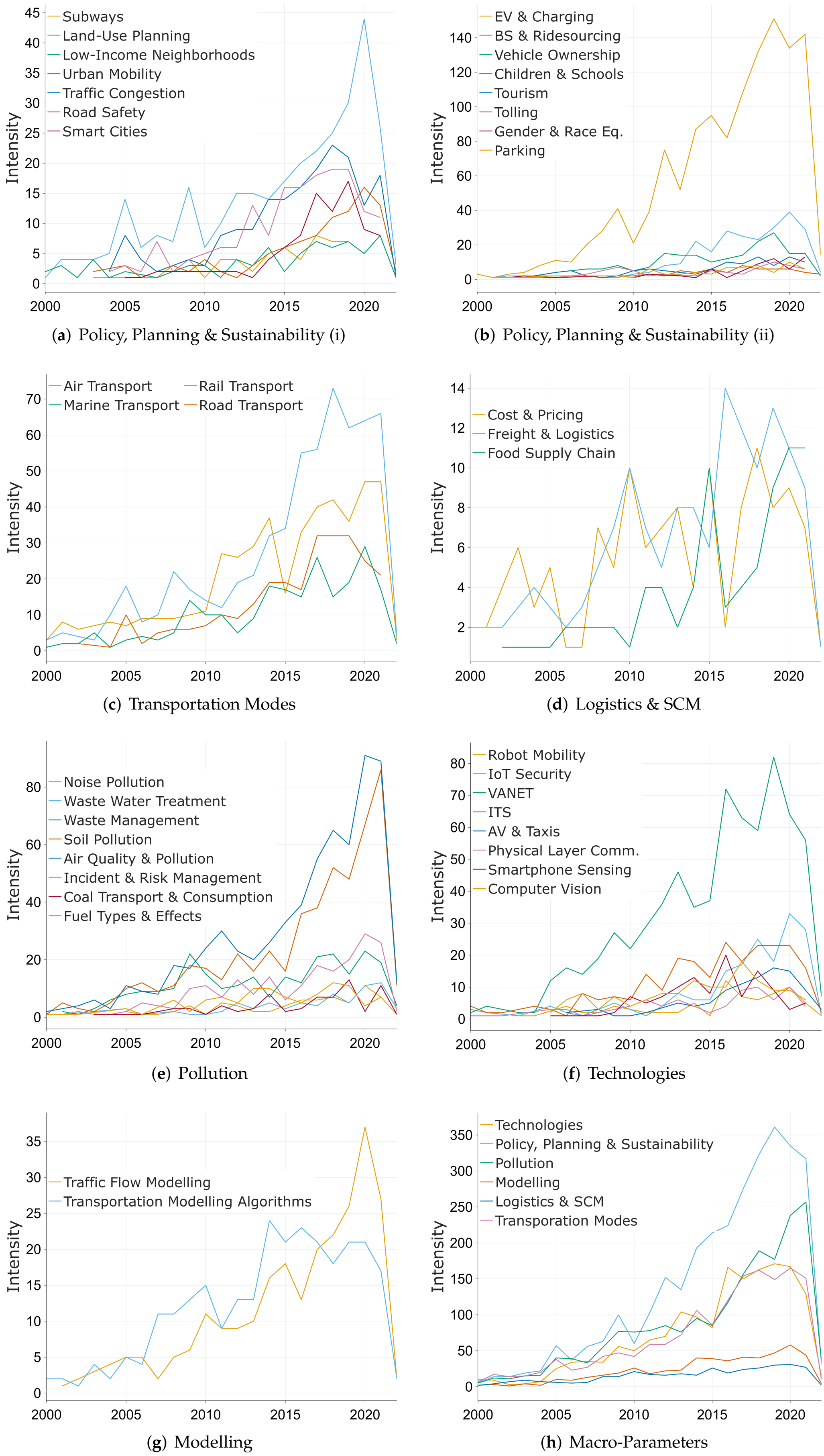

(a) Policy, Planning & Sustainability (i)
(b) Policy, Planning & Sustainability (ii)
(c) Transportation Modes
(d) Logistics & SCM
(e) Pollution
(f) Technologies
(g) Modelling
(h) Macro-Parameters

Figure 27. Temporal Progression of Parameters (Web of Science)

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7. Discussion

The broader aim of our work is to investigate the use of ICT technologies for solving pressing problems in smart cities and societies. Specifically, in this paper, we investigate the use of digital methods to discover and analyse cross-sectional multi-perspective information to enable better decision making and develop better instruments for academic, corporate, national and international governance. We brought together a range of deep learning, big data, and other technologies to discover transportation parameters from three different perspectives using three different types of data sources, viz. a newspaper (The Guardian), a transportation technology magazine (Traffic Technology International), and academic literature on transportation (from Web of Science). These three types of transportation parameters were described in detail in Sections 4 to 6, respectively.

