

Hot Topics in the Fields Mobility and Transport Technologies –

Mapping of International Publications

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Abstract:

The fields mobility and transport technologies have become increasingly important topics in Austria and internationally over the last several decades. Rising traffic volumes and transport related environmental problems represent just a few crucial issues policy makers, scientists, and numerous other stakeholders are faced with today. Bibliometric analysis of international scientific literature and European Union projects can assist in the search for hot topics and critical players in transportation research and ultimately can facilitate the finding of innovative solutions. This article demonstrates different applications of bibliometric analysis with the visualisation software BibTechMon™ and co-occurrence analysis and analyses research activities in the fields mobility and transport technologies. In addition, it examines the topics traffic management/traffic control and alternative fuels in detail.

An analysis of selected topics and institutions involved allows an in-depth look at different specialisation patterns. The findings indicate that North America and European Union countries of all regions of the world dominate the topics traffic management/traffic control and alternative fuels. A comparison of select European countries shows that the United Kingdom, France and Germany lead research activities in alternative fuels. Asia and Japan noticeably allocate most of their resources to research on traffic control systems and as a result dominate all other regions in that field. Austria concentrates proportionally more resources on traffic management/traffic control than any other European country analysed. Lastly, an analysis of the relative importance of topics by organisational types yielded that industry plays a major role in the fields control systems, traffic control/speed detection, and alternative fuels.

Introduction

The topics mobility and innovative transport technologies have gained in importance internationally and in Austria over the last few decades as traffic volumes continue to increase and transport-related environmental problems mount. Policy makers, scientists, researchers, planners, and other stakeholders are called upon to analyse the most pressing issues and to design and implement innovative solutions for the long term.

Bibliometric analysis can facilitate the search for key topics and crucial players in a specific research area. This article will demonstrate different applications of bibliometric analysis through co-occurrence analysis and the visualisation software BibTechMonTM in the field of transport technologies as it is documented in the international scientific literature and in project descriptions of the 4th European Union Framework Programme (FP4) (Kostoff, 1993). Specifically, the analysis will focus on international research activities in transport technology and mobility as a whole and will examine in detail two topics of great international relevance: traffic management/traffic control and alternative fuels.

The article will identify and highlight different specialisation patterns such as the relative importance of selected fields of research in various countries and regions. It will also examine the importance of different organisational types on selected topics. This paper presents results from the first year of a three-year research project. Hence, only a selection of a number of crucial topics could be analysed in detail.

Databases

Search Methods:

A wide range of databases were selected to offer a comprehensive look at the topics mobility and transport technologies. In order to obtain literature to various topics within mobility and transport, search terms were logically connected as follows. One of the four terms transport, traffic, mobility, and infrastructure had to occur together with a term from a list of subtopics in the areas of information and communication technologies (ICT) and services, sustainability, or innovative technologies. The query was restricted to titles only and to citations published in the period between 1992 and 2000 in order to obtain a representative, yet manageable sample. All articles downloaded contained standard bibliographic information such as title, author, institution, keywords, and abstracts, but not the full text.

The following table illustrates the databases used, shows the thematic foci, and includes the number of citations drawn from each.

Table 1: Selected Databases and Number of Citations

Database	Thematic Focus	Number of Citations
INSPEC	Physics, Electrical engineering, and computer science	563
Compendex	Engineering	348
NTIS (National Technical Information Service)	Technology	404

TRIS (Transport Research Information System)	Transport, Transport Technologies	1910
Enviroline	Environment, Sustainability, Environmental Technology	78
Environmental Bibliography	Environment, Environmental Technology	29
CORDIS (FP4 Projects of European Commission)	Transport	977
TOTAL		4309

Methodology

Automatic Indexing:

To represent the contents of the articles described above such that they are suitable for further analysis, the titles and abstracts had to be indexed automatically. For this purpose, a stemming procedure based on the context sensitive longest-match principle and a phrase recognition algorithm were applied to titles and abstracts (Widhalm et al. 1999).

In a separate procedure, descriptors listed on each citation were pulled from each article and added to the pool of words. In total, the process yielded 1600 words and phrases which provided the basis for further analysis.

Standardisation of Data:

In order to be able to apply the bibliographic analysis with the software BibTechMon™ for the network analysis, the spelling of authors, institutions, or keywords had to be unified. In addition, synonyms and abbreviations were standardised.

