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A CONCEPTUAL SNAPSHOT OF THE FIRST DECADE (2002–2011) OF THE INTERNATIONAL JOURNAL OF INFORMATION TECHNOLOGY & DECISION MAKING

A. G. LÓPEZ-HERRERA*, E. HERRERA-VIEDMA†, M. J. COBO‡
and M. A. MARTÍNEZ§

Department of Computer Science and Artificial Intelligence
University of Granada, Granada 18071, Spain
**lopez-herrera@decsai.ugr.es*
†*viedma@decsai.ugr.es*
‡*mjcobo@decsai.ugr.es*
§*mnglsmartinez@gmail.com*

GANG KOU

School of Management and Economics
University of Electronic Science and Technology of China
Chengdu 610054, China

YONG SHI¶

Research Center on Fictitious Economy and Data Sciences
Chinese Academy of Sciences, Beijing 100190, China

College of Information Science & Technology
University of Nebraska at Omaha, Omaha, NE 68182, USA
yshi@unomaha.edu

In this paper, we carry out a study about the main themes treated by the *International Journal of Information Technology & Decision Making* during its first 10 years (2002–2011). The themes are detected, quantified and visualized using an approach that combines performance analysis and science mapping. Bibliometric maps based on co-word analysis will help us to visualize the division of the journal into several subfields and their relationships, providing interesting insight into the main topics being discussed in the journal in these years. In addition, the study will show the most productive themes (according to published papers) and the most impacting ones (according to received citations).

Keywords: Science mapping; authomatic topic detection.

1. Introduction

On March 2002 the *International Journal of Information Technology & Decision Making* (IJITDM) launched its first issue. More than 400 papers have been published. In general, these published papers are research works that show how

¶Corresponding author.

information technology improves decision techniques as well as how the development of decision-making tools affects the information technology era.

A lot of effort has been done by everyone, including authors and co-authors, anonymous reviewers, editorial board and editorial office, in order to increase the quality of the journal. As a result, nowadays IJITDM is indexed in the most important journal ranking, the Journal Citation Reports (JCR) published by the Thompson Institute for Scientific Information (Thompson ISI), appearing in the JCR-2010 in top positions in different categories (Computer Science-Artificial Intelligence, Computer Science-Information Systems, Computer Science-Interdisciplinary Applications, and Operations Research & Management Science) with a high impact factor (3.139).

In the years 2009 and 2010 (at the beginning of each year), the editor in-chief of the IJITDM has published papers describing briefly the content of the main papers published during the year before. These papers[58,59] reported the main research trends of the papers published in 2008 and 2009, respectively. These two works, although are very much oriented and detailed, are very much limited due to the size of the period examined, just one year in each case.

In this paper, we try to complete those previous works,[58,59] in order to offer an expeditious perspective of a bigger period, the first decade (2002−2011), of the IJITDM by identifying themes, predicting emerging trends, and determining relationships with other themes/fields. The analysis is done using co-word as a content technical analysis. Co-word has been proved as a powerfull technique for describing the research trends in other research fields.[7,13,18,36,40,41,44,69,78]

The paper is structured as follows. Section 1 describes the methodological framework and the data used. Section 2 visualizes and describes the main themes treated by IJITDM. Section 3 analyzes and determines the influencing themes of the IJITDM, and predicts future research trends. Finally, some conclusions are drawn.

2. Method: Bibliometric Tool and Data

In bibliometrics, there are two main procedures to explore a research field: performance analysis and science mapping.[68] Performance analysis aims at evaluating groups of scientific *actors* (countries, universities, departments, researchers) and the impact of their activity on the basis of bibliographic data. Science mapping aims at displaying the structural and dynamic aspects of scientific research, delimiting a research field, and quantifying and visualizing the detected subfields by means of co-word analysis[14] or documents co-citation analysis.[61]

2.1. *Bibliometric analysis tool*

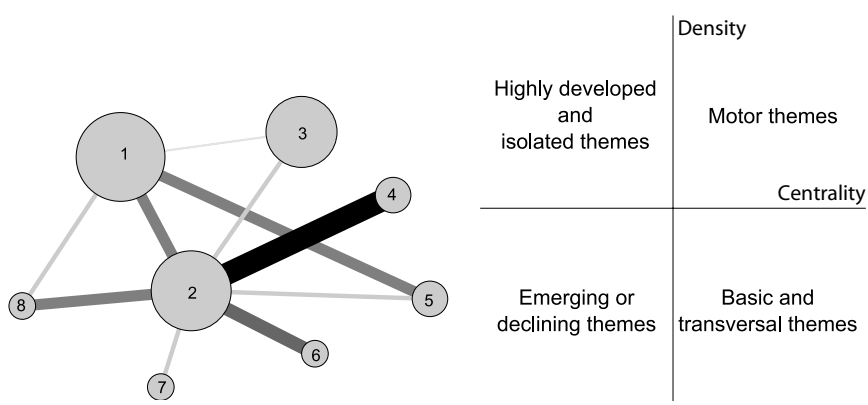
In Ref. 16, we define a bibliometric approach that combines both performance analysis tools and science mapping tools to analyze a research field, to detect and visualize its conceptual subdomains (particular topics/themes or general thematic areas) and its thematic evolution. Co-word analysis is used in a longitudinal

framework which allows us to analyze and track the evolution of a research field.[24] Additionally, we develop a performance analysis of a specific theme or thematic area using different basic bibliometric indicators.

The main steps to develop a bibliometric analysis based on co-word are the following:

(1) *To detect the research themes.* To do so, first we have to compute the co-occurrence matrix by assuming that the co-occurrence frequency of two keywords is extracted from the corpus of documents by counting the number of documents in which the two keywords appear together. Second, we have to compute the equivalence index among keywords,[13] called e_{ij}: $e_{ij} = \frac{c_{ij}^2}{c_i c_j}$, where c_{ij} is the number of documents in which two keywords i and j co-occur, and c_i and c_j represent the number of documents in which each one appears. At the end of this phase, we cluster keywords to topics/themes by using the simple centers algorithm,[20] which automatically returns labeled clusters, so a post-process to label the clusters is not needed. Through this process of clustering we locate keyword networks that are strongly linked to each other and which correspond to centers of interest or to research problems that are the object of significant interest among researchers. Each cluster network or *thematic network* is defined as an interconnected network of keywords as it is shown in Fig. 1(a). In it, several keywords are interconnected, where the volume of the spheres is proportional to the number of documents corresponding to each keyword, the thickness of the link between two spheres i and j is proportional to the equivalence index e_{ij}.

Together with the whole network of interconnected themes and keywords a second network is built, based on the documents linked to each thematic network. In this second network, documents with keywords associated to any detected thematic network are linked to it. Given a thematic network, a document d is associated to it if



(a) (b)

Fig. 1. A thematic network (a), and the strategic diagram (b).

d has at least two keywords presented in the thematic network. These second networks of documents are used in the third phase.

(2) *To build strategic diagrams.* In the clustering process we obtain a set of interconnected networks or themes. Then, in this context each keyword network or theme can be characterized by two parameters (Centrality and Density)[13]:

- *Centrality*: It measures the degree of interaction of a network with other networks and it can be defined as: $c = 10 * \sum e_{kh}$, with k a keyword belonging to the theme and h a keyword belonging to other themes. Centrality measures the strength of external ties to other themes. We can understand this value as a measure of the importance of a theme in the development of the entire research field analyzed.
- *Density*: It measures the internal strength of the network and it can be defined as: $d = 100\frac{\sum e_{ij}}{w}$, with i and j keywords belonging to the theme and w the number of keywords in the theme. Density measures the strength of internal ties among all keywords describing the research theme. This value can be understood as a measure of the theme's development.

A Strategic Diagram is a two-dimensional space built by plotting themes according to their centrality and density rank values. As an example, in Fig. 1(b) a strategic diagram is presented. Thus, with both parameters a research field can be understood to be a set of research themes, mapped in a two-dimensional space and classified into four groups[13]:

- Themes in the upper-right quadrant are both well developed and important for the structuring of a research field. They are known as the *motor-themes* of the specialty given that they present strong centrality and high density.
- Themes in the upper-left quadrant have well-developed internal ties but unimportant external ties and so are of only marginal importance for the field. These themes are very specialized and peripheral in character.
- Themes in the lower-left quadrant are both weakly developed and marginal. The themes of this quadrant have low density and low centrality, mainly representing either emerging or disappearing themes.
- Themes in the lower-right quadrant are important for a research field but are not developed. So, these quadrant groups are transversal and general, basic themes.

Furthermore, the strategic diagrams can be enriched by adding a third dimension in order to show more information. So, for example, the themes can be represented as a sphere, its volume being proportional to different quantitative (or qualitative) data, such as, for example, the number of documents associated with the theme or the number of citations received by the documents associated with the theme.

(3) *To carry out a performance analysis.* In this phase, we can measure (quantitatively and qualitatively) the relative contribution of themes and thematic

areas to the whole research field, detecting the most prominent, productive, and highest-impact subfields. To do so, we use the following bibliometric indicators applied to the different detected themes: the number of published documents, the number of received citations, and the h-index.[3,10,27]

We should point out that the co-word analysis was carried out with the software CoPalRed.[17,19,41] It is based on the simple center algorithm to detect the themes through different subperiods of years. The plotting of the themes in the strategic diagram, the drawing of the thematic networks were done with specific ad-hoc software.

