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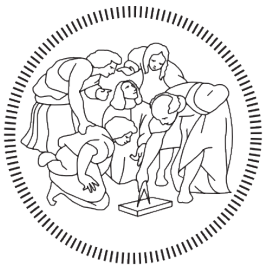

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TECHNOLOGY FORESIGHT

"A LITERATURE REVIEW FOCUSING ON TOOLS"

Supervisor: Prof. Tommaso Buganza
Co-supervisor: Dr. Daniel Trabucchi

MSc Thesis by: Ajay Vasmate 875237

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Thanks to colleagues, for their incredible support in this wonderful journey. Finally, to my family and friends, for making this journey a beautiful one and having a strong belief in me.

ABSTRACT

Although the technology foresight is not a new concept, but it is still being used very steadfast and widely from past few decades. This data can help in learning, adopting and applying on different technology for foresight purposes. The data is collected from the systematic literature review from various journals, through which different tools were gathered and based on the similarities and dis-similarities tools were segmented and explained. This study helps in selecting the proper tool to apply with respect to the type of data gathering. Due to different analysis of tool helps us in solving complex method of technology foresight. From this research the companies, organization and education institution can capture the value by using the data in order to predict the future technology foresight and various requirement to adopt the foresight tools.

KEYWORDS: technology foresight, tools.

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Introduction:

The term "Technology foresight" explains about the predicting particular technology, this method is being used from centuries but in very informal way, Technology foresight (TF) become a trendy approach concerning to science, technology and innovation (STI) for policymakers and studies purpose from early 1990's on. TF got popularity from Japan and western European countries afterwards rest of world adopted TF methodology for policymaking and studies purpose.

According to United Nations Industrial Development Organization (UNIDO) definition of technology foresight can be expressed as "Technology foresight is regarded as the most upstream element of the technology development process. It provides inputs for the formulation of technology policies and strategies that guide the development of the technological infrastructure. In addition, technology foresight provides support to innovation, and incentives and assistance to enterprises in the domain of technology management and technology transfer, leading to enhanced competitiveness and growth".

The objective of technology foresight is not only to hypothesize a various list of technologies that must be very much prioritized for future development but also to create a platform for government, industries, institution and public to communicate with each other and gain insight about the supply and demand of science and technology and social development. Through the technology foresight process, they can garner new understandings to face future challenges together and form a more closely connected social network. The standard process and steps of technology is been showed in the below figure (Yang, 2015), which had three major process, which are demand, forecasting and selecting, here based on the demand of any technology Foresighting is done by using the specific or sometimes diverse tools to analyze the future growth, based on which selecting of specific technology is done.

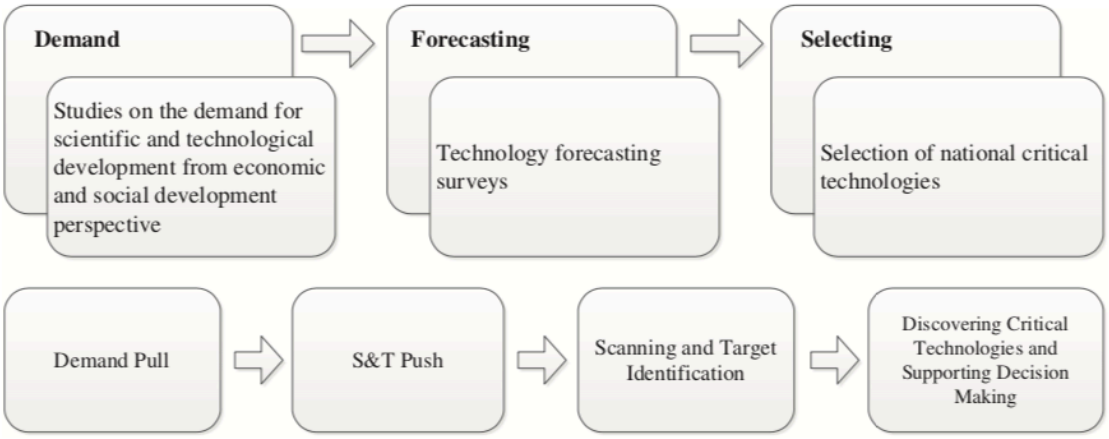

Figure 1: A basic technology foresight process (Yang, 2015).

Research Questions:

Based on the early stage of research and literature review different question aroused and to expose the unanswered question regarding the technology foresight the research was conducted. Further, those unanswered question became the prime motive of this research, questions like:

- What all the different methods used to determine the TF?
- Clustering tools based on the characteristics?
- How the characteristics of different tools can be identified?

This answer for these questions were solved in the later stage of the thesis process.

Literature review:

The literature review is done to provide an overview of the significant literature published about the topic. Its main purpose is instructional, and to interpret the major issues and learning surrounding technology foresight topic and to describe the relationship of each work to the others under consideration.

In the process of literature review, 150 journals were collected from the Scopus website which were dated from 1993 to 2018, it was downloaded by using the key words “technology foresight” in field of research article, energy, computer science, social science, decision science, economics, engineering, business, management, accounting.

Based on the downloaded of journal the data base was created to further proceeding to our research. The data was divided in different segments.