Co-occurrences:

A statistical measure is needed that systematically assesses which keywords are closely related to one another and as a result would form a topic. It is assumed that keywords of one topic occur more frequently together in one document than keywords belonging to different topics. As a measure for each pair of keywords, the number of co-occurrences in a document (number of articles or project descriptions, where pairs of keywords occur) is counted. For statistical reasons, the Jaccard Index was used to normalise the elements of the respective co-occurrence matrix (Callon et al., 1983, Kostoff, 1993, Leyersdorf, 1989)

Cluster Analysis of Keywords:

A cluster analysis on the basis of the Jaccard matrix was performed which led to the formation of groups of thematically related keywords that were subsequently called subtopics. In a separate manual procedure, these subtopics were grouped into topics to simplify further analysis.

Visualisation:

Although the above described matrix allows a grouping of keywords, a visualisation method is needed that transforms the matrix into a readable and easy to interpret two-dimensional map. A mechanical spring model that functions as follows is thus applied (Kopsca and Schiebel, 1998). Keywords in this

model are mass points with a mass and size proportional to the total frequency. The mass points are connected with each other by forces (springs) correlated to the Jaccard Index. They are positioned randomly at their starting position and will then move driven by the forces defined above. This is done by iteration of the respective n-dimensional differential equation system. Through this model, the keywords are positioned according to their correlation; intensively correlated operating terms will be pictured in close proximity to one another.

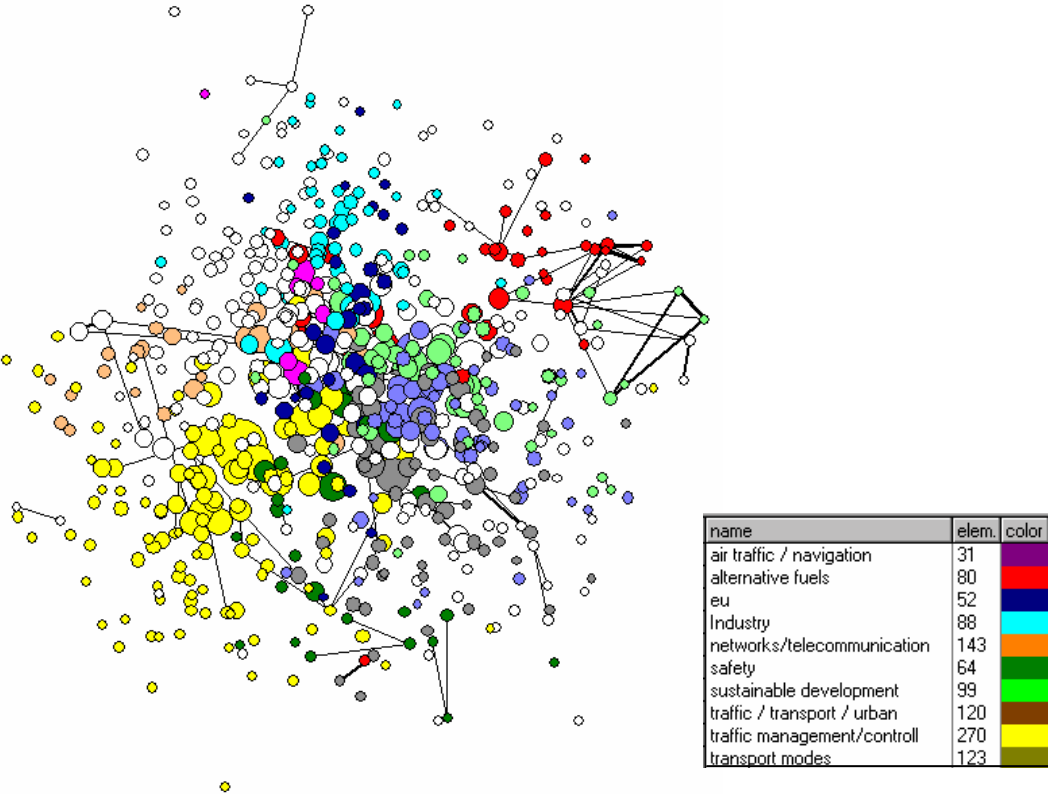
Thus, the map provides information based on the size of the objects and their relative position to one another (see also van Raan, 1992). Additional information such as colour-coding of objects to identify themes or to visualise other parameters of interest can also be applied.