2.2. *Data set*

We downloaded them from ISI Web of Science[a] (ISIWoS) for the years 2004 to 2011 (inclusive). For the two first years (2002 and 2003) data was manually downloaded from the IJITDM's website.[b] The data set includes 415 papers including articles, letters, proceeding papers and reviews. We have not considered editorial material. In Figs. 2 and 3 the distribution of published documents and citations per year are shown.

As mentioned above, the keywords of the documents are used to develop our analysis. Due to the fact that the majority of the data have been downloaded from the ISIWoS, the author-provided keywords and the Keywords Plus of the documents are jointly used. A normalization process is carried out prior to this over the keywords, where the plural and singular forms of the keywords are joined. The acronyms are also joined with the respective keywords. Finally, we have obtained 330 valid

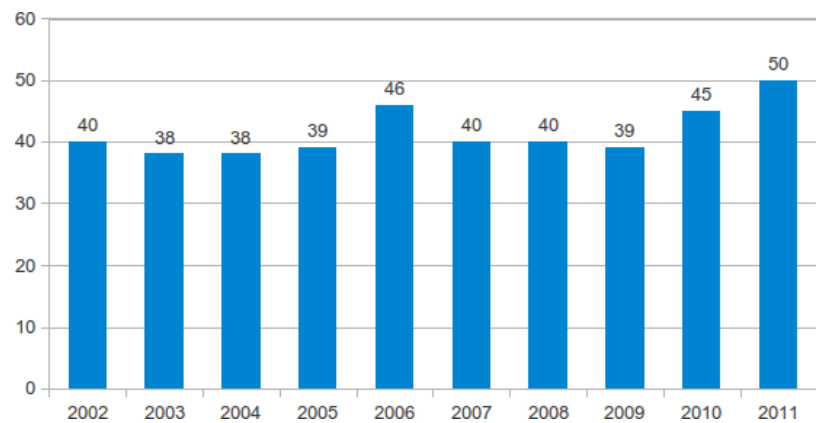


Fig. 2. Documents published in IJITDM from 2002 to 2011.

[a] http://scientifc.thomson.com/products/wos/.
[b] http://www.worldscinet.com/ijitdm/.

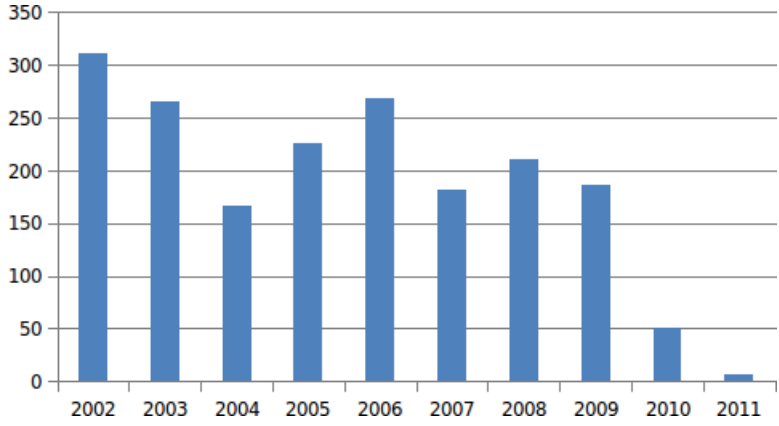


Fig. 3. Citations count for documents published in IJITDM from 2002 to 2011.

keywords for our study. We consider valid keywords to be those that present both frequency and co-occurrence greater than 2.

In this study the citations of the documents are also used. We have considered for each paper the citations received until November 15th 2011 (the data were downloaded on that date). The citations that we take into account proceed from the ISIWoS (for the papers published from 2004) and Scholar Google[c] (for the papers manually downloaded from the journal's website during the years 2002 and 2003).

3. Visualizing the Main Themes Treated by IJITDM

Using the approach described above, 17 themes were automatically detected by CoPalRed, these are: AGENTS, ANALYTICAL-HIERARCHY-PROCESS, CONSENSUS, DATA-ENVELOPMENT-ANALYSIS, DATA-MINING, DECISION-SUPPORT-SYSTEM, GROUP-DECISION-MAKING, INTERNET-QUALITY-OF-SERVICE, INTERPRETIVE-STRUCTURAL-MODELING, MANAGEMENT, OPTIMIZATION, PERFORMANCE-EVALUATION, SHAPLEY-VALUE, SOFTWARE-DEFECT-PREDICTION, TECHNOLOGY-ACCEPTANCE, TIME-SERIES, UNCERTAINTY.

In order to analyze the most highlighted themes treated by IJITDM for the studied period (2002−2011), two kinds of strategic diagrams were built using CoPalRed. In the first one, the volume of the spheres is proportional to the number of documents associated with each theme; and in the second one, it is proportional to the number of citations received by the documents of each theme. These strategic diagrams are shown in Figs. 4 and 5, respectively, and whose main aspects are:

- According to the number of documents, the themes ANALYTICAL-HIERARCHY-PROCESS (19 papers), DATA-ENVELOPMENT-ANALYSIS (17), MANAGEMENT

[c]http://scholar.google.com.

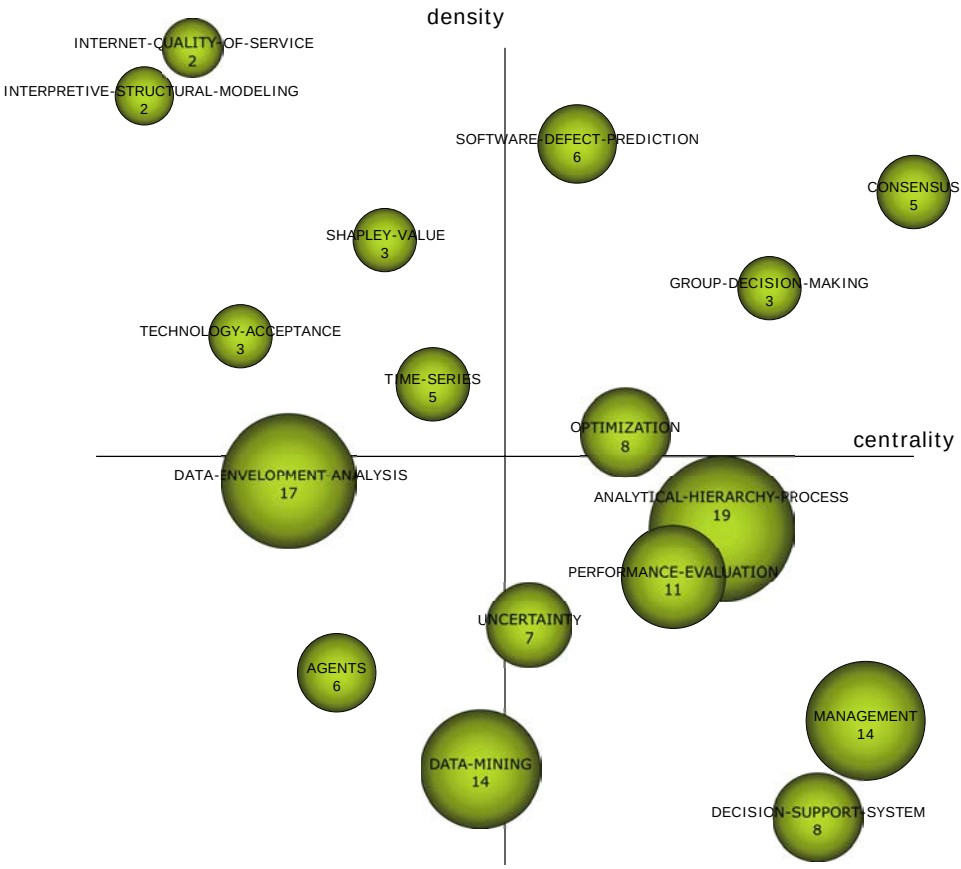


Fig. 4. Strategic diagram based on documents count.

(14), DATA-MINING (14) and PERFORMANCE-EVALUATION (11) are the five more productive one.

- Taking into account the citations, the themes DATA-MINING (with 156 citations), ANALYTICAL-HIERARCHY-PROCESS (106), CONSENSUS (93), DATA-ENVELOPMENT-ANALYSIS (75), MANAGEMENT (48) and TIME-SERIES (48) are the six most cited themes. On the other hand, the documents associated to the theme INTERPRETIVE-STRUCTURAL-MODELING has not cited.
- On the other hand, analyzing the ratio documents/citations, the themes CONSENSUS (with 18.60 citations per paper), GROUP-DECISION-MAKING (13.33), DATA-MINING (11.14) and TIME-SERIES (9.60) have been the most impacting themes.
- With respect to the h-index, the themes ANALYTICAL-HIERARCHY-PROCESS (with 7), DATA-ENVELOPMENT-ANALYSIS (6), CONSENSUS (5) are the three one with higher value. We have to remark that the theme CONSENSUS