- Author name
- Abstract
- Technology foresight topic in article (Yes/No)
- Definition of tool
- Tool used
- Positive review based on article
- Negative review based on article
- Rating based on tools
- Extra information about tools
- Determination of tools used, or no tools are used

Furthermore, based on the data gathered the reconstruction of data was done to understand the descriptive analysis of the data it helps in describing and also understanding the characteristics of specific data by giving brief summaries about the data collected and data was measured and computed. From the 150 journal the descriptive analysis of:

- Most citied paper's in the database
- Top authors in the database
- Top journals in the database
- Number of papers published per year
- Tools used in the journals

Additionally, the table was constructed for all the above-mentioned analysis and different results were obtained, in which different tools were used to find technology foresight. Different tools were gathered and how tool was used in different papers was collected and further process of methodology was constructed.

Descriptive analysis:

Based on the different tools collected from the literature analysis the structure and explanation of tools were constructed. From journal 22 tools were generated as shown in below table.

TOOLS USED	NO. TIMES USED IN RESEARCH PAPERS
Delphi method	26
Road mapping	6
SWOT	3
Three phase method (Design/methodology/approach)	3
Expert advice	5
FURPS+ model	1
Grey model	1
Multiple correspondence analysis (MCA) model	2
Qualitative analysis	3
Trending on internet	3
Map	1
Linking	1
3rd generation Technology forecasting	3
Step-wise Weight Assessment Ratio Analysis (SWARA) method is one of the new MCDM methods	1
MENTALMODEL (experience, training, conditioning and education)	2
Technology forecasting (future predicting by mapping)	3
Radical technology foresight	1
Future oriented technology analysis (FTA)	1
Scenario- based assessment model (SBAM)	3
Cognitive value for technology Foresighting	1
Early warning system three main elements – scenarios, scanning, and monitoring	1

Table 1: List of tools gathered from different journals.

Each and every tool were explained in details and characteristics of each tool were constructed based on the details generated from different journals.
The basic architecture of all tool, described by appropriate definition which explains the tool work and impression, after which enlightenment of the tool was done to understand the process, phases and figure, tables, advantage, dis-advantage of tools are elucidated.

Result:

Based on the different methods of tool collected from the journals, we applied the iterative approach to fetch the data hidden in it. However, in this research we used the qualitative approach to analyze all the tools. We analyzed each and every tool thoroughly and also with the scrutinizing of tools we also formed the cluster by using the similarity characteristics using matrix which can be explained as, from the obtained database creating the pattern on similarities and dissimilarities in order to get some essential data out of research finding and other method was foresight diamond (Popper, 2008), which is unconventional method to find the clustering, foresight diamond is in diamond shape and with four edges each edge denotes different attributes, in our case we used evidence, creativity, interaction and expertise as our main edges, here evidence denotes as the availability of the proof of the statement or research, any reliable documents with stats and figures regarding some findings, these is very helpful in understanding actual state of development of project and the second edge is creativity, it explains about mixture of originality with the imaginative thinking and which is non-traditional method, basically one who use it we call them Tech-gurus. Interaction focuses on exchange of view and idea with the other experts and solve the problem together. And the last edge which is expertise which indicates how knowledgeable about that particular technology or subject. (see also Ansoff, 1975; Cassingena Harper and Pace, 2004) (see also Kuusi, 1999; Scapolo and Miles, 2006) (see also Andersen and Jæger, 1999; Cuhls, 2003; Brummer et al., 2007) (see also Porter et al., 1980; Armstrong, 2006), mentioned model will help in to get the valuable data to this literature review process. All the technology foresight tools can be used for specific purposes and this is one of the outcomes of the above research.
The tools for technology foresight share the common personalities, and it is very important to cluster based on its characteristics, due to qualitative data it was little difficult to cluster with the traditional method. So, the diamond foresight comes into picture as shown in below figure 2.

Figure 2: Foresight diamond.

And other clustering is based on the different similarities and dis-similarities tools, the tools were plotted, and explanations is described in conclusion part of this research. In detailed study is presented in discussion part. Finally, in the clustering of figure 3 as shown below carries out the survey based on tool analysis and based on expert involvement in the process. Characteristics of individual tool is plotted with respect to the expert involvement in complete process of technology foresight.

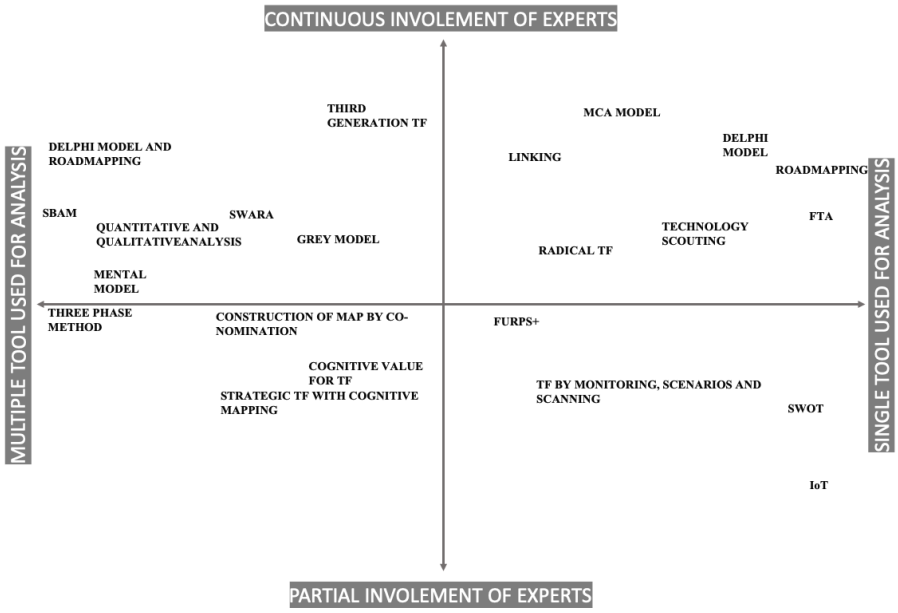

Figure 3: Differentiating tools based on characteristics

Discussion:

In order to get the clear picture of different tool methodology and characteristics, tools were mapped based on clustering and tentative research have been directed. The technology foresight tool was arranged based on the similarities so that clustering task can be done. The clustering can be defined as from the obtained database creating the pattern on similarities and dissimilarities in order to get some essential data out of research finding. In this research we used the qualitative approach to analyze the all tools. However it was an intuitive method and knowledge gained during the entire process of research.

Clustering 1:

Based on the different tool analysis, the graphical representation was done, the main thing extracted from this representation was qualitative and quantitative approach's for different tools, before selecting any tools for the technology foresight and based on what kind of survey has to take place or how it has to take place?, from acquired survey results we can be apply on the technology foresight for that selection of proper tool can be chosen before the process, there are

three segment which was formed after the carefully examining the tools. which are qualitative, quantitative and both qualitative and quantitative, qualitative helps in examining the thoughts and idea it can be structured based on similarities, exert opinion or some research in our case almost all tools use the qualitative research excluding the grey model, and quantitative analysis are sometimes intuitive. In quantitative analysis it talks about collecting, data, facts and figure, the data can be used to solve the problem, however this approach is very complicated by result oriented, the tools like grey model which is completely dependent on quantitative type of approach. Coming to the both qualitative and quantitative are more effective way to technology foresight they use the qualities of each other approaches and hide their drawbacks in order to get a valuable data of foresight as you can see in below table. In all cases of approach, the data is collected through survey, questionnaires', interview, online polls etc.

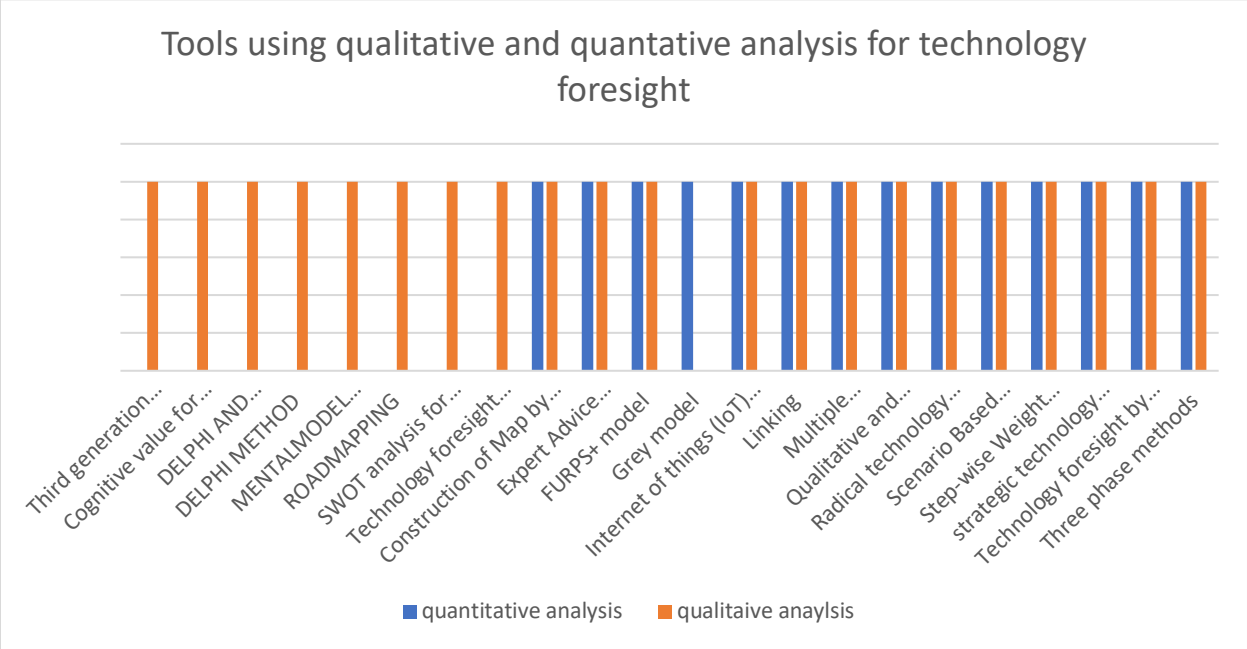

Table 2: Tools using qualitative and quantitative approaches.