All tables and figures were generated with the bibliographic data drawn from the databases.

Discussion and Analysis

The following map (network of keywords) generated through BibTechMon™ will serve as a base map. It depicts nine different topics, which are colour-coded for easier interpretation. The size of the dots indicates the relative importance of certain keywords, whereas the proximity (indicated by physical closeness and lines on the map) to one another is an indication of the number of citations in which certain keywords occur. The closer they are to one another, the more articles where keywords co-occur.

Figure 1: Network of keywords



Selection of Topics:

Two topics visible in yellow and red on the map were selected for further analysis: sustainable development (SD) and traffic management/traffic control (TMC). Interesting to note also is the close proximity of the topics sustainable development and alternative fuels and the apparent thematic relationship between sustainable development, traffic/transport/urban planning and transport modes. Similarly, the topics EU/policy, safety and traffic management/traffic control also seem to possess common keywords.

The topics SD and TMC were then subdivided in previously identified subtopics (cluster analysis). Of those, alternative fuels (AF), belonging to SD, control systems, highway traffic control, intelligent transport systems, traffic control systems, traffic control/speed detection and traffic management, all of which belong to TMC will be further discussed. In addition, TMC as a topic that is comprised of 9 subtopics in total will be analysed separately.

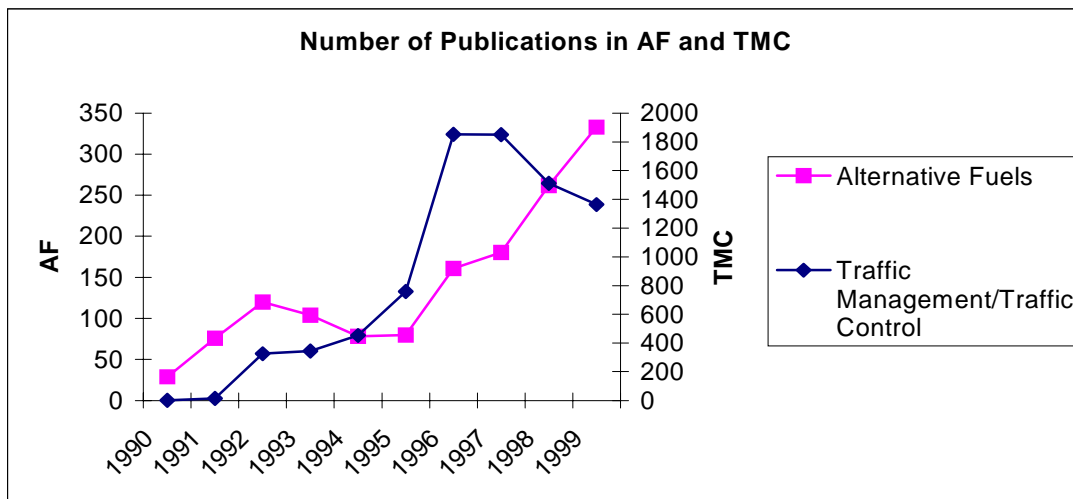
The following table illustrates which keywords and phrases occur in connection with TMC and AF.

Table 2: Keywords and Phrases used in TMC and AF

Traffic Management/Traffic Control	Alternative Fuels
Fuzzy logic	Fuel cells
Traffic surveys	Electricity
Automated toll collection	Fuel substitution
Warning systems	Cost-benefit analysis
Advanced traveller information	Electrochemistry
Computerised monitoring	Hydrogen
Dynamic route guidance	Membrane
Bus priority	Biomass

Several reasons facilitated this choice. On the one hand, the map indicates that AF and TMC are not closely related thematically as they are located on opposite ends of the map. Only very few terms seem to co-occur in articles of both topics. On the other hand, both topics seem to have been very dominant topics in the international literature in the period between 1992 and 1999 as depicted in figure 2, although the volume of publications in each differs significantly. The number of publications in AF is still rising indicating a growing interest in the topic while TMC has reached its peak in 1997 and has been dropping since.

