Research Methods used in Engineering and Technology Management research: A Trend analysis

Course Title: ***ETM 590 Engineering and Technology Management Synthesis***

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1.0 Introduction

Engineering and Technology Management takes a comprehensive approach to management. It is not a system for automating management. It seeks to draw on generally accepted practices in engineering and apply them accordingly to a business and corporate setting. In fact there is an entire area of engineering which focuses on the management and administration of engineering projects. People who work in this area tend to look at the big picture by estimating costs and evaluating the worth of projects. They also deal with issues of safety, efficiency and organization. ETM has many different tracks such as Operation Research, Decision Making, Technology Marketing, New Product Development etc. Research methods are revolving in the field of ETM; different areas might use different research methods.

There are many different conferences available in the field on Engineering and Technology Management:

- IEEE International Engineering Management Society Conference (IEMC) [1]
- International Association for Management of Technology (IAMOT) [2]
- Portland International Center for Management of Engineering and Technology (PICMET) [3]

IEMC established in 1987 by the IEEE Engineering Management Society (EMS) was the first annual conference focused to promoting the research and practice of engineering management. This was followed by IAMOT in 1988, and PICMET in 1989. These organizations transformed engineering and technology management as a professional discipline, encouraging theory development for managing organizations with a high engineering or technical content. We chose PICMET for our research paper due to the success of this conference and also access to the PICMET database through Dr. Timothy Anderson. PICMET attendees are growing gradually since its first conference in 1991. PICMET 2011 alone attracted authors representing about 300 organizations in 37 countries [4]. The conference is held throughout the world with odd numbered years held in Portland, Oregon.

Our intention in this paper is to provide a reference for researchers and doctoral candidates for research method selection in the field of Engineering and Technology management; specifically papers from Portland International Center for Management of Engineering and Technology (PICMET). Further, our research can be beneficial for the

PICMET committee to identify popular research areas in engineering and technology management and hence expand the scope of research and future planning for research area setting.

2.0 Research Objective

The aim of this research paper is to identify the popular research methods used in Engineering & Technology Management and their trend. This is accomplished by retrieving the published papers from PICMET database for the years 1991, 2001 and 2011. Further the study focuses on identifying the popular research field, their trend and provides list of common research methods used in specific research field. The present study answers the following in detail:

(a) Identify the most popular research areas by looking at the frequency of papers published in PICMET in 1991, 2001 and 2011

(b) Identify most popular research methods in data gathering, data analysis and analyze their trend

(c) Analyze the trend in qualitative and quantitative research methods in data gathering and data analysis categories.

(d) Identify most popular research methods used in specific research fields

Answers to objective (a) and (d) can help researchers and doctoral candidates in selection of research methods for specific research fields. It also helps PICMET committee in designing the future conference research area selection while (b) and (c) solely provides reference to PhD students in the selection of right research methods.

3.0 Research Methodology

The research began with the literature research to come up with classification/taxonomy for coding. The research methods were broadly classified into three different categories –Data Gathering, Data Analysis & Mixed methods. Data gathering and data analysis were further classified as qualitative and quantitative methods. The classification of research field was also identified through the PICMET database in other words as per PICMET classification. Further, both the list was updated throughout the review period as the team came across new research methods.

To investigate the trend of research field and methods, following methods were used:

1. **Description Analysis:** Analysis of number of papers published in 1991, 2001, and 2011 was done. This study identified all the missing and not available papers along with ones with full data. Also, frequency and trend analysis of research paper published in specific research field was analyzed.

2. **Content Analysis,** which is defined as "any methodological measurement applied to text for social sciences purposes" [5]. Overall there were 278 papers from PICMET 1991 and 93 of them were excluded as they were unavailable in the database, leaving 185 for analysis. Similarly, out of 314 papers from PICMET 2001 and 275 papers from PICMET 2011, 30 and 23 papers respectively were excluded for the same reason. All the papers were grouped into three sets for every year and each set was reviewed by two experts to remove any bias. Each paper was analyzed based on research field and research method used. After reviewing each paper individually both the reviewers met to discuss the degree of agreement between their analyses. The papers that had differences were discussed until a consensus was reached. Finally the trend was analyzed statistically. Fig 1 summarizes our followed methodologies.

Fig 1: Methodology

4.0 Literature Review:

Similar research has been made in various areas such as organizational science, technology management, general management, etc. We reviewed many papers, however focused more on four papers: Podsakoff and Dalton [6]; Chang and Pan [7]; Aguinis etal. [8]; Scandura and Williams [9].

Podsakoff and Dalton [6] reviewed the research methods and analysis that are employed in the field of organizational studies. The author's content analyzed all the papers published in 1985 volumes of the five empirical journals, dedicated almost exclusively to organizational studies. About 193 papers were reviewed and analyzed by dividing it into 12 coding dimensions. Final results showed about 70 percent of all research conducted relied on information gathered from either survey instruments or laboratory research. Thus their research gave us a way to analyze PICMET papers based on the content analysis and thus derive the trend in research methods used for particular research field.

Chang and Pan [7] analyzed the trend development of innovation issue by reviewing 273 articles in TECHNOVATION journal from 1995 to 2009. The authors analyzed the distribution across years, nations and important authors using description analysis. Further content analysis was used to perform research methodologies analysis, domain industries analysis and innovation issue analysis. The paper concluded saying qualitative and quantitative research balanced in TECHNOVATION journal; region/network, product/NPD and organizations were top three concepts relevant to innovation issues. As following sections depict, we used description analysis to analyze the trend analysis of papers published, number of papers published in specific research field, and trend analysis of papers published in specific research field. Content Analysis was used to check the popular research methods used, trend in research methods and popular research methods in specific research field in both data gathering and data analysis category.

Similarly Aguinis etal [8] conducted a content analysis of 193 articles published in the first 10 volumes (1998 to 2007) of Organizational Research Methods (ORM). The study checked the topical areas that have been consistently or increasingly popular in the past decade and if the research already in ORM provided necessary methodological tools for future organizational science related research.

Scandura and Williams [9] compared the methodological strategies reported in articles published from 1985 to 1987 versus 1995 to 1997 in AMJ, ASQ, and JOM journals. The review was done through formal theory, literature reviews and empirical data. Results indicated some potentially important trends in reports of research strategies as well as decrease in the internal, external, and construct validity of studies. The use of content analysis to perform the research further bolstered our study.

5.0 Classification/Taxonomy:

As explained in the methodology section, in order to perform the content analysis the starting point was to come up with taxonomy for data gathering and data analysis research methods used in PICMET papers. Based on the literature review, we came up with initial classification which was used for coding the papers. The list was updated as and when we came across new method during our review. The table 1 shows the classification we used to code the PICMET papers. Refer Appendix 1 for definitions for the research methods used.

Coding process:

Each paper was independently coded by the authors of this paper. As practice, the coders coded the first 50 papers from 2001 PICMET independently using the taxonomy and if any discrepancies were resolved by discussing to analyze the reason for that discrepancy. Finally a consensus was reached. Upon completion of this review, papers in each year were then reviewed by two coders and the results were compared; the differences' were discussed and agreed.

Research Methods					
Data Gathering		**Data Analysis**			
Quantitative	**Qualitative**	**Quantitative**		**Qualitative**	**Mixed Methods**
Case study	Action Research	ANOVA	Hypothesis test	Concept Mapping	AHP
Data Mining	Archival	Balanced score card	Grounded Theory Research	Conjoint Analysis	Content Analysis
Documents	Biographical Method	Bayesian networks	Life cycle analysis	Document Interpretation	
Experimental design	Clinical Research	Behavior Recording	Linear regression	Multisource ratings	
Liteature research	Ethnography	Bibliometric Analysis	Literature research	Narrative Analysis	
Open ended interview	Focus group	Case study	Logistic Regression	Non parametric Analysis	
Research setting	Grounded Theory Research	Causal Mapping	Longitudinal Data Analysis	Policy ratings	
Sampling method	Observation data	Chi-square test	Mathematical Model	Semiotic Analysis	
Survey	Policy Capturing	Citation Analysis	Multilevel research		
Time Series /event history		Cluster Analysis	Multiple Regression		
Web content		Comparitive analysis	Network analysis		
Delphi method		Confidence Interval	Non -linear regression		
		Correlation analysis	Pair wise Comparison		
		DEA	Partial least square method		
		Delphi method	Patent analysis		
		Description analysis	Path Analysis		
		Descriptives	Sensitivity Analysis		
		Discriminant Analysis	Simulation		
		Effect size	Social Network analysis		
		Factor Analysis	Time Series Analysis		
		Gray relational analysis	T-test		

Table 1: Classification

6.0 Research field Taxonomy

For coding the research field, we have adopted research field categories from the PICMET. The table 2 lists all research fields used for coding.