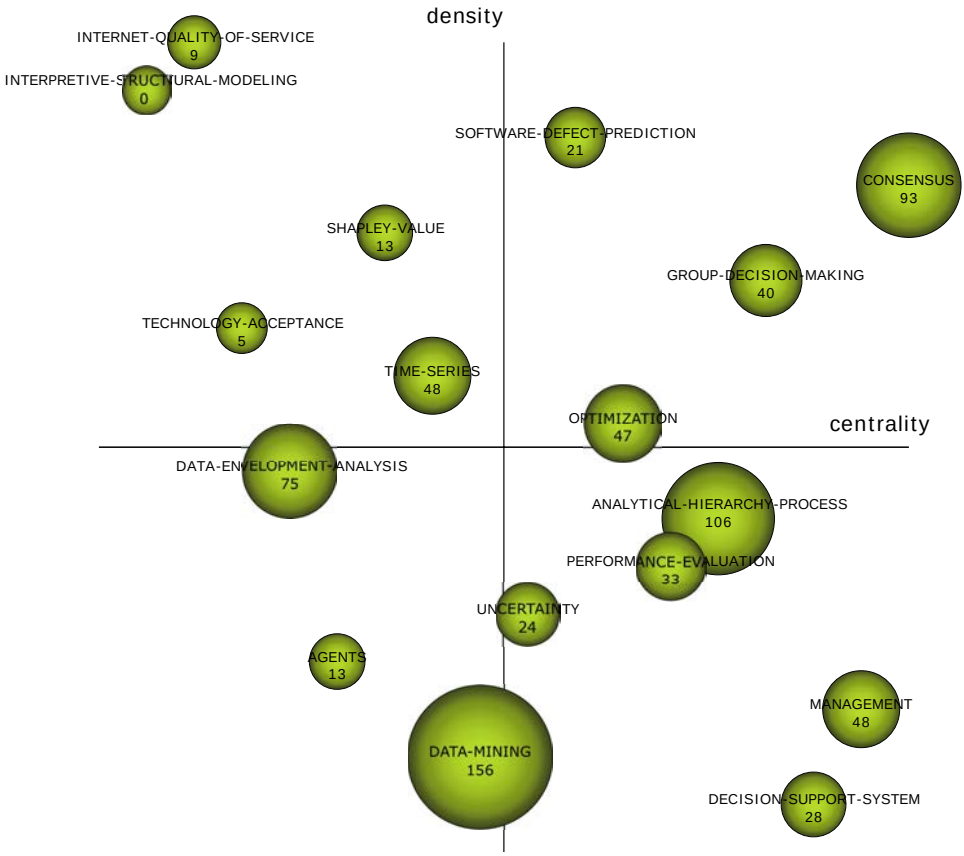


Fig. 5. Strategic diagram based on citations sum.

has obtained the highest h-index value that it is possible with its five associated papers.

- Analyzing their strategic location in the strategic diagrams, the themes ANALYTICAL-HIERARCHY-PROCESS, PERFORMANCE-EVALUATION, MANAGEMENT, DECISION-SUPPORT-SYSTEM AND UNCERTAINTY are supposed transversal and *basic-themes*; whereas CONSENSUS, GROUP-DECISION-MAKING and SOFTWARE-DEFECT-PREDICTION are supposed *motor-themes*, given that they present strong centrality and high density, i.e., they are understood as very much developed themes with also high importance/weight in the development of other themes and of the whole journal in the analyzed period.
- Moreover, themes like: INTERNET-QUALITY-OF-SERVICE, INTERPRETIVE-STRUCTURAL-MODELING, SHAPLEY-VALUE, TECHNOLOGY-ACCEPTANCE and TIME-SERIES are considered as very specialized and low interconnected one, being INTERNET-QUALITY-OF-SERVICE and INTERPRETIVE-STRUCTURAL-MODELING the most isolated ones.

- Due to their strategic location, the themes DATA-ENVELOPMENT-ANALYSIS, AGENTS and DATA-MINING have to be considered as new and emerging themes.
- Attending to the kind of themes, all the detected themes, except SOFTWARE-DEFECT-PREDICTION, INTERNET-QUALITY-OF-SERVICE, PERFORMANCE-EVALUATION and MANAGEMENT are considered as "methodological" or "theoretic" themes rather than "practical" or "applied" one.

Performance data, including quantity of associated documents, sum and average of citations and h-index, for these detected themes are summarized in Table 1.

3.1. *Visualizing the most highlighting themes*

In this section, we draw the most highlighting themes according to the number of associated documents, citations and locations at the strategic diagrams.

- The theme CONSENSUS, whose thematic-network is shown in Fig. 6, is related with the keywords (or topics): *aggregation*, *assessments*, *labels*, *owa-operators*, *consistency* and *operators*.
  The four most cited paper associated to this theme are:
  - Cabrerizo, FJ, Alonso, S, Herrera-Viedma, E, A CONSENSUS MODEL FOR GROUP DECISION MAKING PROBLEMS WITH UNBALANCED FUZZY LINGUISTIC INFORMATION. IJITDM 8:1 (2009) 109–131. Times cited:35
  - Xu, ZS, AN APPROACH TO GROUP DECISION MAKING BASED ON INCOMPLETE LINGUISTIC PREFERENCE RELATIONS. IJITDM 4:1 (2005) 153–160. Times cited:21

Table 1. Basic measures of the themes of the period 2002−2011.

Theme	Documents	h-Index	Average Citations	Total Citations
AGENTS	6	2	2.17	13
ANALYTICAL-HIERARCHY-PROCESS	19	7	5.58	106
CONSENSUS	5	5	18.60	93
DATA-ENVELOPMENT-ANALYSIS	17	6	4.41	75
DATA-MINING	14	4	11.14	156
DECISION-SUPPORT-SYSTEM	8	3	3.50	28
GROUP-DECISION-MAKING	3	2	13.33	40
INTERNET-QUALITY-OF-SERVICE	2	2	4.50	9
INTERPRETIVE-STRUCTURAL-MODELING	2	0	0.00	0
MANAGEMENT	14	4	3.43	48
OPTIMIZATION	8	3	5.88	47
PERFORMANCE-EVALUATION	11	4	3.00	33
SHAPLEY-VALUE	3	2	4.33	13
SOFTWARE-DEFECT-PREDICTION	6	3	3.50	21
TECHNOLOGY-ACCEPTANCE	3	1	1.67	5
TIME-SERIES	5	4	9.60	48
UNCERTAINTY	7	3	3.43	24

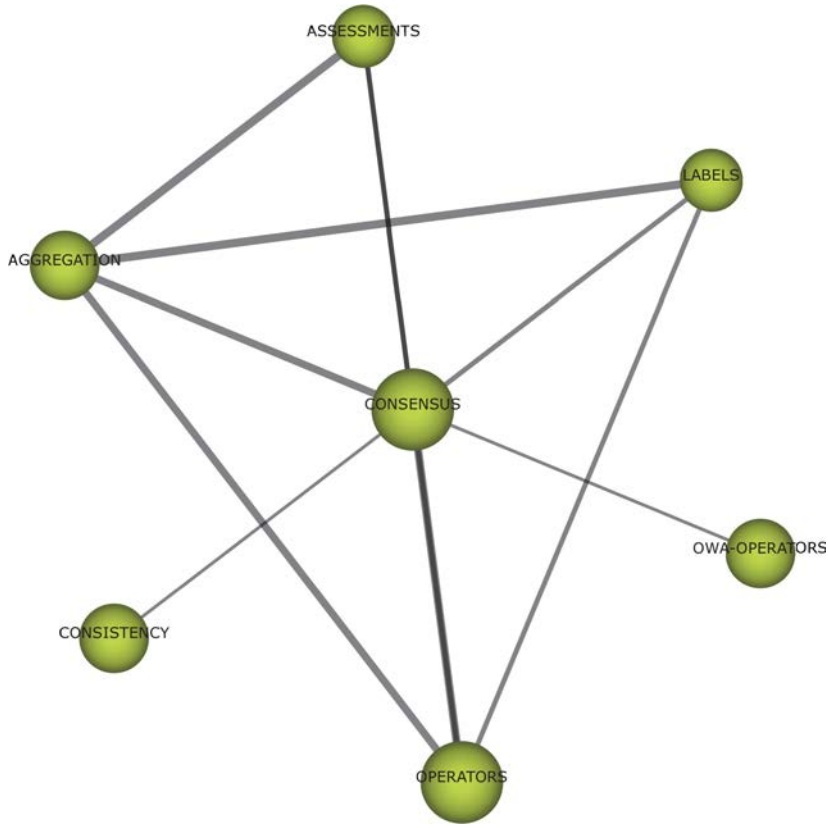


Fig. 6. Thematic network for the theme CONSENSUS.