Figure 2: Number of Publications in AF and TMC

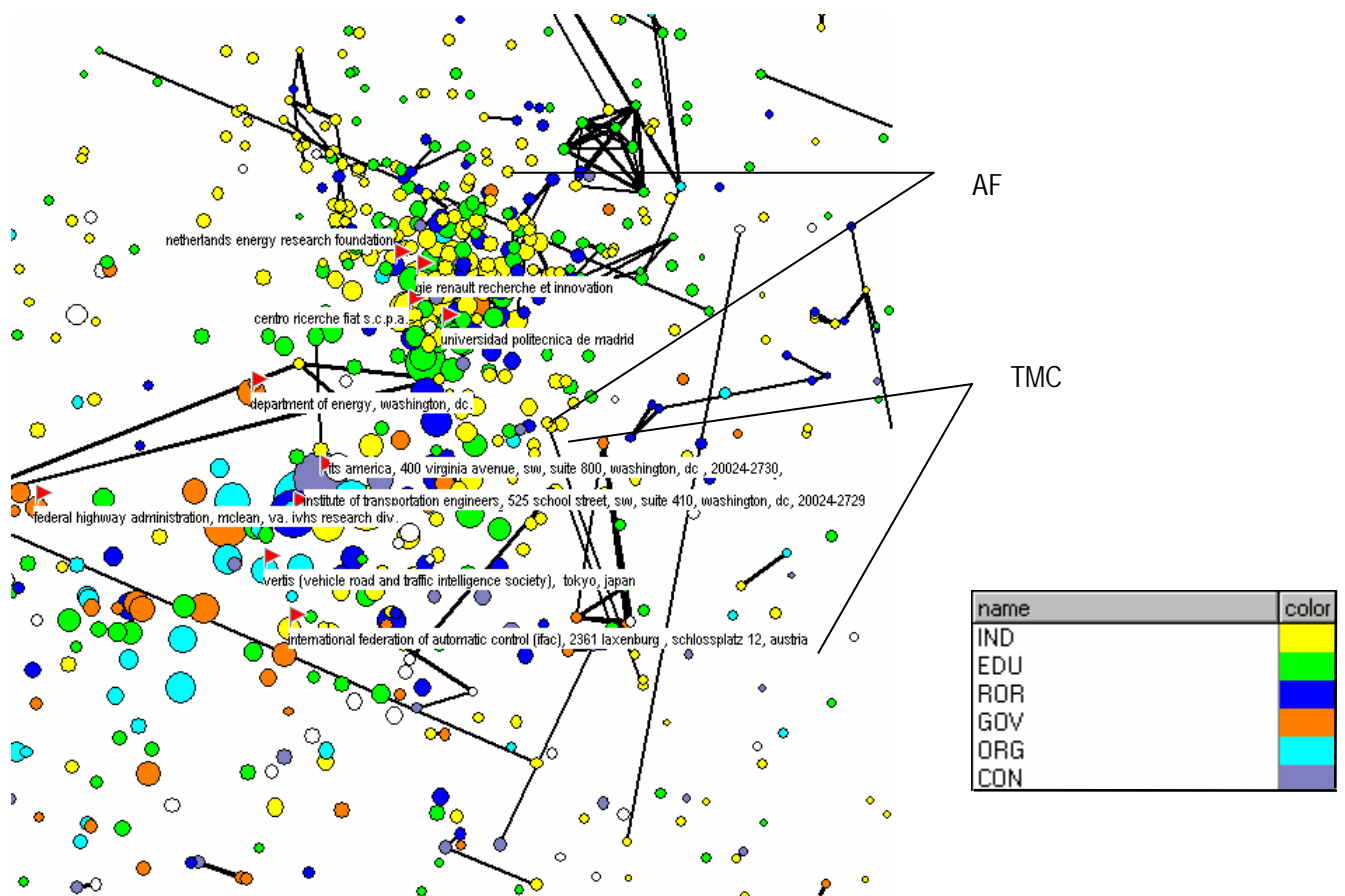


Analysis of Institutions:

An analysis of the relative importance of institutions (their publishing activity on certain topics) offer further insights into the topics at hand. Institutions are defined as those organisations that an author of a publication or a project is affiliated with; the institutions were divided into the following types: industry (IND), consultants (CON), organisation (ORG; i.e. non-profit), government (GOV), university institute (EDU), and research organisation (ROR).