Clustering 2:

we also used the unconventional method to find the clustering which is foresight diamond, which is in diamond shape and with four edges each edge denotes different attributes. It was introduced by the popper in the handbook of technology foresight of (Georghiou, 2008), in our case we used evidence, creativity, interaction and expertise as our main edges, here evidence denotes as the availability of the proof of the statement or research, any reliable documents with stats and figures regarding some findings, these is very helpful in understanding actual state of development of project and the second edge is creativity, it explains about mixture of originality with the imaginative thinking and which is non-traditional method, basically one who use it we call them Tech-gurus. Interaction focuses on exchange of view and idea with the other experts and solve the problem together. And the last edge which is expertise which indicates how knowledgeable about that particular technology or subject. (see also Ansoff, 1975; Cassingena Harper and Pace, 2004) (see also Kuusi, 1999; Scapolo and Miles, 2006) (see also Andersen and Jæger, 1999; Cuhls, 2003; Brummer et al., 2007) (see also Porter et al., 1980; Armstrong, 2006)

In this type clustering main focus was differentiate different tools based on four characteristics which they use to process the technology foresight, in our case we used expertise, evidence, interaction and creativity (each characteristic is explained above):

Each tool was placed in different zone based on the methodology and tool near to any edge assumed their characteristics in technology foresight process. The clustering helps in understanding the different tools with focusing factors based on which tools can used, to summarize this proposed clustering can help organization to select the tool with based on their requirement. The above clustering information was obtained and analyzed by looking into various factors such as qualitative, quantitative, requirement of expert, use of questionnaire and survey, type of analysis, graphical or statistics generation, mathematical equations, computational, cognitive, just based on citation and literature review. Based on its placement of tools were engaged.

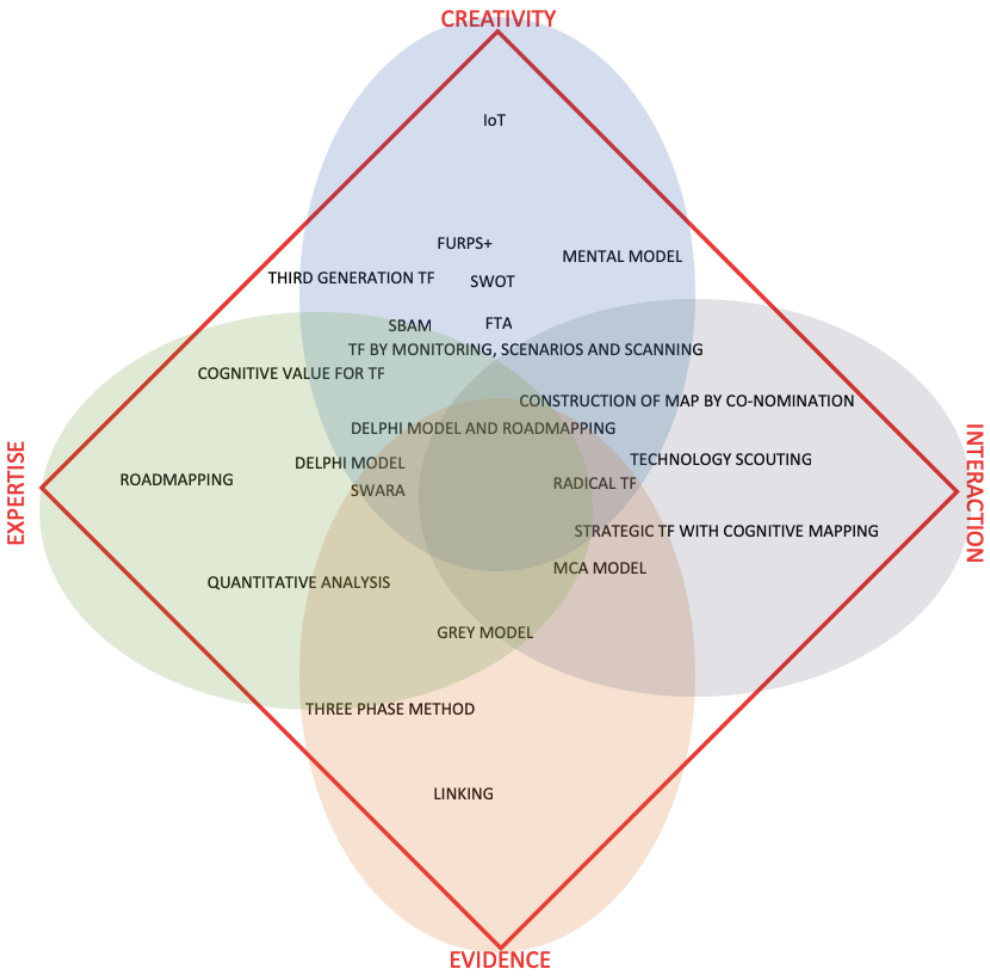

Figure 4: Diamond foresight.

Clustering 3:

It contains two axes, x-axis is single tool used for analysis called as independent tool and on other pole is dependent tool which use multiple tool for analysis, and other y-axis indicates level of expert involvement in the particular tool purpose. Independent tool is one which are created or derived without the help of any other tool or any foresight tool. Dependent tool is one which is derived from directly or indirectly with the help of different tool in order solve the technology foresight problem. The level of expert required to solve the problem in whole process of technology foresight is varies based on the different tools, experts are required to conduct the

foresight process, some tools use very high expert guidance, and some take very less, as shown in figure 5.

However, it is placed based on the level of experts required in complete process, so we can see that tools like Delphi, roadmapping, FTA, MCA model uses the high expert involvement and they are independent tools. But, tool like IoT which requires very less involvement of experts, the experts are required only at beginning of the process of coding and later stage a skilled worker can understand the trends and foresight from the output data. Furthermore, tools like mental model and three phase model uses the methods like Delphi method, STEEP method and other tools to uncover technology foresight.