Research field	
Collaboration for Technology Management	Science & Technology Policy Issues
Competitive Strategies in Technology Management	Social Networks
Corporate strategies in information age	Software Management
Cultural Issues	Strategic Management of Technology
Decision making for technology management	Supply chain Management
E-business	Sustainability
Emerging Technologies	Technical Organizations and Workforce
Entraprenuership/Intrapreneurship	Technology Adoption
Environmental Issues in Technology Management	Technology and Industry Convergence
Global Issues	Technology Assessment & Acquisition
Human Resource Development in the network Economy	Technology Management Education
Information/Knowledge management	Technology Management framework
International Issues in Technology Management	Technology Management in Biotechnology Industry
Management of Engineers and scientists	Technology Management in Energy Industry
Management of Technological Change	Technology Management in Government
Management of Technology -Based organizations.	Technology Management in Health Industry
Management of Technological Innovation	Technology Management in Semiconductors Industry
Manufacturing Management	Technology Management in Service Industry
New Product Development	Technology Management in Transportation Industry
New Venture Management	Technology Planning & Forecasting
Open Innovation	Technology Roadmapping
Productivity Management	Technology Transfer
Project/Program Management	Technology Diffusion
R & D Management	Technology Marketing
Radical Innovations	Telecommunication Management
Resource Management in the Knowledge Era	

Table 2: Research Field Taxonomy

7.0 Analysis & Results:

Table 3 gives an overview of the results covered in the following sections mentioned in parenthesis:

<table>
<tr><th colspan="4">Result (7.0)</th></tr>
<tr><th rowspan="2">Description Analysis (7.1)</th><th colspan="2">Content Analysis (7.2)</th><th rowspan="2">Combination (7.3)</th></tr>
<tr><th>Data Gathering</th><th>Data Analysis</th></tr>
<tr><td>No of papers published during review period</td><td>Popular research methods in quantitative & Qualitative category</td><td>Popular research methods in quantitative & Qualitative category</td><td>Research methods used in Specific research field.</td></tr>
<tr><td>Frequency of papers in specific research field</td><td>Trend in quantitative & qualitative research methods</td><td>Trend in quantitative & qualitative research methods</td><td rowspan="3"></td></tr>
<tr><td rowspan="2">Trend in research papers published for specific research field</td><td rowspan="2">Analyze trend in most popular research methods used in qualitative & quantitative sub-category during the review period</td><td>Analyze trend in most popular research methods used in qualitative & quantitative sub-category during the review period</td></tr>
<tr><td>Identify popular mixed research methods and analyze trend</td></tr>
</table>

Table 3: Results and Analysis

7.1 Description Analysis:

Trend analysis of research paper published:

Table 4 below shows the number of research papers published in PICMET conference years 1991, 2001 & 2011 excluding the industry specific papers. Papers that are not available are classified as "Missing papers" while papers with incomplete information are classified "Not available." The rest of the papers are categorized as "Papers Reviewed". Fig 2 below illustrates the trend of number of papers published. The number of "Not Available" papers has decrease from 93 in 1991 to 5 in 2011. Also, total number of papers published has decreased in 2011 due to a lot of reasons; one major factor being the economic downturn.

	1991	2001	2011
Total number of papers published	278	314	275
Not available for review	93	7	5
Papers reviewed	185	284	252
No of paper Missing	0	23	18

Table 4: Frequency of papers published

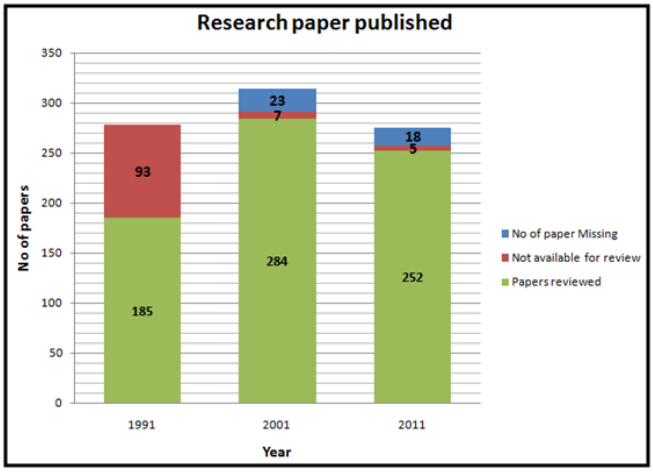


Fig 2: Trend Analysis

Most popular research field during the review period:

The Fig 2 below shows the number of research papers published in top research areas. There are 51 Research fields identified as per PICMET classification for the last two decades. Management of technological innovation is ranked topmost with 63 papers written over the three mentioned years, followed by Information/knowledge management with 61 papers and Project/Program Management with 58 papers. Fig 3 shows the top five Research Fields.

Trend in research papers published for specific research field:

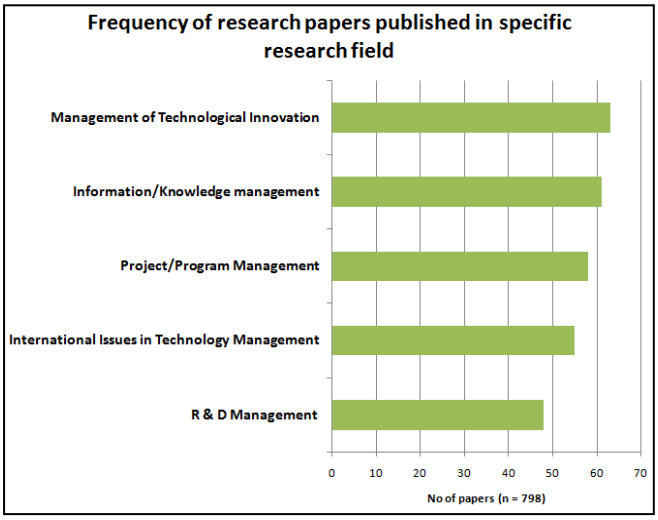


Fig 3: Popular research field

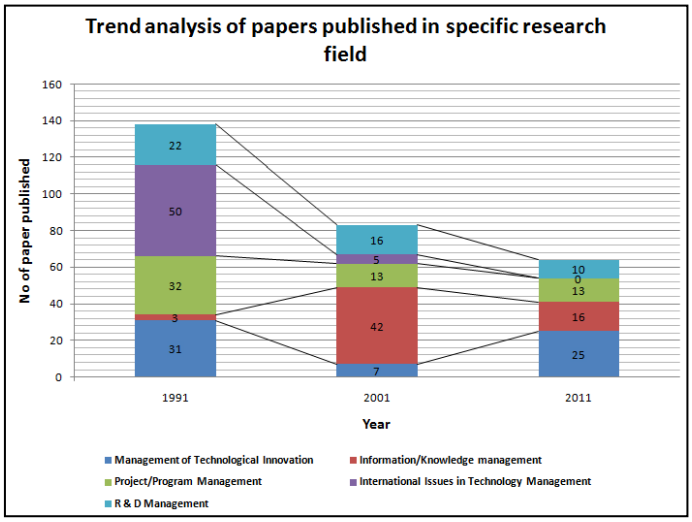


Fig 4: Trend analysis of research fields

Fig 4 shows the trend in papers published in the five popular research areas. It shows that trend in "International Issues in Technology Management" related papers have declined from 50 papers in 1991 to zero in 2011. Further the focus of PICMET conference each year also explains the high concentration of papers in particular fields. For example the theme for PICMET'91 was technology management resulting in 50 papers submitted in this research area. Similarly Information/knowledge management and Technology Management in Energy Industry were the areas in focus for the years 2001 and 2011 resulting in 42 and 22 papers respectively. Refer appendix 2 for the full list of research field.