The following figure depicts the distribution of all institutions organised by keywords for all topics, not just the selected ones, and shows the distribution of organisational types. As opposed to Figure 1, the size of the dots in this figure indicates the number of keywords a particular institution is listed with: the more keywords, the bigger the dots. The proximity in this case illustrates how many times articles with common keywords used by a particular pair of institutions occur. Two institutions would be closely correlated, if their respective publications are represented by common keywords. Proximity, however, does not indicate whether they co-operated on a publication. The most important institutions and thus key players for AF and TMC are shown on the map. Viewed from top to bottom, the first 5 have published in the field of alternative fuels, the remaining ones in TMC.

Figure 3: Network of Institutions:



Relative Importance of Topics in Different Countries and Regions:

Zooming in the selected topics enables a more detailed analysis of the institutions involved and allows an in-depth look at different specialisation patterns of countries and regions. Specifically, the relative importance of different countries and regions in which institutions are located will be examined for the topics and subtopics selected. The countries listed represent a small portion of all countries whose institutions published to AF and TMC and were selected because of their relevance in the transport sector in Austria and Europe. The regions, however, represent publications from countries all over the world and consequently allow for a world-wide comparison by region for the topics AF and TMC. Japan was classified as a region, because its number of publications was proportionally much higher compared to the rest of Asia. Institutions from countries of the European Union may be slightly over-represented, because publications drawn from the CORDIS database generally had more than one, often several institutions listed, whereas the majority of publications from other databases listed only one institution.

Table 3 illustrates the number of times keywords are used by an institution from a specific country or a region on the topics and subtopics selected.

Table 3: Number of Keywords per Topic Used by Institutions from a Country or a Region

Topic/Subtopic	Africa	Asia	Australia	EU	Japan	North America	Other Europe	GERMANY (DE)	NETHERLANDS (NL)	AUSTRIA (AT)	SWEDEN (SE)	SWITZERLAND (CH)	FRANCE (FR)	FINLAND (FI)	UNITED KINGDOM (GB)	ALL
alternative fuels	0	17	10	2410	7	805	68	403	189	37	191	27	390	62	418	3340
control systems	1	35	6	605	12	151	11	106	41	18	28	4	89	10	144	823
highway traffic control	0	16	11	33	5	242	4	4	3	0	2	0	0	2	15	326
intelligent transport systems	0	12	26	180	15	233	3	21	11	3	11	0	23	6	49	473
traffic control systems	1	56	12	675	65	484	13	94	41	33	28	4	82	17	192	1326
traffic control/speed detection	2	11	26	724	7	197	9	90	65	23	44	3	134	21	146	986
traffic management	6	36	89	1082	55	1130	20	97	85	26	50	5	113	42	383	2463
TMC	17	208	246	4545	260	4216	96	590	330	156	251	27	588	141	1213	9748
TOTAL	77	689	718	76646	735	18131	2220	12606	6151	1890	3983	829	13079	1987	15461	100456

By viewing the table in absolute numbers, the dominance of the European Union (EU) and North America (NA) on both topics quickly becomes evident. However, there is a three-fold difference between the EU and NA in the field of AF. The United Kingdom (UK) clearly dominates the topic TMC, whereas Germany and France, although in second place, only use half as many keywords. The remaining countries such as Austria and Switzerland are orders of magnitude behind the other three. Keywords used are more evenly distributed across countries in the field of alternative fuels, although the UK, France and Germany still dominate.

An analysis of countries and regions in terms of their specific thematic foci offers a different picture. Table 4 depicts the relative importance of each topic in a country or a region.