— Alonso, S, Herrera-Viedma, E, Chiclana, F, Herrera, F, INDIVIDUAL AND SOCIAL STRATEGIES TO DEAL WITH IGNORANCE SITUATIONS IN MULTI-PERSON DECISION MAKING. IJITDM 8:2 (2009) 313–333. Times cited:15
— Xu, ZS, AN APPROACH TO PURE LINGUISTIC MULTIPLE ATTRIBUTE DECISION MAKING UNDER UNCERTAINTY. IJITDM 4:2 (2005) 197–206. Times cited:15

- The thematic-network of the theme ANALYTICAL-HIERARCHY-PROCESS is shown in Fig. 7. This theme was mainly related with the topics: *preference*, *decision* and *multicriteria-decision-making*.
  The three most cited papers:

  — Saaty, TL, Vargas, LG, THE POSSIBILITY OF GROUP WELFARE FUNCTIONS. IJITDM 4:2 (2005) 167–176. Times cited:15
  — Ahmad, N, Berg, D, Simons, GR, THE INTEGRATION OF ANALYTICAL HIERARCHY PROCESS AND DATA ENVELOPMENT ANALYSIS IN A MULTI-CRITERIA DECISION-MAKING PROBLEM. IJITDM 5:2 (2006) 263–276. Times cited:14

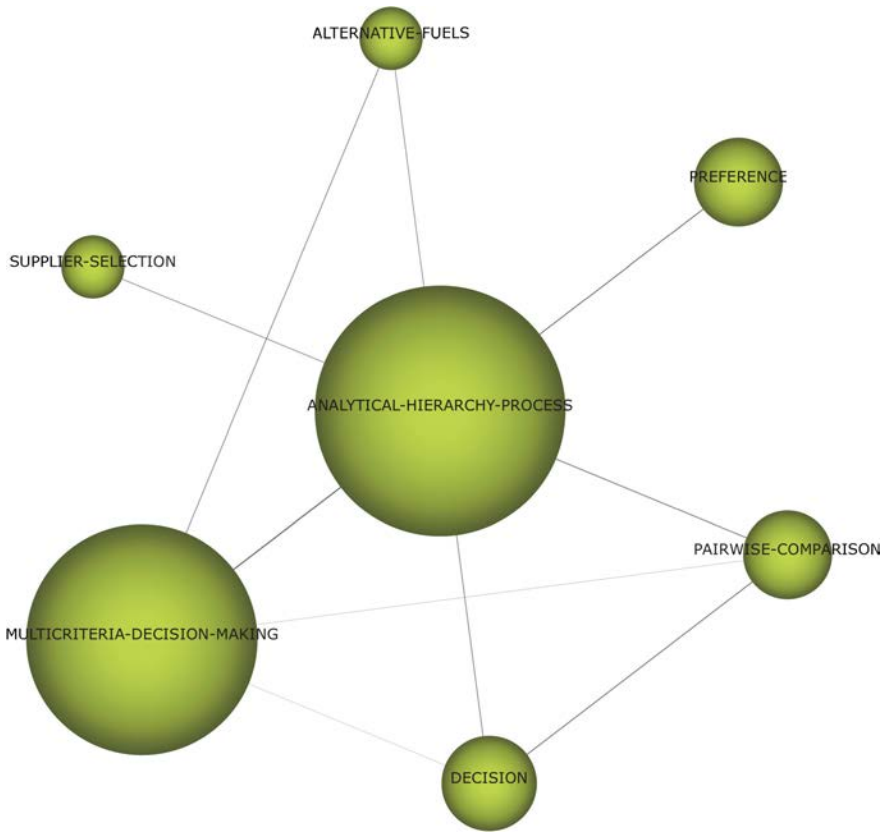


Fig. 7. Thematic network for the theme ANALYTICAL-HIERARCHY-PROCESS.

— Al-Aomar, R, Dweiri, F, A CUSTOMER-ORIENTED DECISION AGENT FOR PRODUCT SELECTION IN WEB-BASED SERVICES. IJITDM 7:1 (2008) 35–52. Times cited:11

- DATA-ENVELOPMENT-ANALYSIS was strongly related with the topics: *benchmarks*, *efficiency* and *banks*. The network of interconnected keywords associated to this theme is shown in Fig. 8.
  The three most cited papers:
  - — Ahmad, N, Berg, D, Simons, GR, THE INTEGRATION OF ANALYTICAL HIERARCHY PROCESS AND DATA ENVELOPMENT ANALYSIS IN A MULTI-CRITERIA DECISION-MAKING PROBLEM. IJITDM 5:2 (2006) 263–276. Times cited:14
  - — Koksalan, M, Tuncer, C, A DEA-BASED APPROACH TO RANKING MULTI-CRITERIA ALTERNATIVES. IJITDM 8:1 (2009) 29–54. Times cited:12
  - — Chen, Y, Motiwalla, L, Khan, MR, USING SUPER-EFFICIENCY DEA TO EVALUATE FINANCIAL PERFORMANCE OF E-BUSINESS INITIATIVE IN THE RETAIL INDUSTRY. IJITDM 3:2 (2004) 337–351. Times cited:8

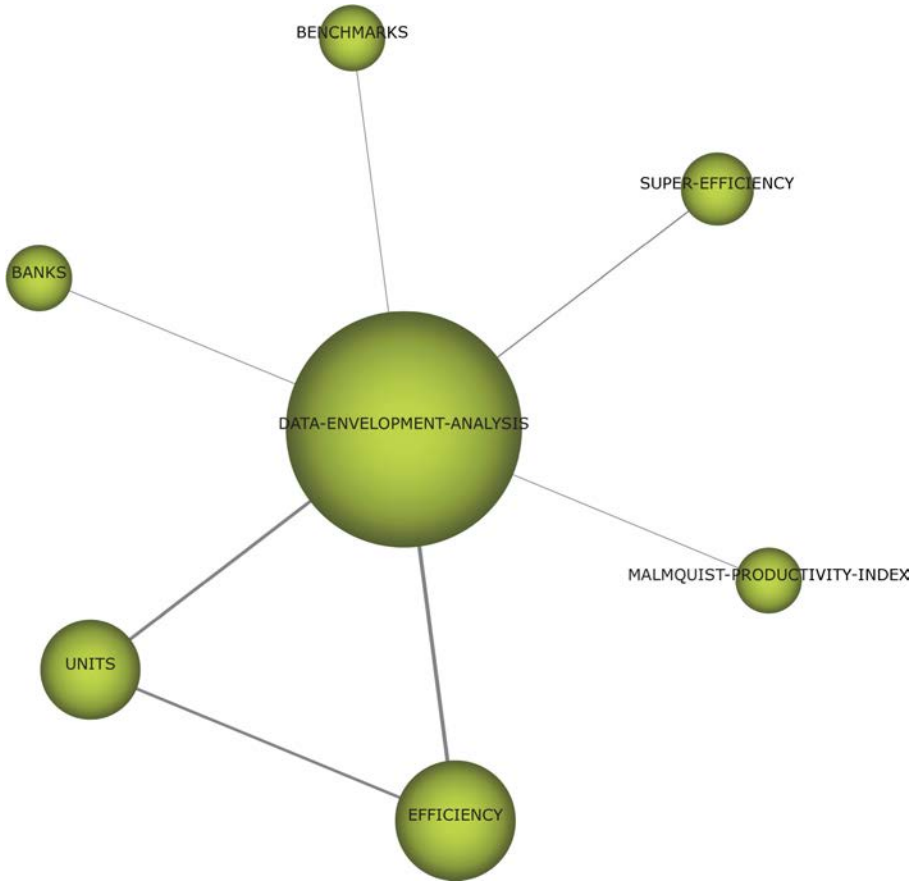


Fig. 8. Thematic network for the theme DATA-ENVELOPMENT-ANALYSIS.

- On the other hand, DATA-MINING was associated with *clustering*, *databases*, *knowledge-management*, *multi-aspect-analysis*, *discovery* and *fuzzy-linear-programming*. The associated thematic network is drawn in Fig. 9.
  The three most cited papers:
  - Peng, Y, Kou, G, Shi, Y, Chen, ZX, A DESCRIPTIVE FRAMEWORK FOR THE FIELD OF DATA MINING AND KNOWLEDGE DISCOVERY. IJITDM 7:4 (2008) 639–682. Times cited:57
  - Yang, Q, Wu, XD, 10 CHALLENGING PROBLEMS IN DATA MINING RESEARCH. IJITDM 5:4 (2006) 597–604. Times cited:53
  - He, J, Liu, XT, Shi, Y, Xu, WX, Yan, N, CLASSIFICATIONS OF CREDIT CARDHOLDER BEHAVIOR BY USING FUZZY LINEAR PROGRAMMING. IJITDM 3:4 (2004) 633–650. Times cited:31

- The theme GROUP-DECISION-MAKING was connected (see Fig. 10) with *words*, *fuzzy-linguistic-modeling* and *preference-relation*.

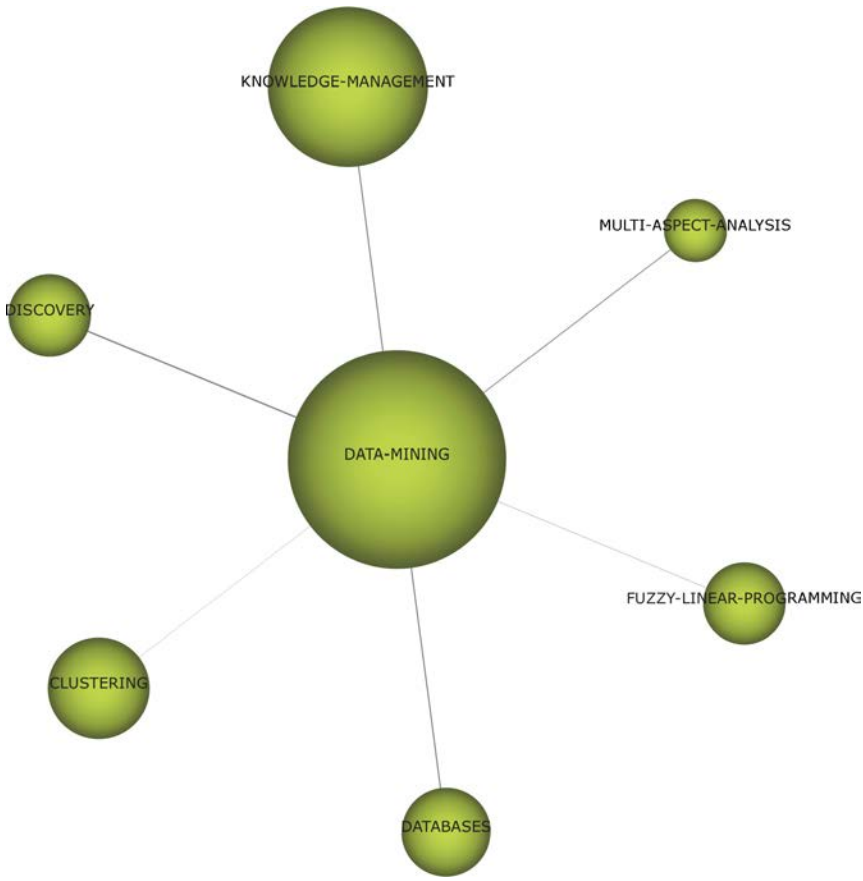


Fig. 9. Thematic network for the theme DATA-MINING.