7.2 Content Analysis:

Trend in Research Methodologies over Two Decades:

The research methodologies used in the PICMET'91, 2001, and 2011 are classified into Data gathering, Data analysis and Mixed Methods. Data gathering and Data Analysis is further classified into qualitative and quantitative methods.

Data Gathering:

Popular Methods Used in Qualitative and Quantitative Category:

Fig 5 shows that literature research has been the most widely used quantitative research method. It has been used about 247 times to gather information for research purposes. This was followed by documents ranked second. Case

study and survey ranked third with pretty close usage of 202 and 199 respectively. In contrast, observation data ranked the most with its usage being 50 in PICMET'91, 2001 and 2011 with respect to qualitative type of data gathering.

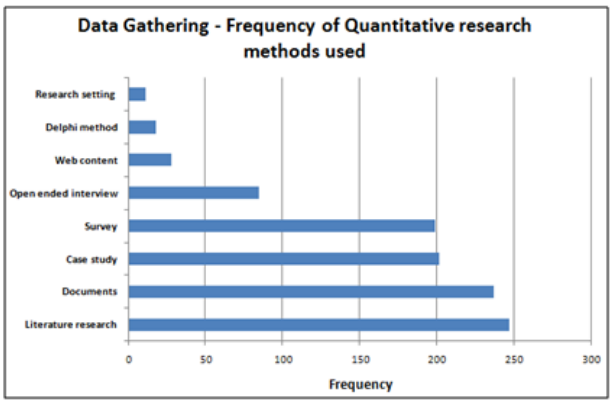


Fig 5:Popular Quantitative research methods

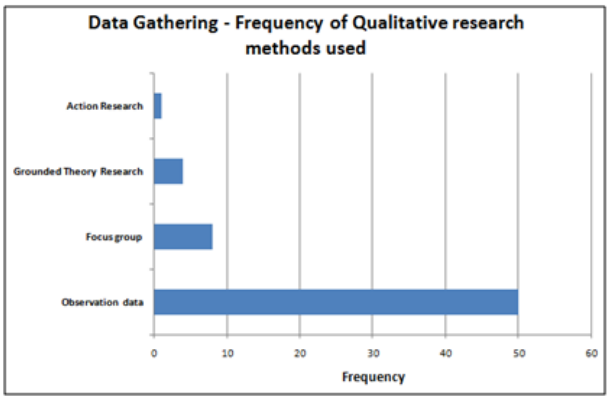


Fig 6: Popular Qualitative research methods

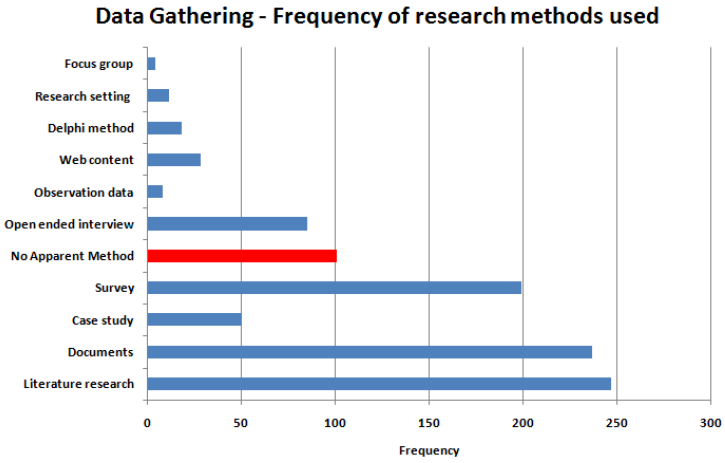


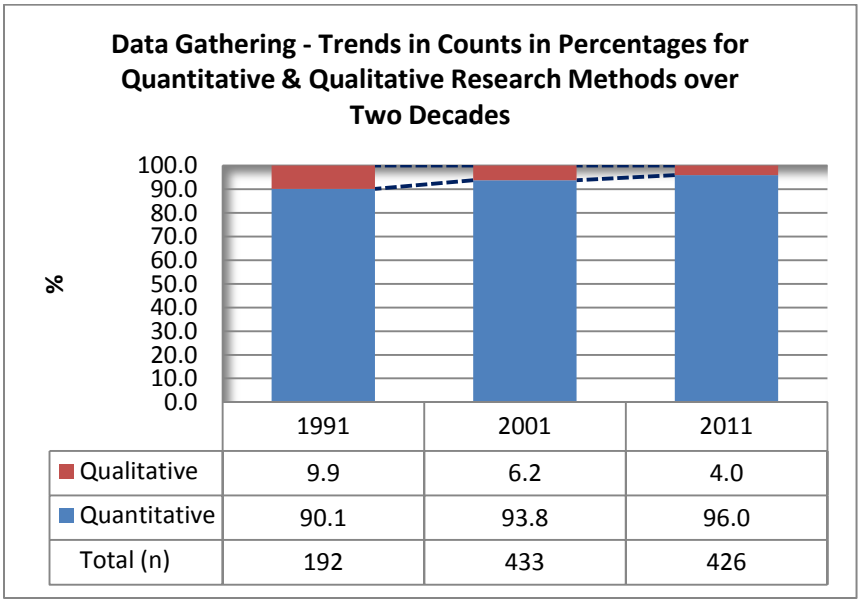
Fig 7 (Note: Research methods with count less than 4 is omitted)

Fig 7 shows the trend of all popular research methods irrespective of whether the research method is qualitative or quantitative. About 101 papers either used no method or indicated no specific methods in the paper. This is shown as "No Apparent Method" in the graph.

Trend in Quantitative & Qualitative research methods used in data gathering during review period:

Fig 8 illustrates the trend of both quantitative and qualitative methods used in PICMET'91, 2001 and 2011 PICMET papers for data gathering. Quantitative methods were used about 90 percent compared to qualitative methods in the year 1991. This has increased over two decades; 96 percent quantitative versus 4 percent qualitative in PICMET'11.

The use of qualitative methods for data gathering however has declined in 2011 compared to 1991. This shows that researchers are using more concrete data to perform their analysis. Refer appendix 3 for data & calculation.



	1991	2001	2011
Qualitative	9.9	6.2	4.0
Quantitative	90.1	93.8	96.0
Total (n)	192	433	426

Fig 8: Trend in quantitative & qualitative research methods

Trend in Most Popular Research Methods Used in Qualitative and Quantitative Category During the Review Period:

Fig 9 shows the trend of popular quantitative and qualitative research methods over two decades. Refer appendix 4 for data and calculation. Literature research which was ranked highest in quantitative data gathering has shown a decrease in its usage in 2011 compared to 1991. However the usage of survey, case study and documents is increasing slowly. Similarly, observation data which was the most used qualitative method is also declining drastically in usage while focus group is gaining momentum over time.

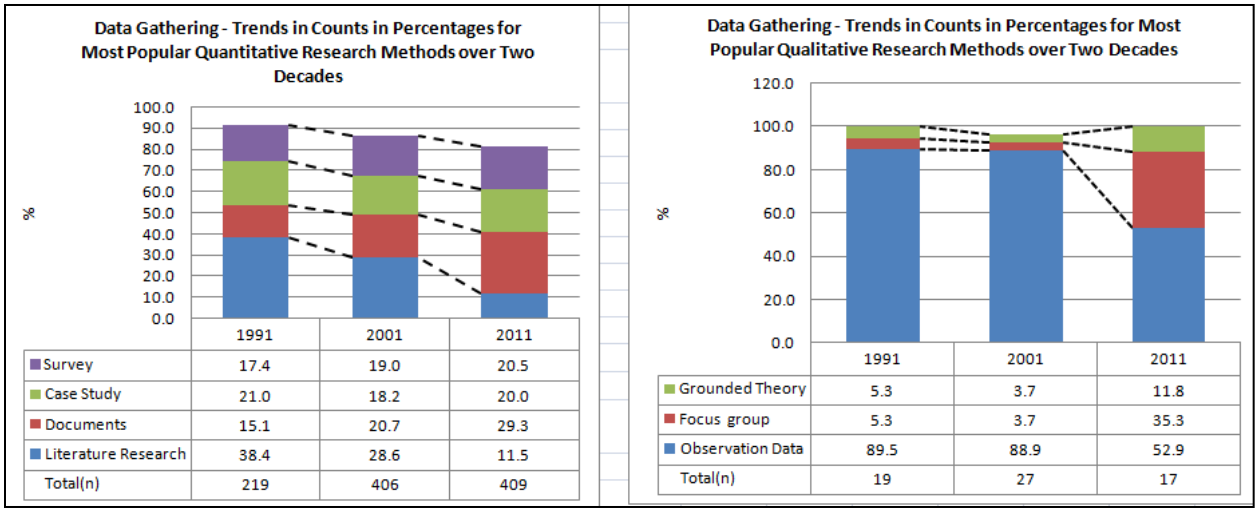


Fig 9: Trend in popular research methods in Quantitative and qualitative methods

Data Analysis:

Popular Methods Used in Qualitative and Quantitative Category:

Literature research is the most popular method used (count = 247) followed by case study (count = 202) in the quantitative research category. Descriptive and mathematical model were ranked next with count of 73 and 66 respectively. In contrast, concept mapping ranked highest in qualitative category with a count of 39. Fig 11 illustrates the most frequent qualitative and quantitative methods used in PICMET'91, 2001 and 2011.