We discovered a total of 25 parameters from the Guardian dataset and grouped them into six macro-parameters, namely Road Transport; Rail Transport; Air Transport; Crash & Safety; Disruptions & Causes; and Employment Rights, Disputes, & Strikes. Figure 28 depicts the word cloud of the keywords of the Guardian parameters discovered by the BERT modelling, where the size of each keyword denotes its frequency that can be related to the importance of the keywords. The figure shows that the Guardian newspaper is primarily concerned with the government, trains, passengers, the general public, and accidents. As the Guardian is a UK-based newspaper, the train is one of the most used public transport in the UK, which is clearly seen in the word cloud by the following keywords: train, rail, and railtrack. Additionally, some major transportation issues, like accidents, delays, injuries, traffic, safety, and crashes, are also shown in this figure. Heathrow Airport is the central international airport in the UK and is visible in the word cloud.

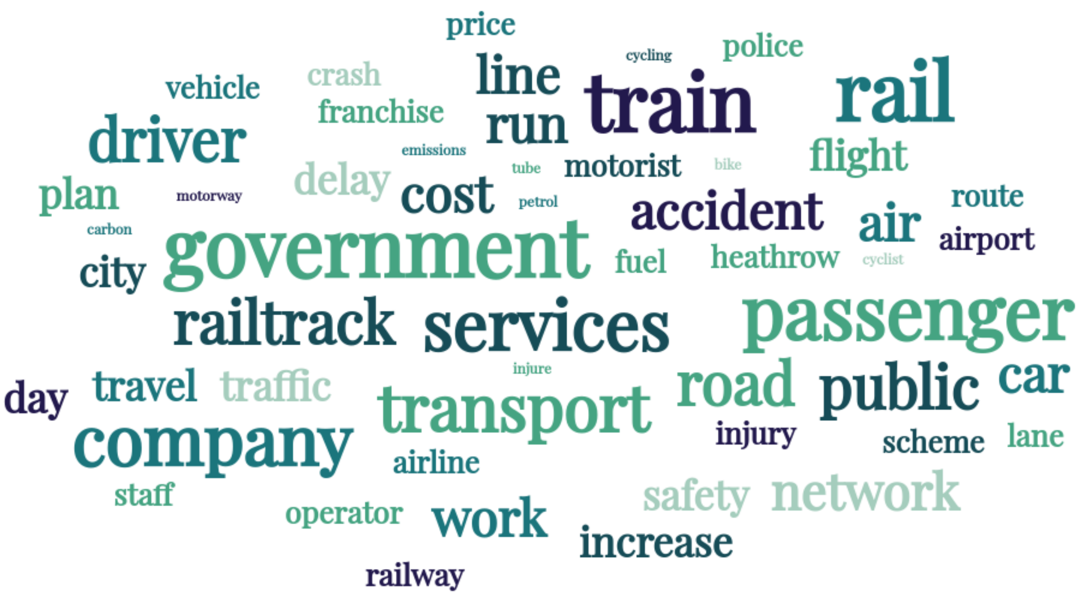

Figure 28. A Word Cloud Generated from the Transportation Parameter Keywords (The Guardian)

A total of 15 parameters were discovered from the TTI dataset and grouped them into five macro-parameters, namely Industry, Innovation, & Leadership; Autonomous & Connected Vehicles; Sustainability; Mobility Services; and Infrastructure. Figure 29 depicts the word cloud of the keywords of the TTI parameters discovered by the BERT modelling, where the size of each keyword denotes its frequency. The word cloud for transportation magazines is heavily dominated by the transportation industry. The keywords like tech- nology, project, system, traffic, solution, autonomous vehicles are highly related to the transport industry field. Datum is a well-known organisation that has been providing solutions and services in the transportation sector since 1999, especially in the UK and

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Europe, where the majority of transport infrastructure and projects are done under this organisation.