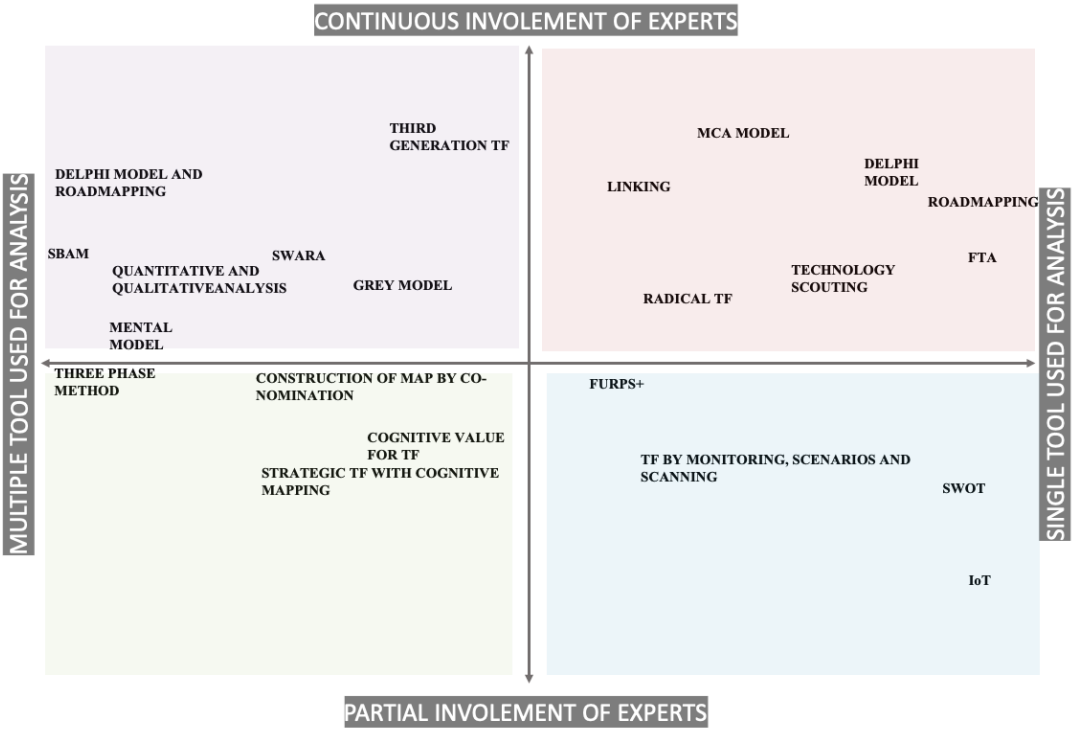

Figure 5: Differentiating tools based on characteristics.

Conclusion:

This research helps in understanding the value concealed in tools and help in construct the appreciated technology foresight of particular technology and give the answer for the research question and also the limitation regarding the technology foresight is discussed.

This literature review is very much engrossed on technology foresight, this research can help in explain about construction of tool, comprehensive clarifications about tool and when to use of particular tool for technology foresight.
Moreover, the different literature indicates that how technology foresight is being used in various aspects to determine the estimate value of particular technology. During the research period it is observed that many universities and companies were very much concerned, and technology foresight is being used in various field of innovation.

Industrial implication: Technology foresight and industrial development strategy need to be taken very seriously in order to shape the technology changes and economic growth. It is also said that technology foresight and industrial work are the different faces of the same coin, they need to logically design and implement for the better economical outcome, based on several research paper it is being stated that the industries which are using technology foresight that would more successful (Pietrobelli,2016).

Government implication: It is evident base that for the innovation and related policy foresight activity is limited, but wide range of countries USA, Australia, South Korea, UK, Germany, France, among others as well as at European level are investing on technology foresight in S&T sector. Most of the policy are being used for the technology foresight in defense, but however many researches are done on infrastructure, health, Argo, food security to name few. (Knut Blind, Cuhls, & Grupp, 1999).

Academic implication: From the research in technology foresight in university and institution level, many universities are considering the research on different technology foresight and in some reputed institution there is a particular course regarding technology foresight.
The main intention is to overcome the traditional method of technology foresight tool and replace it with the accurate technology foresight tool for different research focused on technology.

1.INTRODUCTION:

From centuries, innovation in technology bought the complete revolution in the society, one who find innovation and adopt the new technology are the rulers of particular market segment. To develop a radical thinking technology foresight is basic and important tools to predict the future of particular technology. The term “technology foresight” is describes to deal with long term issues, it has multiple meaning to convey different objective. It has been used in different fields for studying futuristic outcome and impacts.

1.1 Evolution and history of technology foresight definition:

The word foresight explains about the predicting about particular object or element, this method is being used since centuries but in very informal way for example the Delphi method was derived from the “Oracle of Delphi”. Theory states that, “the group judgments are more valid than individual judgments”. This kind of judgment was very popular across the world, but it lacked in foresight because this method was used and taken by few selected people with or without knowledge of particular theme under the guidance of king/queen of the particular region.

Furthermore, in the year of 1865 Jevon’s stated that, “foresight used for the demographic and economic forecasting tool where statistical data and methods could be brought to bear and there occasional warning of resource depletion”. The development of this definition included the experts from particular field and helped in determining the future changes and it was only used for some non-technological situation only they never explored in field of technology foresight.

The really TF came into picture after the second world war, the work of William F. Ogburn and colleagues is important both for this evaluation of the innovation process and for the development of tools for assessing trends and impacts of change in the coming future. Due to which it was used military program, space program and other large-scale techno space project.