The two most cited papers:

— Cabrerizo, FJ, Alonso, S, Herrera-Viedma, E, A CONSENSUS MODEL FOR GROUP DECISION MAKING PROBLEMS WITH UNBALANCED FUZZY LINGUISTIC INFORMATION. IJITDM 8:1 (2009) 109–131. Times cited:35

— Cabrerizo, FJ, Lopez-Gijon, J, Ruiz, AA, Herrera-Viedma, E, A MODEL BASED ON FUZZY LINGUISTIC INFORMATION TO EVALUATE THE QUALITY OF DIGITAL LIBRARIES. IJITDM 9:3 (2010) 455–472. Times cited:5

- MANAGEMENT was a practical theme which was related with the topics: *business-strategies*, *project-management*, *simulation*, *systems and sites* and *multicriteria-decision-support-systems*. Its associated thematic network is drawn in Fig. 11.

The three most cited papers:

— Stummer, C, Kiesling, E, A MULTICRITERIA DECISION SUPPORT SYSTEM FOR COMPETENCE-DRIVEN PROJECT PORTFOLIO SELECTION. IJITDM 8:2 (2009) 379–401. Times cited:11

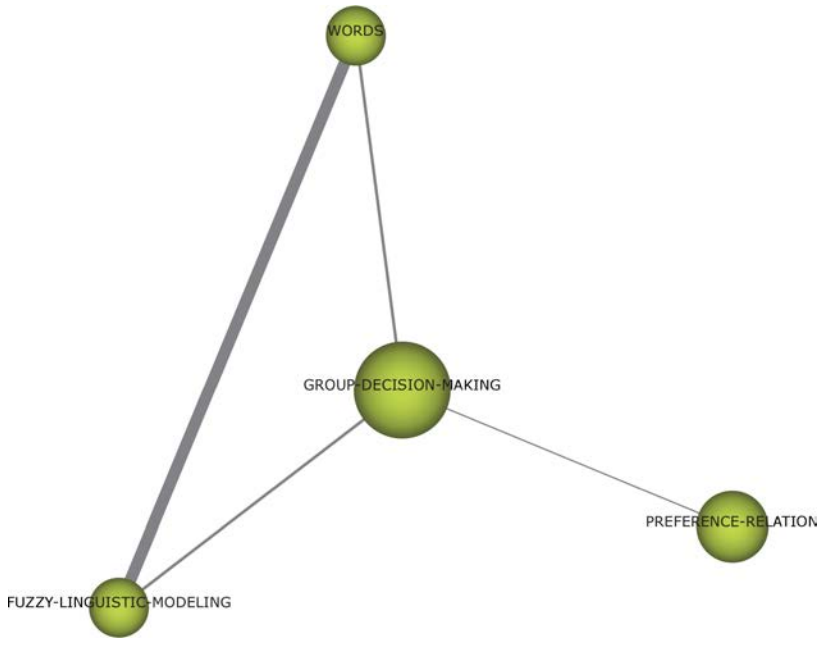


Fig. 10. Thematic network for the theme GROUP-DECISION-MAKING.

— Lee, J, Lee, H, STRATEGIC AGENT BASED WEB SYSTEM DEVELOPMENT METHODOLOGY. IJITDM 7:2 (2008) 309–337. Times cited:7
— Gupta, A, Kalyanaraman, S, Zhang, LY, A SPOT PRICING FRAMEWORK FOR PRICING INTRA-DOMAIN ASSURED BANDWIDTH SERVICES. IJITDM 4:1 (2005) 35–58. Times cited:6

- The theme PERFORMANCE-EVALUATION was mainly related with the topics: *trust*, *acceptance*, *ranking*, *impact* and *market*. Its associated thematic network is drawn in Fig. 12.
  The four most cited documents associated to PERFORMANCE-EVALUATION are:

  — Huang, W, Lai, KK, Nakamori, Y, Wang, SY, Yu, L, NEURAL NETWORKS IN FINANCE AND ECONOMICS FORECASTING. IJITDM 6:1 (2007) 113–140. Times cited:13
  — Ramayah, T, Omar, R, INFORMATION EXCHANGE AND SUPPLY CHAIN PERFORMANCE. IJITDM 9:1 (2010) 35–52. Times cited:6
  — McLain, DL, Aldag, RJ, COMPLEXITY AND FAMILIARITY WITH COMPUTER ASSISTANCE WHEN MAKING ILL-STRUCTURED BUSINESS DECISIONS. IJITDM 8:3 (2009) 407–426. Times cited:4
  — Peng, Y, Kou, G, Wang, GX, Wang, HG, Ko, FIS, EMPIRICAL EVALUATION OF CLASSIFIERS FOR SOFTWARE RISK MANAGEMENT. IJITDM 8:4 (2009) 749–767. Times cited:4

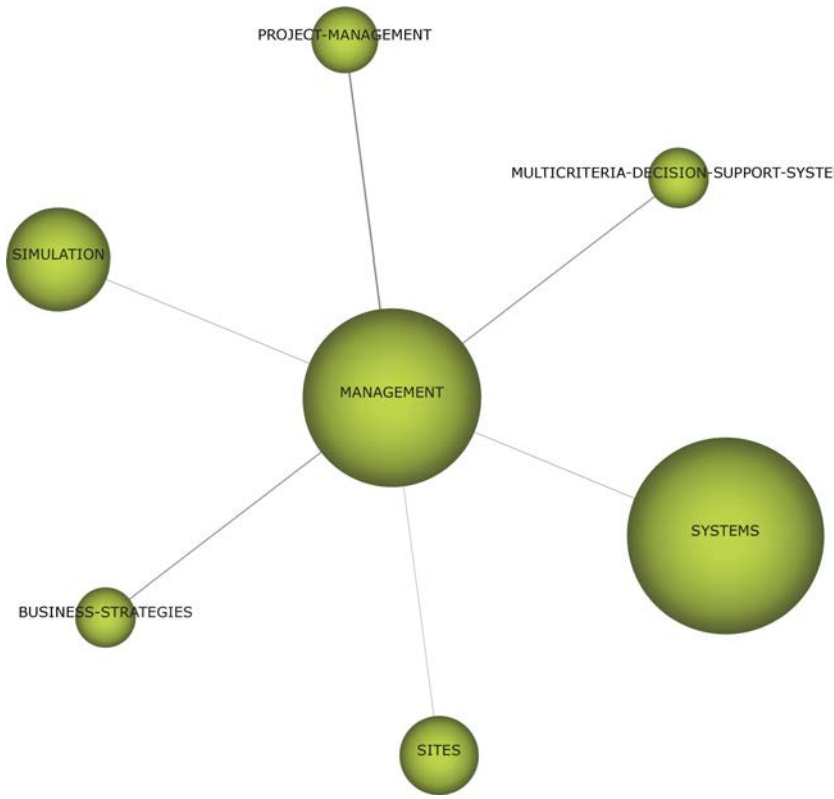


Fig. 11. Thematic network for the theme MANAGEMENT.

- TIME-SERIES was related with *fuzzy-regression*, *forecasting* and *rate-prediction* as it can be observed in Fig. 13.
  The three most cited documents are:
  - Ruey-Chyn Tsaur, Hsiao-Fan Wang, JIA-CHI O.-YANG, FUZZY REGRESSION FOR SEASONAL TIME SERIES ANALYSIS. IJITDM 1:1 (2002) 165–175. Times cited:16
  - Kumar, A, Agrawal, DP, ADVERTISING DATA ANALYSIS USING ROUGH SETS MODEL. IJITDM 4:2 (2005) 263–276. Times cited:14
  - Huang, W, Lai, KK, Nakamori, Y, Wang, SY, Yu, L, NEURAL NETWORKS IN FINANCE AND ECONOMICS FORECASTING. IJITDM 6:1 (2007) 113–140. Times cited:13

4. Estimating the Most Beneficial Themes for the Journal: Future Research Trend

In this section, we introduce a simple analysis that could be done in order to detect the most beneficial themes for the journal. For this analysis, we only use the last two years of the journal, i.e., 2010 and 2011.