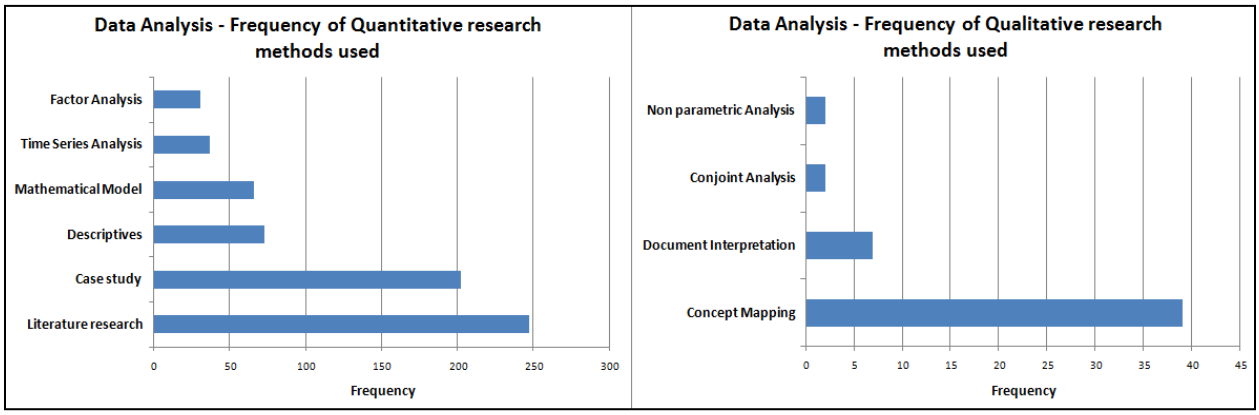


Fig 10: popular research methods in Quantitative and qualitative categories

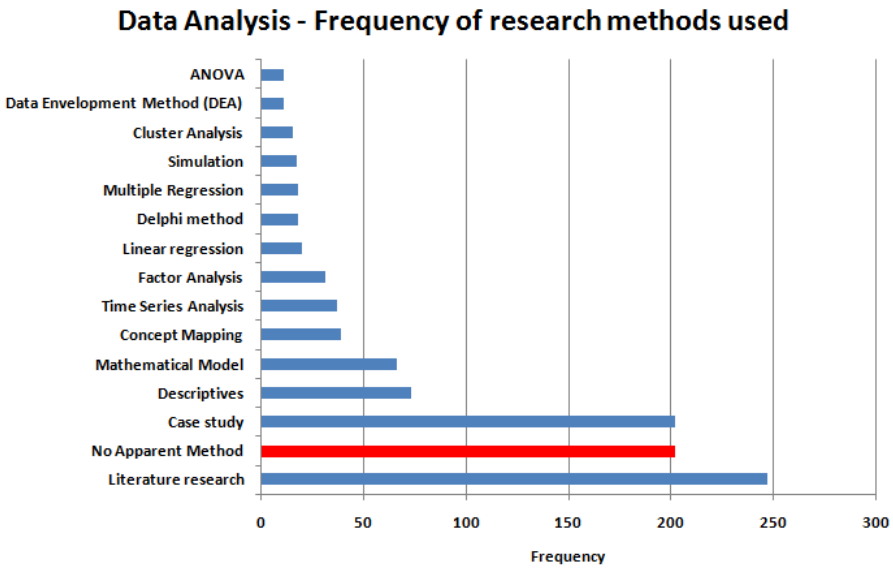


Fig 11(Note: Research methods with count less than 10 are omitted)

Fig 11 shows the frequency of all research methods used irrespective of qualitative and quantitative category for analyzing data. About 202 papers had no proper research methods used or the author does not mention the type of research method used for analysis. This is denoted as "No Apparent Method" in the graph.

Trend in Quantitative & Qualitative research methods used in data analysis during review period:

Fig 12 illustrates the trend of both the quantitative and qualitative methods used in PICMET'91, 2001 and 2011 papers. Refer appendix 3 for data & calculation. The quantitative methods are most widely used in data analysis with more than 90 percent giving a level of consistency in the trend of Quantitative methods for the last two decades. Qualitative methods are used rarely as a tool for data analysis. Finally the trend for mixed method is less than Qualitative methods. However it would be interesting to keep an eye on qualitative and mixed method trend in the future.

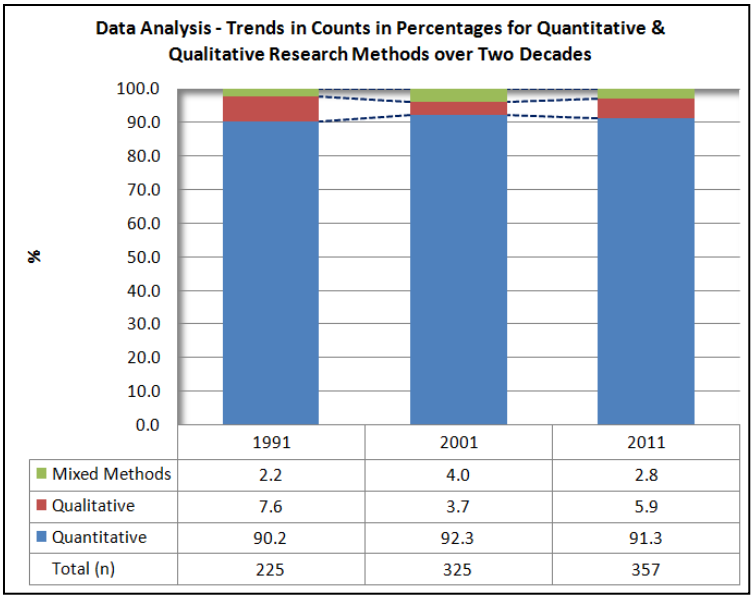


Fig 12 Data analysis (Quantitative & Qualitative Trend)

Trend in Most Popular Research Methods Used in Qualitative and Quantitative Category During the Review Period:

The literature Research is considered the most popular quantitative method used for data analysis however its trend has declined in 2011. The usage of descriptive has increased compared to 1991 while the usage of case study has pretty much remained consistent over the years. With respect to the qualitative methods, concept mapping is increasingly used comparatively. Document interpretation, ranked second is reducing from approximately 24 percent in 1991 to 10 percent in 2011. Also, it can be observed that non-parametric analysis is gaining impetus over the years. Fig 13 shows the trend of most popular qualitative and quantitative research methods used over two decades. Refer Appendix 4 for data and calculations.