Technology foresight (TF) become a trendy approach concerning to science, technology and innovation (STI) for policymakers and studies purpose from early 1990’s on. TF got popularity from Japan and western European countries afterwards rest of world adopted TF methodology for

policymaking and studies purpose. Nowadays the TF is defined by United Nations Industrial Development Organization (UNIDO) is "Technology foresight is regarded as the most upstream element of the technology development process. It provides inputs for the formulation of technology policies and strategies that guide the development of the technological infrastructure. In addition, technology foresight provides support to innovation, and incentives and assistance to enterprises in the domain of technology management and technology transfer, leading to enhanced competitiveness and growth".

1.2 Technology foresight: used in

- University level studies: Because of countless opportunity in the field of the TF, most of the big university are studying about various technology foresight concept around the globe, furthermore their paper is very helpful for policymakers and also for the university in order to adopt and explore in the unexplored technological field.

- Future oriented technology: The government policy makers try to determine the future projects and policies by trying to explore in particular technology, which possible could be disruption in future and way to adopt and determine the future usage and outcome. For example, cash less payment by biometric technology, space colonization and picture on demand content technology like Netflix, amazon prime.

- Particular technology component studies: Many institutes try to study about particular component of complex technology which would bring disruptive changes to society, for example the hydrogen engine for car, autonomous driving for vehicle and aircraft. E.g. Tesla, Jaguar autonomous car.

- Identification of critical technology: determination of unknown technology is very difficult to identify, so foresight of particular technology is necessary to study the future impact and diversification of technology. Example biometric usage in different fields.

- Government policy making purposes: based on the future technology the government has to design the policy, therefore policymaker study TF of particular tech, based on which policy are made and restriction will be put. For example, bitcoin usage.

Above methods are used in different field in order to attain proper investment in different R&D and also investment in particular technology and also for particular technology component. Technology Foresighting is a subset of technology road mapping, technology intelligence, technology assessment and technology forecasting.

1.3 Foresighting typology:

The below table 3 (Porter, 2010) explains about mapping of technology foresight based on different issues, dimensions and state values. The issues focus on the content and process where content explains about the matter being used to determine the technology foresight by further diversifying into different direction based on the dimension in which if we choose for example the key motivation, different drivers coming into factors, what are the scope and what are the locus point, time to finish the work and purpose of that particular studies are the key and important aspects of the content side.

Whereas the process helps in explain about the operation of the particular technology by focusing on target users, participation, and the duration of studies. However, the tables give us the systematic idea for mapping our technology foresight (Porter, 2005).

Issues	*Dimension*	*State values*			
Content	Motivation	Extrapolative	Normative		
	Drivers	Science (Research)	Technology (Development)	Innovation	Context
	Scope	Single topic or technology	Multiple technologies	Wide-ranging planning	
	Locus	Institution	Sector	Nation/Region	Global
	Time horizon	Short (1–2 year)	Mid-range (3–10 year)	Long (15 + years)	
	Purpose	Informational	Action-oriented		
Process	Target users	Few; knowledgeable	Diverse		
	Participation	Narrow mix, closed process	Intermediate	Diverse mix, representative process	
	Study duration	Day(s)	Month(s)	Year(s)	

Table 3: Technology foresight typology.

1.4 Different tools to analyze:

There are different methods families which can be used to determine the technology foresight. Different methods families take a different direction and steps to determine the required outcome, some process is simple and quick, and some are complicated and time consuming. Henceforth it is being used based on user requirement. Different method shown in table 4. The table 4 explains about different methods families based on which tools can be selected and required TF can be achieved for example, Delphi method is used under the expert opinion methods family. Similarly, for creative approaches family visioning tool can be used to solve the problem.

Methods families	*Sample methods*
Creativity approaches	TRIZ, future workshops, visioning
Monitoring and intelligence	Technology watch, tech mining
Descriptive	Bibliometrics, impact checklists, state of the future index, multiple perspectives assessment
Matrices	Analogies, morphological analysis, cross-impact analyses,
Statistical analyses	Risk analysis, correlations
Trend analyses	Growth curve modelling, leading indicators, envelope curves, long wave models
Expert opinion	Survey, delphi, focus groups, participatory approaches
Modelling and simulation	Innovation systems descriptions, complex adaptive systems modelling, chaotic regimes modelling, technology diffusion or substitution analyses, input-output modelling, agent-based modelling
Logical/Causal analyses	Requirements analysis, institutional analyses, stakeholder analyses, social impact assessment, mitigation strategising, sustainability analyses, action analyses (policy assessment), relevance trees, futures wheel
Roadmapping	Backcasting, technology/product roadmapping, science mapping
Scenarios	Scenario Management, Quantitatively based scenarios
Valuing/Decision-aiding/economic analyses	Cost-Benefit Analysis (CBA), Analytical Hierarchy Process (AHP), Data Envelopment Analysis (DEA), Multicriteria Decision Analyses
Combinations	Scenario-simulation (gaming), Trend impact analysis

Table 4: Tools for technology foresight.

technology foresight's scale & scope of growths are the key requirements for such proposed exercises are increasingly strict; meanwhile technology foresight methods tend to be diversified and integrated; however, technology foresight methodology becomes a research hotspot regarding experts and scholars in related fields. Cameron et al. (1996) presented a “Triangle Structure” for foresight methodology, based on European and international technology foresight activities, to analyze ten methods from the creativity, expertise, and interaction dimensions. As technology foresight rapidly grows worldwide, the foresight method system is increasingly enriched; for example, many quantitative methods have emerged. Therefore, based on the “Triangle Structure” Popper (2008) added the “evidence” dimension and proposed a “Foresight Diamond,” which contains 33 foresight methods and employed three font styles to indicate the type of technique(Popper, 2008), which is further explained in result part of this research:

- Qualitative: Qualitative method is the preliminary part to understand the underlying motivations, belief and incentive. It provides the spur for the problem and helps in developing ideas to solve the problem. Qualitative research helps in exposure of the particular topic trend, thoughts and examine. Qualitative data may be structured or unstructured based on the topic, some of the common method used expert opinion, research paper, interview.