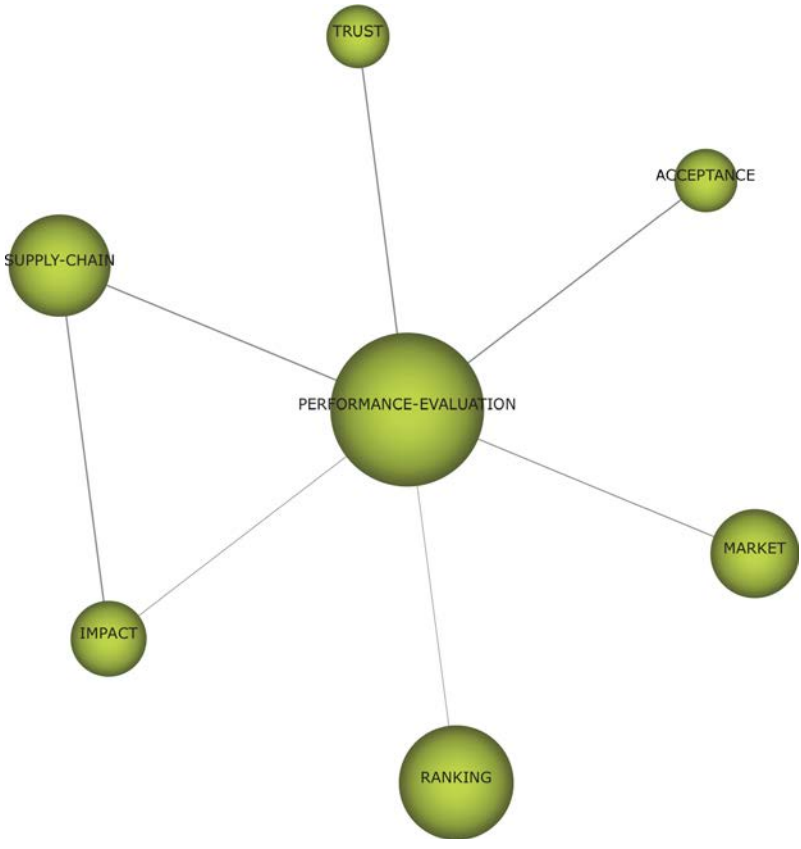


Fig. 12. Thematic network for the theme PERFORMANCE-EVALUATION.

In Table 2 a list of the themes associated to the documents published during 2010 and 2011 is shown. This list includes quantitative and qualitative measures as the number of documents (#Doc) associated to each theme, references of each document, the citations and citation average (Average). The information included in this table allows us to distinguish to type of themes, *hot-themes* and *cold-themes*. For us, a hot-theme is that one with a citation average higher (or equal) to 1.00, i.e., themes with at least one cite per each associated document. These hot-themes are those themes giving positive citation to the journal, helping to increase the impact factor of the journal, whereas, the cold-themes are themes penalizing the journal, decreasing its impact factor. In this sense, themes as SOFTWARE-DEFECT-PREDICTION (with 4.00 cites per document), GROUP-DECISION-MAKING (2.25 cites per document), MANAGEMENT (1.75), ANALYTICAL-HIERARCHY-PROCESS (1.56) and PERFORMANCE-EVALUATION (1.43) are supposed, in general, very beneficial themes for the journal, clearly contributing to a high impact factor.

This *a posteriori* classification could be used by the reader as a predictive estimation about what themes will be beneficial for the journal in next years (2012 or

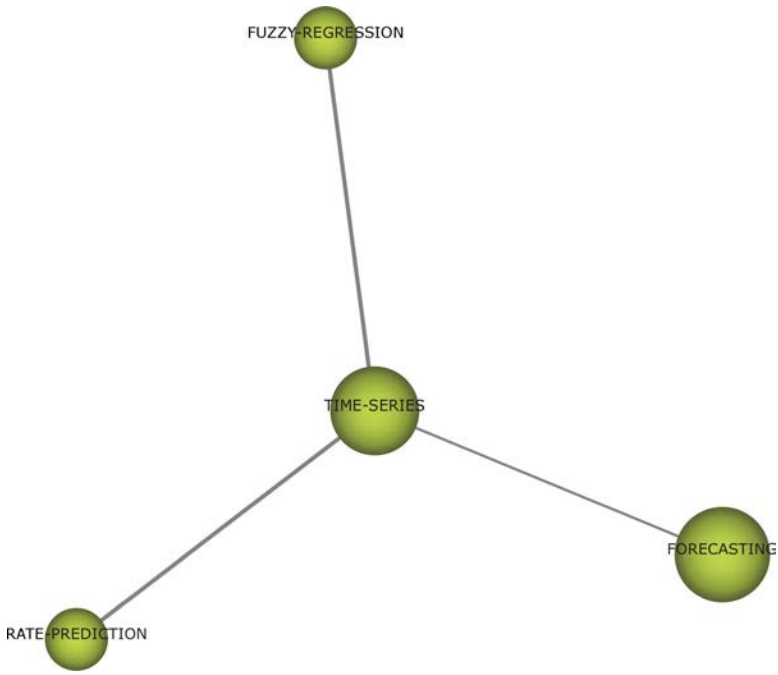


Fig. 13. Thematic network for the theme TIME-SERIES.

Table 2. Basic measures of the themes associated to the documents published during 2010 and 2011.

Theme	#Doc	Citations	Average	References
SOFTWARE-DEFECT-PREDICTION	3	12	4.00	6,50,52
GROUP-DECISION-MAKING	2	5	2.25	12,25
MANAGEMENT	4	7	1.75	31,48,52,64
ANALYTICAL-HIERARCHY-PROCESS	9	14	1.56	9,31,35,38,50,56,62,72,76
PERFORMANCE-EVALUATION	7	10	1.43	15,28,31,46,52,57,79
DECISION-SUPPORT-SYSTEM	3	3	1.00	21,47,53
DATA-ENVELOPMENT-ANALYSIS	2	1	0.50	8,71
AGENTS	2	1	0.50	22,79
TECHNOLOGY-ACCEPTANCE	2	1	0.50	29,66
UNCERTAINTY	3	0	0.00	43,51,70
DATA-MINING	6	0	0.00	37,39,42,45,67,77
OPTIMIZATION	3	0	0.00	33,65,70
INTERPRETIVE-STRUCTURAL-MODELING	2	0	0.00	5,35

even 2013). This predictive analysis could be even done and used by the journal editorial board to help them to select the priority thematics for the journal, given preference to documents associated to presumably hot-themes. Anyway, this predictive analysis (and the associated editorial decisions) has to be carefully done otherwise it is also possible to find cold-themes with some particular highly cited

Table 3. Most cited papers and their associated themes.

Document (Reference)	Year	Citations	Associated Theme/s
49	2008	57	DATA-MINING
75	2006	53	DATA-MINING
11	2009	35	CONSENSUS // GROUP-DECISION-MAKING
26	2004	31	DATA-MINING
60	2005	29	OPTIMIZATION
73	2005	21	CONSENSUS
54	2002	16	TIME-SERIES
4	2009	15	CONSENSUS // UNCERTAINTY
74	2005	15	CONSENSUS
55	2005	15	ANALYTICAL-HIERARCHY-PROCESS
1	2006	14	ANALYTICAL-HIERARCHY-PROCESS // DATA-ENVELOPMENT-ANALYSIS
34	2005	14	TIME-SERIES
30	2007	13	DECISION-SUPPORT-SYSTEM // PERFORMANCE-EVALUATION // TIME-SERIES
32	2009	12	DATA-ENVELOPMENT-ANALYSIS
2	2008	11	ANALYTICAL-HIERARCHY-PROCESS
63	2009	11	MANAGEMENT
23	2007	10	ANALYTICAL-HIERARCHY-PROCESS

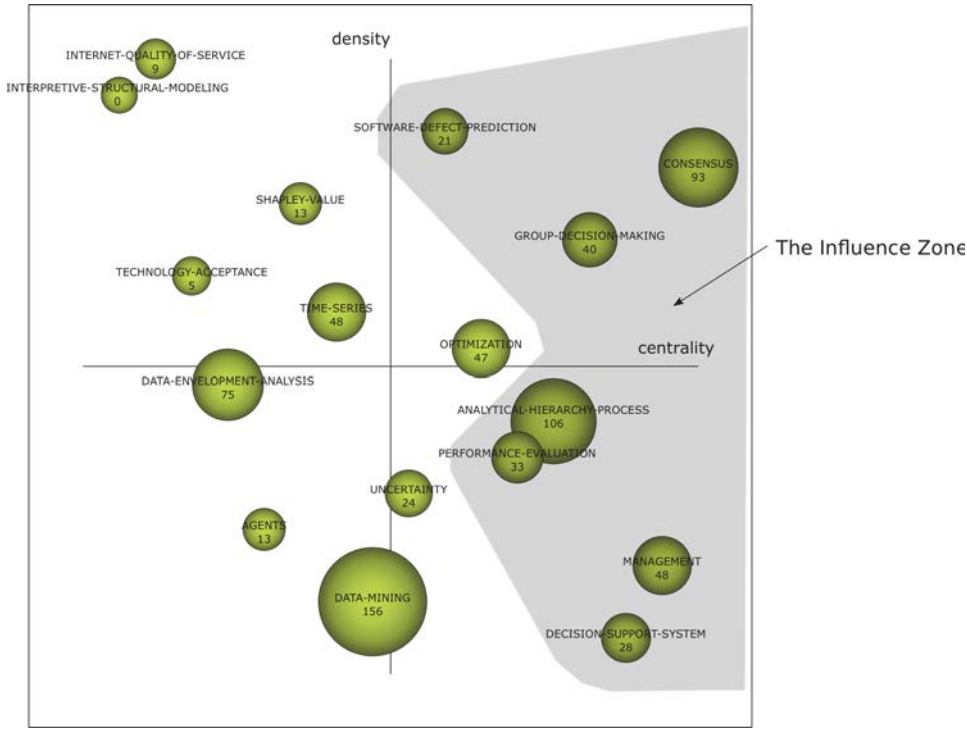


Fig. 14. The influence zone of IJITDM in 2010 and 2011.

documents, as it is shown in Table 3. In Table 3, the historical (considering papers published from 2002 to 2011) most cited papers are shown. We can see as relatively recent papers (2009) as Refs. 4 and 11 (associated to CONSENSUS) and Ref. 63 (associated to MANAGEMENT) are highly cited papers.