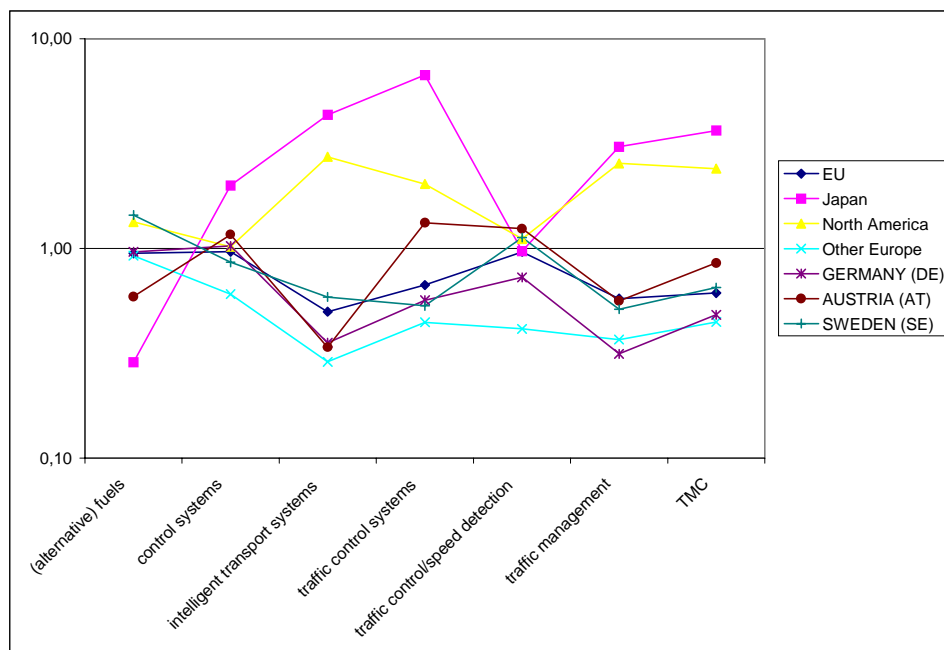
Table 4: Relative Importance of Topics by Country and Region

Topic/Subtopic	Africa	Asia	Australia	EU	Japan	North America	Other Europe	GERMANY (DE)	NETHERLANDS (NL)	AUSTRIA (AT)	SWEDEN (SE)	SWITZERLAND (CH)	FRANCE (FR)	FINLAND (FI)	UNITED KINGDOM (GB)	ALL
alternative fuels	0,0%	2,5%	1,4%	3,1%	1,0%	4,4%	3,1%	3,2%	3,1%	2,0%	4,8%	3,3%	3,0%	3,1%	2,7%	3,3%
control systems	1,3%	5,1%	0,8%	0,8%	1,6%	0,8%	0,5%	0,8%	0,7%	1,0%	0,7%	0,5%	0,7%	0,5%	0,9%	0,8%
highway traffic control	0,0%	2,3%	1,5%	0,0%	0,7%	1,3%	0,2%	0,0%	0,0%	0,0%	0,1%	0,0%	0,0%	0,1%	0,1%	0,3%
intelligent transport systems	0,0%	1,7%	3,6%	0,2%	2,0%	1,3%	0,1%	0,2%	0,2%	0,2%	0,3%	0,0%	0,2%	0,3%	0,3%	0,5%
traffic control systems	1,3%	8,1%	1,7%	0,9%	8,8%	2,7%	0,6%	0,7%	0,7%	1,7%	0,7%	0,5%	0,6%	0,9%	1,2%	1,3%
traffic control/speed detection	2,6%	1,6%	3,6%	0,9%	1,0%	1,1%	0,4%	0,7%	1,1%	1,2%	1,1%	0,4%	1,0%	1,1%	0,9%	1,0%
traffic management	7,8%	5,2%	12,4%	1,4%	7,5%	6,2%	0,9%	0,8%	1,4%	1,4%	1,3%	0,6%	0,9%	2,1%	2,5%	2,5%
TMC	22,1%	30,2%	34,3%	5,9%	35,4%	23,3%	4,3%	4,7%	5,4%	8,3%	6,3%	3,3%	4,5%	7,1%	7,8%	9,7%

The subtopic highway traffic control has very little relevance in European countries, whereas its significance in Asia, Australia, and North America is much greater. Asia and Japan also noticeably dominate all other regions and nations in the field of traffic control systems and they focus the majority of resources on that subtopic. Leaders in the field of traffic management appear to be Australia, Africa, Japan, and North America in that order as they place heavy emphasis on that field, whereas European countries again place far behind other regions. Austria concentrates more resources on TMC than any other European country analysed. In alternative fuel research, however, Austria comes in last, although keywords used by institutions in all European countries are fairly evenly distributed. A comparison of regions shows that EU countries, other European nations as well as North America allocate more resources to research in alternative fuels than other regions.

A yet more differentiated picture offers figure 4 where data is represented on a logarithmic scale. It depicts which countries and regions concentrate their activities on certain topics compared to all activities world-wide.