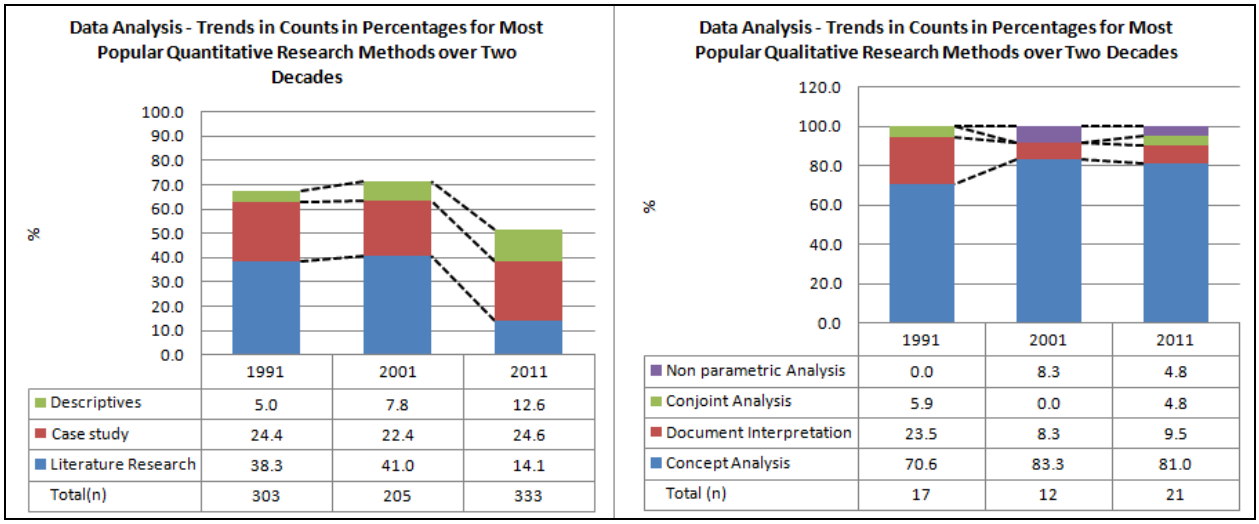


Fig 13:Trend analysis of popular quantitative and qualitative research methods

Mixed Methods:

Frequency of research methods used and its trend:

Among the mixed methods category, analytic hierarchical process (AHP) is most frequently used compared to content analysis. However, AHP gained in popularity in late 90s but fell sharply in the following decade. Content analysis is preferred over AHP and hence its trend is increasing with a usage of almost 60 percent. Fig 14 and fig 15 illustrates the frequency of research methods used along with its trend respectively. Refer appendix 4 for data & calculation.

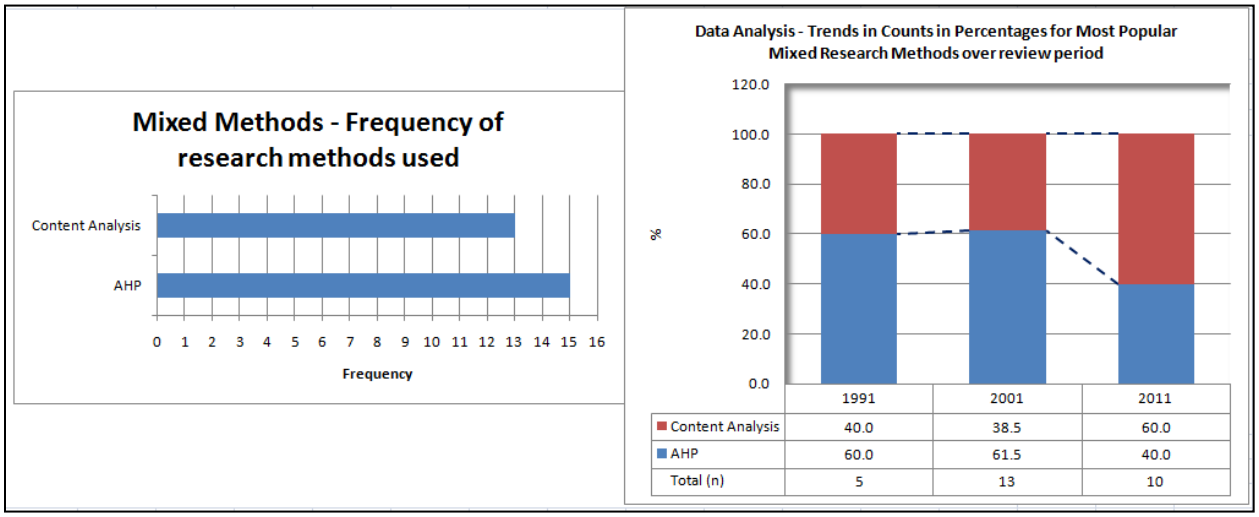


Fig 14: Frequency of research methods used

Fig 15: Most popular mixed research method trend

7.3 Combination

Most Used Research Methods in Top Five Research Areas:

The objective is to identify the most popular research method used in the top five research fields mentioned in fig 3. As illustrated in fig 16, documents is the most used followed by survey is the second most used one; it was used in top four research areas except for Information/Knowledge Management. Case Study ranks third. Fig 16 shows all the top research methods used in top five research areas. Refer appendix 5 for full list of research field with corresponding top three popular research methods used.

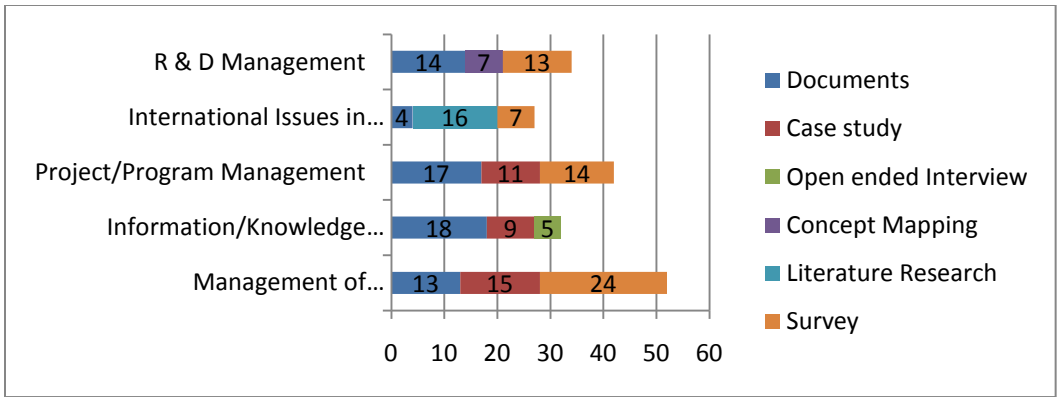


Fig 16: Popular research methods used in specific research fields

8.0 Conclusions

In this research study, we propose following conclusions; these findings can be beneficial to the master's and doctoral students and also to the PICMET committee.

(1) Popular research field in ETM are Management of Technological Innovation, Information/Knowledge management, Project/Program Management, International Issues in Technology Management & R & D Management; Document review, survey & case study are the most common research methods used in these research fields.

(2) The popular research methods in data gathering are literature research, document & case study in quantitative category and observation data, focus group, grounded theory in qualitative category.

(3) In PICMET, the quantitative methods are used more than the qualitative methods for data gathering and the qualitative research methods show a downward trend.

(4) The popular research methods in data analysis are literature research, document & descriptives in quantitative category. Concept mapping, document interpretation and conjoint analysis in qualitative category.

(5) In PICMET, the quantitative methods are used more than the qualitative methods for data analysis but the trend for both shows consistent.

(6) AHP & content analysis are the two mixed methods used in PICMET and AHP shows little decline in 2011.