- Semi- quantitative: semi quantitative is approximate result of the analysis, in this type of analysis the proper tools are being used to determine the approximate result in effective way the tools used in this method.

- Quantitative: Quantitative method main aim is to quantify the problem and research by collecting the data, stats and figures related to the topic of research. Quantitative research uses the measurable data to collect facts and uncover the pattern for the research work, the data collection methods include various form of survey like online survey, interview, paper survey, telephonic interview and online polls.

1.5 Impact of technology foresight:

Technology foresight has divided into various orders, preliminary order involve in fundamental factors, mission, targets and development target and for the medium order clearly illuminates about tactic relation among different factors and finally higher order prioritize regarding the national targets and values which focus on the development strategies. The government which have adopted the concept of the technology foresight like Japan, United Kingdom, South Korea have experienced a solid growth after mid 1990s. The science and technology (s&t) research in these countries is apart from the normal government purposes and it is dedicated to some professional institution for the research.

The instrument to decode the top-level S&T for technology foresight can be done as shown in below figure which include the study about demand, forecast and selection process. A rule was formed during each implementation stage including the structural design method, selection method of different technology, scientific index design and expert advice group and data analyses system to meet decision making demands. This method can guarantee reasonable results for getting better

outcome of technology foresight. The objective of TF is not only to hypothesize a various list of technologies that must be very much prioritized for future development but also create a platform for government, industries, institution and public to communicate with each other and gain insight about the supply and demand of science and technology and social development. Through the technology foresight process, they can garner new under- standings to face future challenges together and form a more closely connected social network. Martin and Johnston (1999) once summarized this kind of connection as "technology foresight for wiring up the national innovation system."

The development in technology foresight in various nation shows us, how technology foresight helped those countries to grow in field of S&T.

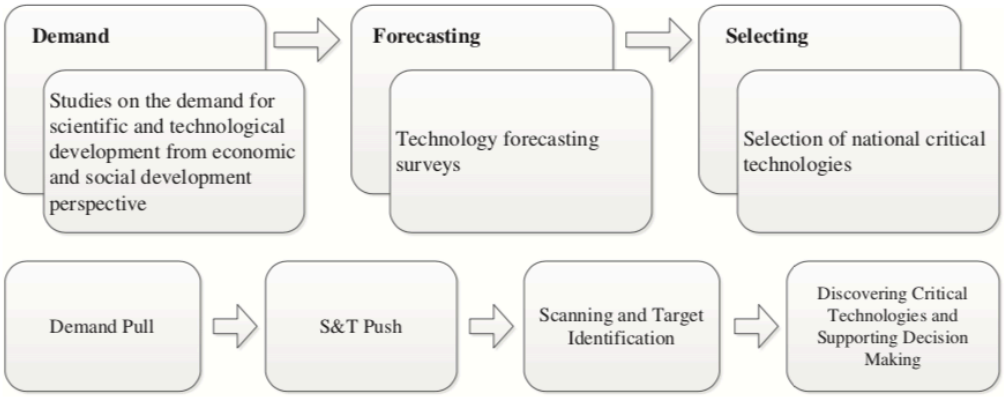

Figure 6: a basic technology foresight process. Yang (2015).

2.RESEARCH QUESTION

The research questions were formulated with reference to a literature review of TF used in various journals and also TF used in different organization and universities.
The main intention behind this literature review was to determine various unsolved question regarding the TF. The work could help in designing, research and implementing various vital information regarding TF. however, the detailed process is being explained in the methodology section of this report. Moving on the different question aroused before starting further literature review are:

2.1 Research Questions

Research question 1: What all the different methods used to determine the TF?

For the early stage of research, it seems like tools used for TF is one of the important factors which can be used for deep review further. In-Depth research in form of literature review can provide a complex answer of TF.

Research question 2: Clustering tools based on the characteristics?

The systematic literature can help in giving the proper analytical data regarding the tools over the period of time, this would help in understanding the nature of tools. This can help in igniting of discovering the various direction in TF.

Research question 3: How the characteristics of different tools can be identified?

During the preliminary research, the different tool used for technology foresight, were having some similarities and dissimilarities characters. So, it was used to analyzed in the further process technology foresight literature review.