We think all this information should be jointly taken into account for determining the "best" themes for the IJITDM. So, we define the *Influence-Zone* as the part of the strategic diagram that groups motor and basic-themes and simultaneously hot-themes with themes with highly cited papers in the last three or four years before 2009, 2010 and 2011 in our case. This influence zone is drawn in Fig. 14.

So, we think that future (mainly 2012 or 2013) papers associated to the influence themes: SOFTWARE-DEFECT-PREDICTION, GROUP-DECISION-MAKING, CONSENSUS, MANAGEMENT, ANALYTICAL-HIERARCHY-PROCESS, PERFORMANCE-EVALUATION and DECISION-SUPPORT-SYSTEM will be very beneficial papers, providing quantity and specially quality and cites to the journal.

5. Conclusion

The purpose of this paper has been to offer an expeditious perspective of the first decade (2002−2011) of the IJITDM by identifying themes, predicting emerging trends, and determining relationships with other themes/fields.

Our analysis has to allow to detect the influence themes of the journal, i.e., those themes with a much relevant role in future years for the journal.

All this has been done using co-word as content analysis technique. However, this task is not free of difficulties due to the biases involved in an analysis of this kind. The main one is that the analysis focuses on priority themes (just those automatically detected by CoPalRed) and will inevitably exclude those that are of only marginal importance. Nonetheless, the analysis serves to legitimize discussions about general trends of the journal.

Since the analysis is constrained by factors such as sample size and the period examined, among others, its "applicability-generalizability" must be further reviewed and tested in the future, preferably at regular intervals.

Finally, experts and novices could use these data, results and maps to understand the current state of the art with regard to IJITDM and predict where future research will lead.

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References

1. N. Ahmad, D. Berg and G. R. Simons, The integration of analytical hierarchy process and data envelopment analysis in a multi-criteria decision-making problem, *International Journal of Information Technology & Decision Making* **5**(2) (2006) 263−276.
2. R. Al-Aomar and F. Dweiri, A customer-oriented decision agent for product selection in web-based services, *International Journal of Information Technology & Decision Making* **7**(1) (2008) 35−52.
3. S. Alonso, F. J. Cabrerizo, E. Herrera-Viedma and F. Herrera, h-index: A review focused in its variants, computation and standardization for different scientific fields, *Journal of Informetrics* **3**(4) (2009) 273−289.
4. S. Alonso, E. Herrera-Viedma, F. Chiclana and F. Herrera, Individual and social strategies to deal with ignorance situations in multi-person decision making, *International Journal of Information Technology & Decision Making* **8**(2) (2009) 313−333.
5. C.-C. Chang, A. H. I. Lee and H.-Y. Kang, An integrated interpretive structural modeling-fuzzy analytic network process-benefits, opportunities, costs and risks model for selecting technologies, *International Journal of Information Technology & Decision Making* **10**(5) (2011) 843−871.
6. P. Baecke and D. Van den Poel, Improving purchasing behavior predictions by data augmentation with situational variables, *International Journal of Information Technology & Decision Making* **9**(6) (2010) 853−872.
7. R. Bailón-Moreno, E. Jurado-Alameda and R. Ruiz-Baños, The scientific network of surfactants: Structural analysis, *Journal of the American Society for Information Science and Technology* **57**(7) (2006) 949−960.
8. G. B. Bi, J. J. Ding, Y. Luo and L. Liang, A new malmquist productivity index based on semi-discretionary variables with an application to commercial banks of china, *International Journal of Information Technology & Decision Making* **10**(4) (2011) 713−730.
9. A. Caballero-Luque, P. Aragones-Beltran, M. Garcia-Melon and C. Dema-Perez, Analysis of the alignment of company goals to web content using anp, *International Journal of Information Technology & Decision Making* **9**(3) (2010) 419−436.
10. F. J. Cabrerizo, S. Alonso, E. Herrera-Viedma and F. Herrera, q^2-index: Quantitative and qualitative evaluation based on the number and impact of papers in the hirsch core, *Journal of Informetrics* **4**(1) (2010) 23−28.
11. F. J. Cabrerizo, S. Alonso and E. Herrera-Viedma, A consensus model for group decision making problems with unbalanced fuzzy linguistic information, *International Journal of Information Technology & Decision Making* **8**(1) (2009) 109−131.
12. F. J. Cabrerizo, J. Lopez-Gijon, A. A. Ruiz and E. Herrera-Viedma, A model based on fuzzy linguistic information to evaluate the quality of digital libraries, *International Journal of Information Technology & Decision Making* **9**(3) (2010) 455−472.
13. M. Callon, J. P. Courtial and F. Laville, Co-word analysis as a tool for describing the network of interactions between basic and technological research — the case of polymer chemistry, *Scientometrics* **22**(1) (1991) 155−205.
14. M. Callon, J. P. Courtial, W. A. Turner and S. Bauin, From translations to problematic networks: An introduction to co-word analysis, *Social Science Information* **22**(2) (1983) 191−235.

15. P. Y. Chu, C. F. Lee and Y. S. Yuen, Innovative business models in semiconductor foundry industry: From silicon intellectual property perspectives, *International Journal of Information Technology & Decision Making* **10**(3) (2011) 411−433.
16. M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma and F. Herrera, An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the fuzzy sets theory field, *Journal of Informetrics* **5**(1) (2011) 146−166.
17. M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma and F. Herrera, Science mapping software tools: Review, analysis and cooperative study among tools, *Journal of the American Society for Information Science and Technology* **62**(7) (2011) 1382−1402.
18. M. J. Cobo, A. G. López-Herrera, F. Herrera and E. Herrera-Viedma, A note on the ITS topic evolution in the period 2000−2009 at T-ITS, *IEEE Transactions on Intelligent Transportation Systems* **13**(1) (2011) 413−420.
19. CoPalRed, Research group Evaluación de la Ciencia y la Comunicación Científica, Universidad de Granada (2005), http://ec3.ugr.es/copalred/.
20. N. Coulter, I. Monarch and S. Konda, Software engineering as seen through its research literature: A study in co-word analysis, *Journal of the American Society for Information Science* **49**(13) (1998) 1206−1223.
21. M. Fasanghari, M. S. Amalnick, S. K. Chaharsooghi and FIS Ko, The fuzzy evaluation of the ict projects in strategic environment (case study: Iran telecommunication research center), *International Journal of Information Technology & Decision Making* **10**(5) (2011) 873−890.
22. M. Filzmoser, J. Rios, S. Strecker and R. Vetschera, The impact of analytical support and preference determination on consistency in e-negotiations. a new method and preliminary results, *International Journal of Information Technology & Decision Making* **9**(5) (2010) 673−694.
23. G. L. Fu, C. Yang and G. H. Tzeng, A multicriteria analysis on the strategies to open taiwan's mobile virtual network operators services, *International Journal of Information Technology & Decision Making* **6**(1) (2007) 85−112.
24. E. Garfield, Scientography: Mapping the tracks of science, *Current Contents: Social & Behavioural Sciences* **7**(45) (1994) 5−10.
25. Z. W. Gong, L. S. Li, J. Cao and F. X. Zhou, On additive consistent properties of the intuitionistic fuzzy preference relation, *International Journal of Information Technology & Decision Making* **9**(6) (2010) 1006−1025.
26. J. He, X. T. Liu, Y. Shi, W. X. Xu and N. Yan, Classifications of credit cardholder behavior by using fuzzy linear programming, *International Journal of Information Technology & Decision Making* **3**(4) (2004) 633−650.
27. J. Hirsch, An index to quantify an individuals scientific research out-put, *Proceedings of the National Academy of Sciences* **102** (2005) 16569−16572.
28. L. A. Ho, T. H. Kuo, C. H. Lin and B. S. Lin, The mediate effect of trust on organizational online knowledge sharing: An empirical study, *International Journal of Information Technology & Decision Making* **9**(4) (2010) 625−644.
29. S. C. Ho, W. Y. C. Wang, D. J. Pauleen and P. H. Ting, Perspectives on the performance of supply chain systems: The effects of attitude and assimilation, *International Journal of Information Technology & Decision Making* **10**(4) (2011) 635−658.
30. W. Huang, K. K. Lai, Y. Nakamori, S. Y. Wang and L. Yu, Neural networks in finance and economics forecasting, *International Journal of Information Technology & Decision Making* **6**(1) (2007) 113−140.
31. A. Ignatius, J. An Mustafa, M. Jantan, C. P. Lim, T. Ramayah and J. Y. A. Leen, A multi-objective sensitivity approach to training providers' evaluation and quota