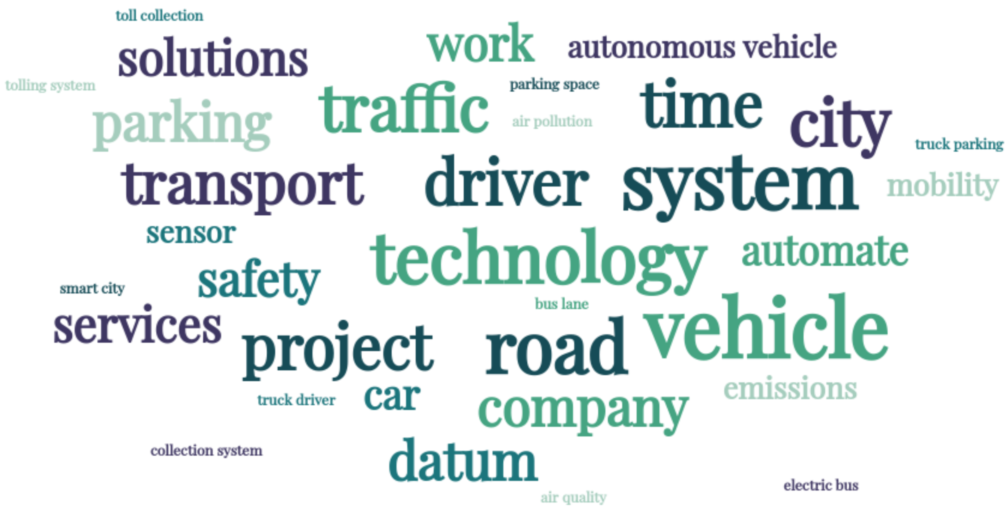

Figure 29. A Word Cloud Generated from the Transportation Parameter Keywords (TTI Magazine)

We discovered 49 transportation parameters from the academic dataset and grouped them into six macro-parameters. These are Policy, Planning & Sustainability; Transportation Modes; Logistics & SCM; Pollution; Technologies; and Modelling. Figure 30 depicts the word cloud of the keywords of the academia parameters. Academic transportation research covers a wide range of topics, such as public transportation, various pollutions, impacts, and solutions, intelligent transportation systems, traffic, supply chain management, cost, and so on.

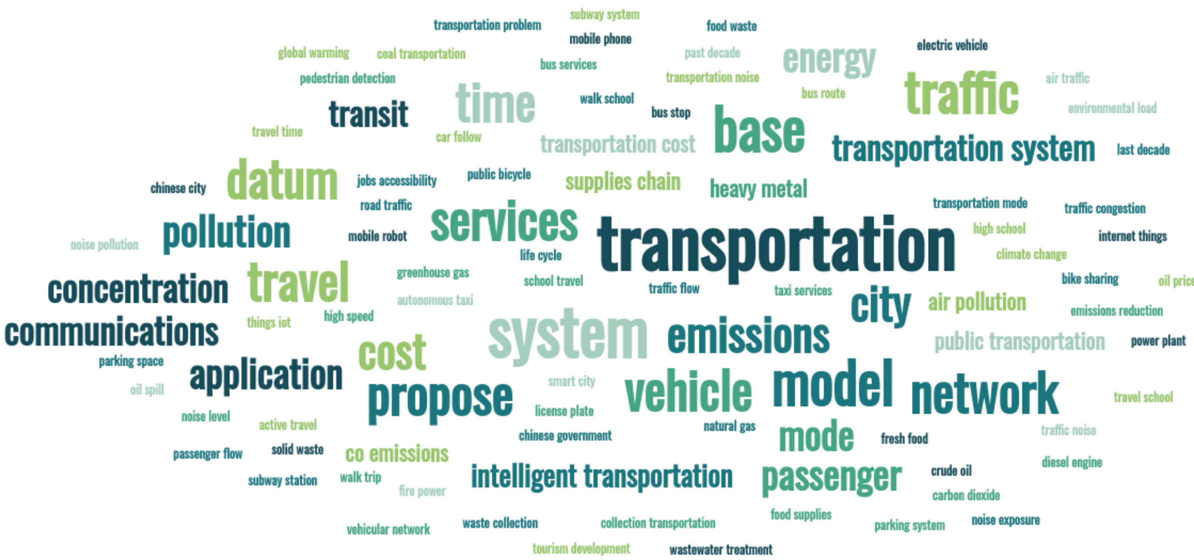

Figure 30. A Word Cloud Generated from the Transportation Parameter Keywords (Web of Science)

Reflecting over the multi-perspective view (public, governance, political, industry, and academia) of transportation gained through the discovery of parameters from three different sources of datasets (see Figure 1; more detailed taxonomies and analyses are provided in the respective sections), we note that the newspaper parameters show a more of a public and political view of transportation with the focus on the road, rail, and air transportation issues highlighting public discontentment, accidents, cycling, pollution and effects on climate, road congestion, fuel prices, travel costs, privatisation and its impacts, dangerous driving, deaths, extreme weather impacts, and employment rights. Rail transport has a very high significance in the newspaper dataset due to the importance of London underground and intercity rail transport in the UK. It may vary from country to country depending on the nature of transport in that country being used for intra- and intercity travel. Megacities tend to rely on rapid transit systems but it can vary. The transport magazine parameters show an industrial view of transportation with the focus a great deal on autonomous and connected vehicles owing to several trials in progress around the world. The spotlights are also on crash and safety, tolling, parking, pollution, and electric vehicles. The Web of Science parameters shows an academic view of transportation with various foci on policy, planning, sustainability, equity, children and schools, vehicle ownership, tourism, four transportation modes, freight and logistics, a wide range of pollutions and its sources, modelling methods, and several technologies.