Figure 4: Level of Concentration on Topics by Institutions from a Country or a Region

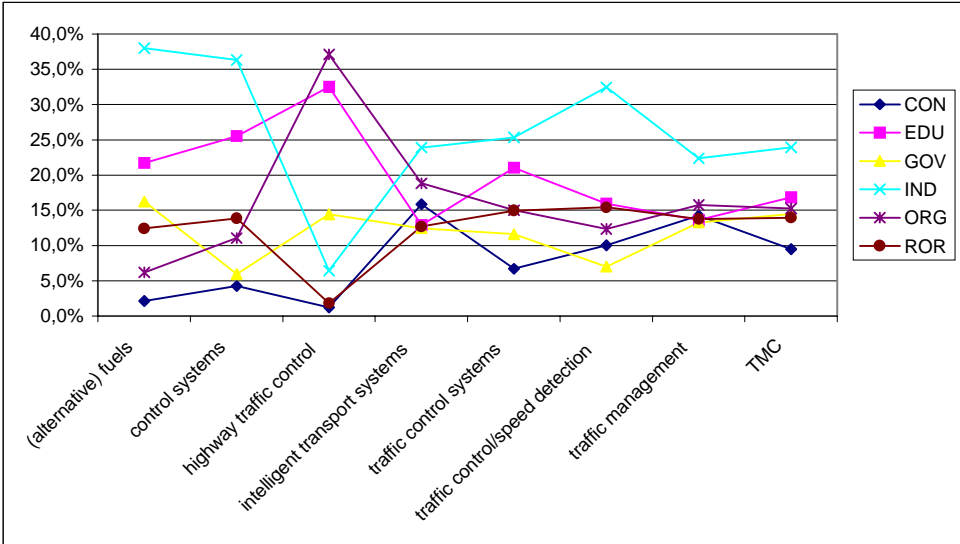


The percentages showing the relative importance of each topic in a country or a region (table 4) were again divided by the percentages indicating the relative importance of each topic world-wide; thus, the number 1 represents the average. Austria, for instance, played a significant role in TMC compared to other European countries as exhibited in table 4. However, compared to activities in other countries world-wide, its role is a minor one. This standardised analysis also shows that the concentration of research activities on alternative fuels in North America as a region and Sweden is proportionally higher than research world-wide.

Relative Importance of Topics or Subtopics by Organisational Type

Figure 5 shows that consultants figure prominently in the field of intelligent transport systems along with industry and organisations, whereas their activities in the fields alternative fuels and highway traffic control are very minor.

Figure 5: Relative Importance of Topics by Organisational Types



Industry plays a major role in the fields control systems, traffic control/speed detection, and alternative fuels clearly dominating all other organisational types. Aside from industry, the share of research activities in the field of alternative fuels is fairly evenly distributed among universities, government and research organisations. Universities also play an important role in the fields control systems, highway traffic control, and traffic control systems.

Conclusions

Hierarchical and one-dimensional structuring of bibliographic data is not sufficient to gain full insight into a research area. With the help of BibTechMon™, multidimensional information can be graphically represented on two-dimensional knowledge maps, which offers an easy-to read and interpret analysis of a research area.

Two different networks are presented; the network of keywords map which illustrates the importance of certain keywords and topics as well as the thematic correlation of different keywords and topics.

The network of institutions map depicts the distribution of institutions organised by keywords and shows key players in certain areas of research. The topics alternative fuels and traffic management/traffic control were identified as hot topics and chosen for an in-depth analysis.

The analysis focused on the relative importance of the selected topics and subtopics in different countries and regions as well as the significance of those topics in a country or region compared to activities world-wide. In addition, the relative importance of various organisational types in selected topics and subtopics was examined. The results highlight different specialisation patterns of countries and regions such as a dominance of the European Union and North America in the research area traffic management/traffic control or Sweden's emphasis on alternative fuels. A close examination of organisational types yielded that e.g. industry plays a major role in the fields control systems, traffic control/speed detection, and alternative fuels.

This article demonstrates that co-occurrence analysis and the visualisation tool BibTechMon™ provide the basis for an in-depth analysis of internationally relevant topics in the field mobility and transport technologies. Since this paper represents work in progress, a characterisation of only a selection of critical topics was possible. Future research will focus on identifying new key topics and crucial specialisation patterns in the fields mobility and transport technologies.

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