allocation planning, *International Journal of Information Technology & Decision Making* **10**(1) (2011) 147−174.
32. M. Koksalan and C. Tuncer, A dea-based approach to ranking multi-criteria alternatives, *International Journal of Information Technology & Decision Making* **8**(1) (2009) 29−54.
33. A. R. Konan, T. I. Gundem and M. E. Kaya, Assignment query and its implementation in moving object databases, *International Journal of Information Technology & Decision Making* **9**(3) (2010) 349−372.
34. A. Kumar and D. P. Agrawal, Advertising data analysis using rough sets model, *International Journal of Information Technology & Decision Making* **4**(2) (2005) 263−276.
35. A. H. I. Lee, H. Y. Kang and C. C. Chang, An integrated interpretive structural modeling-fuzzy analytic network process-benefits, opportunities, costs and risks model for selecting technologies, *International Journal of Information Technology & Decision Making* **10**(5) (2011) 843−871.
36. L. Leydesdorff and P. Zhou, Co-word analysis using the chinese character set, *Journal of the American Society for Information Science and Technology* **59**(9) (2008) 1528−1530.
37. A. Li, Y. Shi, J. He and Y. Zhang, A fuzzy linear programming-based classification method, *International Journal of Information Technology & Decision Making* **10**(6) (2011) 1161−1174.
38. C. T. Lin, C. Lee and C. S. Wu, Fuzzy group decision making in pursuit of a competitive marketing strategy, *International Journal of Information Technology & Decision Making* **9**(2) (2010) 281−300.
39. Y. Liu, J. W. Li, W. K. Liao, A. Choudhary and Y. Shi, High utility itemsets mining, *International Journal of Information Technology & Decision Making* **9**(6) (2010) 905−934.
40. A. G. López-Herrera, M. J. Cobo, E. Herrera-Viedma and F. Herrera, A bibliometric study about the research based on hybridating the fuzzy logic field and the other computational intelligent techniques: A visual approach, *International Journal of Hybrid Intelligent Systems* **17**(7) (2010) 17−32.
41. A. G. López-Herrera, M. J. Cobo, E. Herrera-Viedma, F. Herrera, R. Bailón-Moreno and E. Jimenez-Contreras, Visualization and evolution of the scientific structure of fuzzy sets research in spain, *Information Research* **14**(4) (2009) paper 421.
42. P. Loslever, K. Younsi, J. C. Popieul and P. Simon, Membership-value-based homogenization for a descriptive multifactor multivariate data analysis. example featuring quantitative and qualitative time variables in car driving, *International Journal of Information Technology & Decision Making* **9**(6) (2010) 979−978.
43. J. M. Merigo and M. Casanovas, The uncertain generalized owa operator and its application to financial decision making, *International Journal of Information Technology & Decision Making* **10**(2) (2011) 211−230.
44. F. Muñoz-Leiva, M. I. Viedma-Del-Jesus, J. Sánchez-Ferández and A. G. López-Herrera, An application of co-word analysis and bibliometric maps for detecting the most highlighting themes in the consumer behaviour research from a longitudinal perspective, *Quality & Quantity*, DOI:10.1007/s11135-011-9565-3, in press (2012).
45. A. Nachev, S. Hill, C. Barry and B. Stoyanov, Fuzzy, distributed, instance counting, and default artmap neural networks for financial diagnosis, *International Journal of Information Technology & Decision Making* **9**(6) (2010) 959−978.
46. A. Nieto-Morote and F. Ruz-Vila, A fuzzy ahp multi-criteria decision-making approach applied to combined cooling, heating, and power production systems, *International Journal of Information Technology & Decision Making* **10**(3) (2011) 497−517.
47. Z. K. Ozturk, G. Ozturk and M. Sagir, An automated multi-objective invigilator-exam assignment system, *International Journal of Information Technology & Decision Making* **9**(2) (2010) 223−238.

48. D. Peidro, J. Mula and R. Poler, Fuzzy linear programming for supply chain planning under uncertainty, *International Journal of Information Technology & Decision Making* **9**(3) (2010) 373–392.
49. Y. Peng, G. Kou, Y. Shi and Z. X. Chen, A descriptive framework for the field of data mining and knowledge discovery, *International Journal of Information Technology & Decision Making* **7**(4) (2008) 639–682.
50. Y. Peng, G. Kou, G. X. Wang, W. S. Wu and Y. Shi, Ensemble of software defect predictors: An ahp-based evaluation method, *International Journal of Information Technology & Decision Making* **10**(1) (2011) 187–206.
51. Y. H. Qian, J. Y. Liang, P. Song and C. Y. Dang, On dominance relations in disjunctive set-valued ordered information systems, *International Journal of Information Technology & Decision Making* **9**(1) (2010) 9–33.
52. T. Ramayah and R. Omar, Information exchange and supply chain performance, *International Journal of Information Technology & Decision Making* **9**(1) (2010) 35–52.
53. G. Rigopoulos, D. T. Askounis and K. Metaxiotis, Nexclass: A decision support system for non-ordered multicriteria classification, *International Journal of Information Technology & Decision Making* **9**(1) (2010) 53–79.
54. J.-C. O.- Yang, R.-C. Tsaur and H.-F. Wang, Fuzzy regression for seasonal time series analysis, *International Journal of Information Technology & Decision Making* **1**(1) (2002) 165–175.
55. T. L. Saaty and L. G. Vargas, The possibility of group welfare functions, *International Journal of Information Technology & Decision Making* **4**(2) (2005) 167–176.
56. T. L. Saaty and H. J. Zoffer, Negotiating the israeli-palestinian controversy from a new perspective, *International Journal of Information Technology & Decision Making* **10**(1) (2011) 5–64.
57. C. W. Shen, A bayesian networks approach to modeling financial risks of e-logistics investments, *International Journal of Information Technology & Decision Making* **8**(4) (2009) 711–726.
58. Y. Shi, Current research trend: Information technology and decision making in 2008, *International Journal of Information Technology & Decision Making* **8**(01) (2009) 1–5.
59. Y. Shi, The research trend of information technology and decision making in 2009, *International Journal of Information Technology & Decision Making* **9**(1) (2010) 1–8.
60. Y. Shi, Y. Peng, G. Kou and Z. X. Chen, Classifying credit card accounts for business intelligence and decision making: A multiple-criteria quadratic programming approach, *International Journal of Information Technology & Decision Making* **4**(4) (2005) 581–599.
61. H. Small, Co-citation in the scientific literature: a new measure of the relationship between two documents, *Journal of the American Society for Information Science* **24**(4) (1973) 265–269.
62. B. Soylu, Integrating prometheeii with the tchebycheff function for multi criteria decision making, *International Journal of Information Technology & Decision Making* **9**(4) (2010) 525–545.
63. C. Stummer and E. Kiesling, A multicriteria decision support system for competence-driven project portfolio selection, *International Journal of Information Technology & Decision Making* **8**(2) (2009) 379–401.
64. Z. X. Su, A hybrid fuzzy approach to fuzzy multi-attribute group decision-making, *International Journal of Information Technology & Decision Making* **10**(4) (2011) 695–711.

65. M. H. Sun, A mixed integer programming model for multiple-class discriminant analysis, *International Journal of Information Technology & Decision Making* **10**(4) (2011) 589–612.
66. I. Tanoglu, N. Basoglu and T. Daim, Exploring technology diffusion: Case of information technologies, *International Journal of Information Technology & Decision Making* **9**(2) (2010) 195–222.
67. C. Y. Tsai, C. C. Lo and C. W. Lin, A time-interval sequential pattern change detection method, *International Journal of Information Technology & Decision Making* **10**(1) (2011) 83–108.
68. A. F. J. van Raan, Measuring Science, in *Handbook of Quantitative Science and Technology Research* (Springer, Netherlands, 2005), pp. 19–50.
69. M. I. Viedma-Del-Jesus, P. Perakakis, M. Á. Muñoz, A. G. López-Herrera and J. Vila, Sketching the first 45 years of the journal psychophysiology (1964–2008): A co-word-based analysis, *Psychophysiology* **48**(8) (2011) 1029–1036.
70. S. Y. Wang and C. F. Lee, A fuzzy real option valuation approach to capital budgeting under uncertainty environment, *International Journal of Information Technology & Decision Making* **9**(5) (2010) 695–713.
71. Q. L. Wei and H. Yan, A data envelopment analysis (dea) evaluation method based on sample decision making units, *International Journal of Information Technology & Decision Making* **9**(4) (2010) 601–624.
72. L. T. Wu, X. Cui and R. W. Dai, Judgment number reduction: An issue in the analytic hierarchy process, *International Journal of Information Technology & Decision Making* **9**(1) (2010) 175–189.
73. Z. S. Xu, An approach to group decision making based on incomplete linguistic preference relations, *International Journal of Information Technology & Decision Making* **4**(1) (2005) 153–160.
74. Z. S. Xu, An approach to pure linguistic multiple attribute decision making under uncertainty, *International Journal of Information Technology & Decision Making* **4**(2) (2005) 197–206.
75. Q. Yang and X. D. Wu, 10 challenging problems in data mining research, *International Journal of Information Technology & Decision Making* **5**(4) (2006) 597–604.
76. K. K. F. Yuen, The primitive cognitive network process: Comparisons with the analytic hierarchy process, *International Journal of Information Technology & Decision Making* **10**(4) (2011) 659–680.
77. U. Yun and K. H. Ryu, Discovering important sequential patterns with length-decreasing weighted support constraints, *International Journal of Information Technology & Decision Making* **9**(4) (2010) 575–599.
78. J. Zhang, D. Wolfram, P. Wang, Y. Hong and R. Gillis, Visualization of health-subject analysis based on query term co-occurrences, *Journal of the American Society for Information Science and Technology* **59**(12) (2008) 1933–1947.
79. Y. F. Zhang, S. Bhattacharyya and X. M. Li, From choice of procurement strategy to supply network configuration: An evolutionary approach, *International Journal of Information Technology & Decision Making* **9**(1) (2010) 145–173.