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Appendix-1(Definitions of research methods)

	Research Method	Method Type	Description	References
1	Data Mining	Quantitative	Extraction of hidden predictive information from large databases	"An Introduction to Data Mining.", from http://www.thearling.com/text/dmwhite/dmwhite.htm [July 12, 2011]
2	Experimental Design	Quantitative	Is a systematic and scientific approach to research in which the researcher manipulates one or more variables, and controls and measures any change in other variables.	"Experimental Research.", from http://www.experiment-resources.com/experimental-research.html [July 16, 2011]
3	Literature Research	Quantitative	Is a survey of important articles, books and other sources pertaining to your research topic.	"Literature Review.", from http://linguistics.byu.edu/faculty/henrichsenl/ResearchMethods/RM_3_03.html [July 10, 2011]
4	Open ended interview	Quantitative	Conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation.	Boyce. C. and Neale. Palena., "Conducting in-depth interviews:A guide for designing and conducting in-depth interviews for evaluation input", Pathfinder International Tool Series, May 2006
5	Research setting	Quantitative	Decision regarding the type of setting to conduct research to allow the researcher to see something new or shed new light on the phenomenon of interest.	Bergh. D. D and Ketchen. J. D.; Research Methodology in Strategy and Management, *Emerald Group Publishing Limited,* Vol 5, pp. 162-163, 2009
6	Sampling method	Quantitative	Research based on the data collected from a subset of individuals or observations to make inferences about the entire population.	Herek. M. G., A Brief Introduction to Sampling. Available:http://psychology.ucdavis.edu/rainbow/html/fact_sample.html [July 22, 2011].
7	Survey	Quantitative	Involves asking questions of respondents or a short paper and pencil feedback form, either mailed or accessed electronically.	Trochim. M.K., "Survey Research." Available: http://www.socialresearchmethods.net/kb/survey.php [July 22, 2011]
8	Web content	Quantitative	Web content is the information and pictures that we come to read and view on Web pages	Jennifer Kyrnin."What is Web Content?." Internet:http://webdesign.about.com/od/content/qt/what-is-web-content.htm,[June. 19, 2010].
9	Action Research	Qualitative	Action research is a process in which participants examine their own educational practice systematically and carefully, using the techniques of research.	Eileen Ferrance."Action Research." *Themes od education.* Available: http://www.lab.brown.edu/pubs/themes_ed/act_research.pdf[Aug 14, 2011]
10	Archival	Qualitative	Archival research uses publicly available records and documents as a source of data; thus, the research is one step removed from actual observation	J.W. Whitlow, Jr."ARCHIVAL AND SURVEY RESEARCH METHODS." Available: http://www.camden.rutgers.edu/~bwhitlow/Courses/Experimental/Ch3archival.pdf[Aug 14, 2011]

11	Biographical Method	Qualitative	The biographical method is the collection and analysis of an intensive account of a whole life or portion of a life, usually by an in-depth, unstructured interview	Robert L. Miller & John D. Brewer.(2003) "The A-Z of Social Research."[Online]. Available: http://srmo.sagepub.com/view/the-a-z-of-social-research/n6.xml[Aug 14, 2011]
12	Case study	Qualitative and Quantitative	Case study research excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research. Case studies emphasize detailed contextual analysis of a limited number of events or conditions and their relationships	"The Case Study as a Research Method." Available: http://www.ischool.utexas.edu/~ssoy/usesusers/l391d1b.htm[Aug 14, 2011]
13	Clinical Research	Qualitative	Clinical research is research that either directly involves a particular person or group of people or uses materials from humans, such as their behavior or samples of their tissue, that can be linked to a particular living person	"Clinical Research & Clinical Trials." Internet: http://www.nichd.nih.gov/health/clinicalresearch/[Aug 14, 2011]
14	Document Interpretation	Qualitative	It is a methodology in the social sciences for studying the content of communication. Also it studies of recorded human communications, such as books, websites, and documents.	Leedy and Ormrod ."Data Interpretation Methods".Internet:http://people.uwec.edu/piercech/ResearchMethods/Data%20interpretation%20methods/data%20interpretation%20methods%20index [July, 19 2011]
15	Ethnography	Qualitative	Ethnography is the study of culture and social organization through participant observation and interviewing, an approach known as “fieldwork.” Ethnographers carry out their research by becoming a participant, to varying degrees, in the social settings they wish to study.	Stanton Wortham.(Spring 2010) "ETHNOGRAPHIC RESEARCH METHODS." Available: http://www.gse.upenn.edu/~stantonw/pdf/educ672.pdf[Aug 14, 2011]
16	Focus group	Qualitative	Focus groups are a powerful means to evaluate services or test new ideas. Basically, focus groups are interviews, but of 6-10 people at the same time in the same group. One can get a great deal of information during a focus group session.	Carter McNamara. "Basics of Conducting Focus Groups." Internet: http://managementhelp.org/businessresearch/focus-groups.htm[Aug 14,2011]
17	Observation data	Qualitative	Observational research techniques solely involve the researcher or researchers making observations.	"Observational Field Research." Internet: http://www.socialresearchmethods.net/tutorial/Brown/lauratp.htm[Aug 14, 2011]
18	Policy Capturing	Qualitative	It is a statistical method used to quantify the relationship between a person's judgement and the information that was used to make that judgement.	Moss. S (2008, Dec 4), Policy Capturing. Available: http://www.psych-it.com.au/Psychlopedia/article.asp?id=228 [July 22, 2011]
19	Delphi method	Qualitative	It is a communication technique used as interactive forecasting method which relies on a panel of experts.	Lynn M Stuter."The Delphi Technique — What Is It?." Internet:http://www.learn-usa.com/transformation_process/acf001.htm,March,1999. [Aug 14, 2011]
20	Anova	Quantitative	It is a collection of statistical models, and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation.	Difference between T-Test and ANOVA, Available: http://www.differencebetween.net/miscellaneous/difference-between-t-test-and-anova/ [July 22, 2011]

21	Bayesian networks	Quantitative	Bayesian methods are a formal, quantitative way of combining empirical evidence with prior knowledge to solve real and practical problems. It uses Bayes theory, including prior probabilities, likelihoods, conditional and marginal probabilities, posterior probabilities, and the decision process.	MRES Web Resources-Introduction to Bayesian Statistics, Available: http://mres.gmu.edu/pmwiki/pmwiki.php/Main/BayesianIntro [July 24, 2011]
22	Behavior Recording	Qualitative	It is used on samples that have a certain behavior occurred more than one times over a time interval	Mery Janes "Event/Frequency Recording. " Internet:http://www.msubillings.edu/COEFaculty/LChristense n/Data%20collection%202.htm [July,18.2011]
23	Bibliometric Analysis	Quantitative	It utilizes quantitative analysis and statistics to describe patterns of publication within a given field or body of literature	Dr. Ruth A. Palmquist. "Bibliometrics." Internet: http://www.ischool.utexas.edu/~palmquis/courses/biblio.html [Aug 14,2011]
24	Casual Mapping	Quantitative	A causal map is a network diagram. The method is usually used in Information systems related projects.	Narayanan. V. K.; Causal Mapping: An Historical Overview, Idea Group Inc., 2005
25	Chi-square test	Quantitative	Chi-square is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis.	Dr. Jacqueline S. McLaughlin."Chi-Square Test." Internet: http://www2.lv.psu.edu/jxm57/irp/chisquar.html [Aug 14,2011]
26	Citation Analysis	Quantitative	When one author cites another author, a relationship is established. Citation analysis uses citations in scholarly works to establish links. Many different links can be ascertained, such as links between authors, scholarly works, journals,fields, or even between countries. Citations both from and to a certain document may be studied.	Dr. Ruth A. Palmquist. "Bibliometrics." Internet: http://www.ischool.utexas.edu/~palmquis/courses/biblio.html #Cite[Aug 14,2011]
27	Cluster Analysis	Quantitative	Cluster analysis encompasses a number of different algorithms and methods for grouping objects of similar kind into respective categories.	Tulsa,OK(2011).Electronic Statistics Textbook. Available:http://www.statsoft.com/textbook/cluster-analysis[Aug 14,2011]
28	Computer simulation	Quantitative	It is a computer program used to simulate a model which can be analyzed and studied also computer simulation used to understand how firms operate.	Jamie D.Mills "using Computer simulation Method to teach statistic." internt:http://www.amstat.org/publications/jse/v10n1/mills.ht ml [july, 18. 2011]
29	Confidence Interval	Quantitative	It is a statistical tool estimate population parameters using observed sample data that indicate the reliability of the estimation	Perry D. Drake "Finding Your Confidence Interval." internet :http://www.drakedirect.com/Link_Articles_7.html [Jul. 11 2011]
30	DEA	Quantitative	Data envelopment analysis (DEA) is a nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (or DMUs)	Subhash.c.Ray "Data Envelopment Analysis." internet: http://catdir.loc.gov/catdir/samples/cam041/2003061673.pdf [July 21, 2011]
31	Description analysis	Quantitative	It is a structured communication technique, originally developed as a systematic, interactive forecasting method which relies on a panel of experts	Kerstin Cuhls "Delphi Method." internet: http://www.unido.org/fileadmin/import/16959_DelphiMethod. pdf [july, 18 ,2011]