The three views show that there are many important problems such as transportation operations and public satisfaction that industry and academia seem to not place their focus on or perhaps if they do the solutions do not get to reach the highlights by the policymakers and industrialists. For example, the fare-related parameters for public transport in the Guardian dataset show the importance of this topic for the public while it is not visible in the TTI and academic parameters. This could show the need for research in this area to model fares, provide insights into it, provide solutions for people for lower fares, and so on. Similarly, other parameters, issues, and contents such as the need for better employment conditions for drivers discovered from the public view (The Guardian) could be studied by academics and addressed by the industry, and this could set new trends where the technology-focussed literature could bridge the gaps between social sciences, sustainability, and technology. We can also see that academia produces much broader and deeper knowledge on the subject while many important issues such as a wide range of pollutions affecting the people and planet do not get to reach the public eye. Our deep journalism approach could find the gaps and highlight them to the public and other stakeholders. We called this approach Deep Journalism because it allows capturing and reporting a relatively deeper view of a topic (e.g., transportation) from multiple perspectives, dimensions, stakeholders, and depths. Secondly, we use deep learning to automatically discover multi-perspective parameters about a topic.

8. Conclusions

We live in a complex world characterised by complex people, complex times, and complex social, technological, and ecological environments. There is clear evidence that governments are failing at most public matters. The recent COVID-19 pandemic is a high example of global governance failure both at preventing such pandemics and managing the COVID-19 pandemic. It is time that rather than criticising our governments all of us take responsibility for both success and failure, and look into ways of collaboratively improving the governance of public matters, our matters.

While there are many reasons for government failures, we believe the lack of information availability is a fundamental reason that limits government ability to act smartly and allows the lack of transparency to creep into policy and action leading to corruption and failure. To this end, this paper introduced the concept of deep journalism, a data-driven deep learning-based approach for discovering multi-perspective parameters related to a topic of interest. We discovered the academic, industrial, public, governance, and political parameters for the transportation sector as a case study to introduce deep journalism and our tool DeepJournal (Version 1.0) that implements our proposed approach. We built three datasets specifically for the work presented in this paper. These datasets will be provided openly to the community for further research and development. We elaborated on 89 transportation parameters and hundreds of dimensions reviewing 400 technical, academic, and news articles.

The work presented in this paper and the investigation into the proposed Deep Journalism approach is far from perfect both in terms of its definition and scope as well as its exploration in this paper such as the different types of media, the use of deep learning and other computing methods, the investigations into the specific media and sources used in this paper, and more. We work in a range of research topics including smart cities [383–387], cloud, fog, and edge computing [388–390], big data [391,392], high performance computing [393,394], and healthcare [395,396], and plan to benefit from these technologies and topics for extending and improving Deep Journalism in the future.

As regards NLP (Natural Language Processing), more research is needed to understand the clustering performance of BERT and other clustering methods. For example, some clusters have some similarities so why these clusters are separated by the clustering algorithms or why an article from one topic is included in another, the quality of cluster boundaries, and so on. One obvious reason is that documents are related to all clusters, some more and others less. Another reason by example is a train crash that could also be linked to a road crash because there is something about crashes and similar vocabulary there. Death and injuries can be another link between them. Another matter related to topic modelling, NLP, and BERT performance is to investigate the effects of language used by different communities and sectors, such as in this case newspapers use a different vocabulary because dramatisation is important for newspapers.

The aim of the work presented in this paper partly is to understand the transportation domain comprehensively as best as practically possible, as automatically as possible, and use it to improve the transportation sector. Our research concerns multiple sectors and disciplines, such as healthcare and smart cities, with a focus on developing interdisciplinary methods and technologies for integrated and converged infrastructure allowing minimisation of silos and inefficiencies, through policy and action integration and convergence, and facilitation of holistic designs and optimisations. The proposed approach can also be utilised to create disciplines and curricula for teaching in schools and universities, training for staff in industry and government institutions, and more. Given ICT is penetrating all spheres of our lives, be it transport, politics, corruption investigations, legal actions, and more, capturing such details automatically is useful because it can lead to the development of automated algorithms for cross-disciplinary exploratory analysis, real-time investigations, and decisions making, and more. We believe the possibilities for utilisation and potential impacts of the work presented in this paper and the proposed approach are significant and endless; we invite all communities interested in transportation and otherwise to investigate our proposed approach for a sustainable and joint future for all of us.

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