32	Descriptive	Quantitative	Involves gathering data that describe events and then organizes, tabulates, depicts, and describes the data. Often uses visual aids such as graphs and charts to aid the reader	Alan Valdes "Descriptives Method in Research" internet: http://www.ehow.com/about_6663890_meaning-descriptive-method-research_.html [july 18, 2011]
33	Discriminant Analysis	Quantitative	Discriminant function analysis is used to determine which variables discriminate between two or more naturally occurring groups.	StatSoft, Inc. (2011). *Electronic Statistics Textbook.* Tulsa, OK: StatSoft. Available: http://www.statsoft.com/textbook/discriminant-function-analysis/[Aug 14,2011]
34	Effect size	Quantitative	It is a measure of the strength of the relationship between two variables in a statistical population	Robert Coe "what is effect size and why it is important". internet: http://www.leeds.ac.uk/educol/documents/00002182.htm [jul 18, 2011]
35	Factor Analysis	Quantitative	Factor analysis is a collection of methods used to examine how underlying constructs in°uence the responses on a number of measured variables.	DeCoster, J. (1998). "Overview of Factor Analysis." Available: http://www.stat-help.com/factor.pdf[Aug 14,2011]
36	Gray relational analysis	Quantitative	The Grey relational analysis is a method to analyze the relational grade for discrete sequences.	Ching-Liang Chang,Chih-Hung Tsai and Lieh Chen.(2003). "Applying Grey Relational Analysis to the Decathlon Evaluation Model." *International Journal of The Computer, The Internet and Management.[Online]. Vol. 11(3), 2003, pp. 54 - 62. Available:* http://www.journal.au.edu/ijcim/2003/sep03/ijcimv11n3_art5.pdf[Aug 14,2011]
37	Hypothesis test	Quantitative	Hypothesis testing is the use of statistics to determine the probability that a given hypothesis is true	Weisstein, Eric W. "Hypothesis Testing." From MathWorld--A Wolfram Web Resource. Available: http://mathworld.wolfram.com/HypothesisTesting.html [Aug 14,2011]
38	Grounded Theory Research	Quantitative	Grounded Theory is most accurately described as a research method in which the theory is developed from the data, rather than the other way around. That makes this is an inductive approach, meaning that it moves from the specific to the more general.	"Grounded Theory." Available: http://www.essortment.com/grounded-theory-21638.html[Aug 14,2011]
39	Interpretive	Qualitative	An interpretive method in particular ways and provides particular understandings of research practice a set of concepts which may act as reference points or 'touchstones' for the researcher, including for example: the relationship of problem and method; the nature of inquiry as a negotiated process; the concept of participant and researcher perspectives and constructs; the researcher's agency and reflexivity and so on.	John McIntyre " Arguin for an Interpative Methods" .Internet:http://www.jamc.com.au/documents/ArgInterp.pdf [July. 19.2011]
40	Linear regression	Quantitative	Linear regression analyzes the relationship between two variables, X and Y. For each subject (or experimental unit), you know both X and Y and you want to find the best straight line through the data	Ryan Campbell "the linear Regression of time and Price.". Internet:http://www.investopedia.com/articles/trading/09/linear-regression-time-price.asp#axzz1V5BrwOSV[july, 19 .2011]

41	Logistic Regression	Quantitative	Logistic regression is a technique for making predictions when the dependent variable is a dichotomy, and the independent variables are continuous and/or discrete.	David C. Howell "Logistic Regression". Iternet:http://www.uvm.edu/~dhowell/gradstat/psych341/lectures/Logistic%20Regression/LogisticReg1.html [July, 19,2011]
42	Longitudinal Data Analysis	Quantitative	A longitudinal study refers to an investigation where participant outcomes and possibly treatments or exposures are collected at multiple follow-up times.	Fisher, van Belle, Heagerty, Lumley (Ch. 1). "Longitudinal Data Analysis." Available: http://faculty.washington.edu/yanez/b540/handouts/LDAchapter.pdf[Aug 14,2011]
43	Mathematical Model	Quantitative	A mathematical model is the set of equations which describe the behavior of the system.	Finn Haugen.(Aug 2010).*"Basic Dynamics and Control."* Available: http://techteach.no/publications/books/dynamics_and_control/mathematical_modeling.pdf[Aug 14,2011]
44	Multilevel research	Quantitative	In multi level research, the data structure in the population is hierarchical and sample data are viewed as a multi stage sample from this hierarchical population.	Joop Hox. *Multi level Analysis- Techniques and Applications.* Mahwah, New Jersey:Lawrence Erlbaum Associates, Inc.,2002,pp-1.
45	Multiple Regression	Quantitative	It is a statistical method for studying the relationship between the single dependent variable and one or more dependent variables.	Paul David Allison. *Multiple Regression-A Primer. CA, Sage Publication,1999,pp-1*
46	Network analysis	Quantitative	It is one of the classic methods of planning and controlling the progress of projects.	Mixhael C. Glen " A guide to Network Analysis". Internet http://project.mvps.org/networkanalysis.htm [July 19. 2011]
47	Non -linear regression	Quantitative	It is a form of regression analysis in which data is fit to a model expressed as a mathematical function. It must generate a line (typically a curve) as if every value of Y was a random variable. The goal of the model is to make the sum of the squares as small as possible. Nonlinear regression uses logarithmic functions, trigonometric functions and exponential functions, among other fitting methods.	"Nonlinear Regression." Internet: http://www.investopedia.com/terms/n/nonlinear-regression [Aug 14,2011]
48	Non parametric Analysis	Qualitative	*non-parametric* covers techniques that do not rely on data belonging to any particular distribution	Sprent, P., and N. C. Smeeton. 2001. Applied Nonparametric Statistical Methods, 3rd edition.
49	Pair wise Comparison	Quantitative	Pairwise comparison is a kind of divide-and-conquer problem-solving method. It allows one to determine the relative order (ranking) of a group of items. This is often used as part of a process of assigning weights to criteria in design concept development.	Filippo A. Salustri. "Pairwise Comparison." Internet: http://deseng.ryerson.ca/~fil/t/pwisecomp.html[Aug 14,2011]
50	Partial least square method	Quantitative	Partial least squares (PLS) is a method for constructing predictive models when the factors are many and highly collinear.	Randall D. Tobias. "An Introduction to Partial Least Squares Regression." *SUGI Proceedings*. 1995,pp.1-8. Online: http://www.ats.ucla.edu/stat/sas/library/pls.pdf [Aug 14,2011]

51	Path Analysis	Quantitative	Path analysis is an extension of the regression model, used to test the fit of the correlation matrix against two or more causal models which are being compared by the researcher. The model is usually depicted in a circle-and-arrow figure in which single-headed arrows indicate causation.	"Path Analysis." Internet: http://faculty.chass.ncsu.edu/garson/PA765/path.htm [Aug 14,2011]
52	Sensitivity Analysis	Quantitative	It is a technique used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. This technique is used within specific boundaries that will depend on one or more input variables	"Sensitivity Analysis." Internet: http://www.investopedia.com/terms/s/sensitivityanalysis [Aug 14,2011]
53	Social Network analysis	Quantitative	Social network analysis is based on an assumption of the importance of relationships among interacting units. The social network perspective encompasses theories, models, and applications that are expressed in terms of relational concepts or processes. Along with growing interest and increased use of network analysis has come a consensus about the central principles underlying the network perspective.	Wasserman, S. and K. Faust, 1994, *Social Network Analysis.*
54	Time Series Analysis	Quantitative	A time series is a collection of observations of well-defined data items obtained through repeated measurements over time.	Australian Bureau of statistics."Time series analysis.http://www.abs.gov.au/websitedbs/d3310114.nsf/4a256353001af3ed4b2562bb00121564/b81ecff00cd36415ca256ce10017de2f!OpenDocument,July.25, 2008[Aug 14, 2011]
55	Concept Mapping	Qualitative	It is a method that shows the relationships among concepts or expresses someone's ideas in a graphical or pictorial form.	William M.K. Trochim."Research methods knowledge base."Internet:http://www.socialresearchmethods.net/kb/conmap.php,Oct.20,2006. [Aug 14, 2011]
56	Conjoint Analysis	Qualitative	Conjoint analysis is both a trade-off measurement technique for analyzing preferences and intentions-to-buy responses and a method for simulating how consumers might react to changes in current product/services or the introduction of new products into an existing competitive era	Paul Green, Vithala Rao, Jerry Wind . " Conjiont Analysis : Methods and Application". Internet:http://knowledge.wharton.upenn.edu/paper.cfm?paperID=779 [July, 18.2011].
57	Multisource ratings	Qualitative	Multi source rating contains information that is useful and relevant to the individuals being evaluated and that the ratings are the basis for assessment.	David Bracken, Carol W. Timmreck, Allan H. Church. "*The handbook of multisource feedback."* San Francisco,CA:Jossey Bass, 2002, pp-130.
58	Narrative Analysis	Qualitative	It is the way in which people make and use stories to interpret the world	Tim May."Qualitative research in action," Sage,2002.

59	Semiotic Analysis	Qualitative	Semiotics concerns everything that can be perceived as a sign. Signs constitute printed and spoken words, images, sounds, gestures, and objects. Individuals interpret signs as "signifying something."	Umberto. ; "A Theory of Semiotics." Bloomington: Indiana University Press. 1976
60	Social Network analysis	Quantitative	Social network analysis [SNA] is the mapping and measuring of relationships and flows between people, groups, organizations, computers or other information/knowledge processing entities.	Gretzel. U. (2001, Nov). Social Network Analysis: Introduction and Resources. Available: http://lrs.ed.uiuc.edu/tse-portal/analysis/social-network-analysis/ [July 25, 2011]
61	AHP	Mixed	Developed by Thomas L. Saaty in 1980, the AHP is one of the first methods developed in an environment of discrete multicriteria decision. The AHP method divides the problem into hierarchic levels, which makes its comprehension and evaluation easier and clearly determines a global action for each alternative by the value synthesis of the decision makers, prioritizing or classifying them after finalizing the method.	Saaty, T.L., 2008, "Decision making with the analytic hierarchy process", *International Journal of Services Science*, Vol. 1,No 1,pp.88-97
62	Content Analysis	Mixed	It is method used to summarize the content using qualitative methods initially. This data is then reduced to numerical terms using quantitative methods	Krippendorff. K. Content Analysis: An introduction to its methodology, Sage Publications Inc. 2nd edition, 2004

Appendix-2 (Research field)

Appendix-3 (Data Gathering/Data Analysis - Quantitative & Qualitative trend)

Year	1991		2001		2011	
	n	%	n	%	n	%
Data Gathering	192	46.0	433	57.1	426	54.4
Quantitative	173	90.1	406	93.8	409	96.0
Qualitative	19	9.9	27	6.2	17	4.0
Data Analysis	225	54.0	325	42.9	357	45.6
Quantitative	203	90.2	300	92.3	326	91.3
Qualitative	17	7.6	12	3.7	21	5.9
Mixed methods	5	2.2	13	4.0	10	2.8
Total for year	417	100	758	100	783	100

Appendix-4 (Research Methods Trend)

	Category		1991		2001		2011		1991 to 2011	
		Research Methods	n	%	n	%	n	%	n	%
Data Gathering	Quantitative	Data Mining	0	0.0	1	0.2	0	0.0	1	0.1
		Documents	33	15.1	84	20.7	120	29.3	237	22.9
		Delphi method	2	0.9	6	1.5	10	2.4	18	1.7
		Experimental design	0	0.0	2	0.5	1	0.2	3	0.3
		Open ended interview	9	4.1	33	8.1	43	10.5	85	8.2
		Literature research	84	38.4	116	28.6	47	11.5	247	23.9
		Research setting	6	2.7	4	1.0	1	0.2	11	1.1
		Survey	38	17.4	77	19.0	84	20.5	199	19.2
		Case study	46	21.0	74	18.2	82	20.0	202	19.5
		Web content	1	0.5	9	2.2	18	4.4	28	2.7
		Sampling method	0	0.0	0	0.0	3	0.7	3	0.3
		Total for year	219	100	406	100.0	409	100.0	1034	100.0
	Qualitative	Action Research	0	0.0	1	3.7	0	0.0	1	1.6
		Focus group	1	5.3	1	3.7	6	35.3	8	12.7
		Grounded Theory Research	1	5.3	1	3.7	2	11.8	4	6.3
		Observation data	17	89.5	24	88.9	9	52.9	50	79.4
		Total for year	19	100	27	100	17	100	63	100
Data Analysis	Quantitative	Analysis of Variance - ANOVA	6	2.0	1	0.5	4	1.2	11	1.3
		Bayesian networks	0	0.0	0	0.0	1	0.3	1	0.1
		Balanced Scorecard	1	0.3	0	0.0	0	0.0	1	0.1
		Bibliometric Analysis	1	0.3	0	0.0	5	1.5	6	0.7
		Case study	74	24.4	46	22.4	82	24.6	202	24.0
		Correlation analysis	2	0.7	1	0.5	1	0.3	4	0.5
		Comparative analysis	2	0.7	1	0.5	1	0.3	4	0.5
		Causal Mapping	0	0.0	1	0.5	0	0.0	1	0.1
		Chi-square test	3	1.0	0	0.0	2	0.6	5	0.6
		Citation Analysis	0	0.0	0	0.0	4	1.2	4	0.5
		Cluster Analysis	8	2.6	1	0.5	6	1.8	15	1.8
		Simulation	11	3.6	1	0.5	5	1.5	17	2.0
		Data Envelopment Method (DEA)	4	1.3	0	0.0	7	2.1	11	1.3
		Delphi method	6	2.0	2	1.0	10	3.0	18	2.1
		Description analysis	0	0.0	0	0.0	2	0.6	2	0.2
		Descriptives	15	5.0	16	7.8	42	12.6	73	8.7
		Discriminant Analysis	1	0.3	1	0.5	0	0.0	2	0.2
		Factor Analysis	4	1.3	5	2.4	22	6.6	31	3.7
		Grey relational analysis	0	0.0	0	0.0	1	0.3	1	0.1
		Grounded Theory Research	1	0.3	1	0.5	2	0.6	4	0.5
		Linear regression	4	1.3	5	2.4	22	6.6	31	3.7

		Literature research	116	38.3	84	41.0	47	14.1	247	29.4
		Logistic Regression	0	0.0	0	0.0	2	0.6	2	0.2
		Life Cycle Analysis	1	0.3	0	0.0	0	0.0	1	0.1
		Mathematical Model	29	9.6	22	10.7	15	4.5	66	7.8
		Multiple Regression	6	2.0	3	1.5	9	2.7	18	2.1
		Non -linear regression Analysis	0	0.0	0	0.0	1	0.3	1	0.1
		Pair wise Comparison	0	0.0	1	0.5	0	0.0	1	0.1
		Partial Least Square Regression Analysis	0	0.0	0	0.0	1	0.3	1	0.1
		Path Analysis	0	0.0	2	1.0	2	0.6	4	0.5
		Sensitivity Analysis	1	0.3	3	1.5	3	0.9	7	0.8
		Social Network analysis	0	0.0	0	0.0	7	2.1	7	0.8
		T-test	0	0.0	1	0.5	2	0.6	3	0.4
		Patent Analysis	0	0.0	0	0.0	2	0.6	2	0.2
		Time Series Analysis	7	2.3	7	3.4	23	6.9	37	4.4
		Total for year	303	100	205	100	333	100	841	100
	Qualitative	Concept Mapping	12	70.6	10	83.3	17	81.0	39	78.0
		Conjoint Analysis	1	5.9	0	0.0	1	4.8	2	4.0
		Document Interpretation	4	23.5	1	8.3	2	9.5	7	14.0
		Non parametric Analysis	0	0.0	1	8.3	1	4.8	2	4.0
		Total for year	17	100	12	100	21	100	50	100
Mixed	Mixed Methods	Analytic Hierarchy Model (AHP)	3	60.0	8	61.5	4	40.0	15	53.6
		Content Analysis	2	40.0	5	38.5	6	60.0	13	46.4
		Total for year	5	100	13	100	10	100	28	100
No method	No Apparent Method - Data Gathering	No Apparent Method	169		98		36			

Appendix-5 (Research methods used in specific research field)