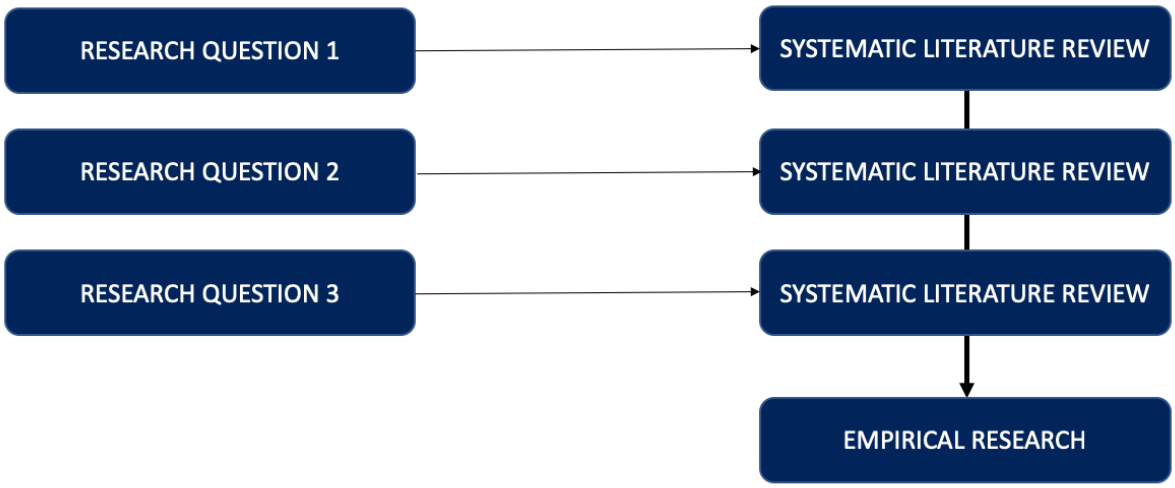

Figure 7: Framework of questionnaires with reference of respective data.

2.2 Value of the research:

The potential value behind this research can help to investigate the different features of TF in order to build one. From the part of academic's point of view, this work aims in covering the unexplored and undefined area of research till now. The main task was to unfold three main aspects. One to create a novel and valuable research on an uncovered area on which more research is required, second is to create awareness by promoting the discussion and creating the valuable data of TF to the society and third is to apply the new ideas of integration of different tools in different sectors. For the part of the practitioner point of view, this work can be used for reference in government or private projects. The data can be used for how to design, implement and research of TF.

3.LITERATURE REVIEW:

This chapter aims at explaining the different methodology adopted at different stages to achieve the answers to the research. It gives insight to the reader about where the various information used in this report had been sourced and how each information, material and data have been used to better understand concepts and frameworks.

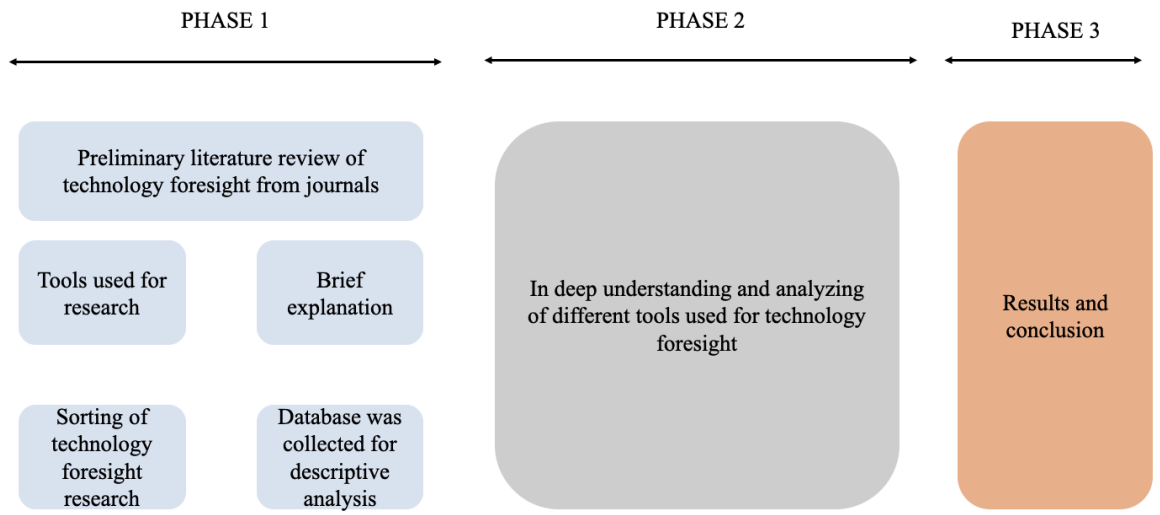

Figure 8: different phases of the research.

3.1 Preliminary literature review:

A researching was done based on quantitative data obtained from different journals and this is preliminary part of this thesis, a research was done based on the 150 journals which were written by the prominent people regarding the technology foresight which were dated from 1993 to 2018. Based on systematic way the research process was conducted the prime motto of research was to determine

- Tools/method used for technology foresight: Here the main aim was to determine the method from which the TF is determined. Based of which, segmentation of different tools was done also determined which are popular tools and also new tools used for tech foresight.

- Definition of tools according to author: Definition of tools according to the writer were determined and added to the research.

- Positive and negative review regarding the method: Based on sortation of positive and negative comment were described and rating were assigned.

- Rating were given based on tools and explanation: Based on the explanations review were given and based on which rating were given to journal and used for the further process of research.

The main intention of using literature review is to give a proper structure to the research by segmenting in various groups based on author, year of publish, citations, tools used for technology foresight, definition of methodology, journal and number of papers published by author. In order to build proper structure. Based on listed segmentation the bibliographic research was conducted which is from 150 journals.

3.2 Searching of journals based on keywords:

Before the bibliographic research of the journals. Different journal was downloaded from the Scopus and science direct website based on the technology foresight as keyword and found around 150 journals dated from 1993 to 2018 the journals were chosen from research article, energy, computer science, social science, decision science, economics, engineering, business, management, accounting.

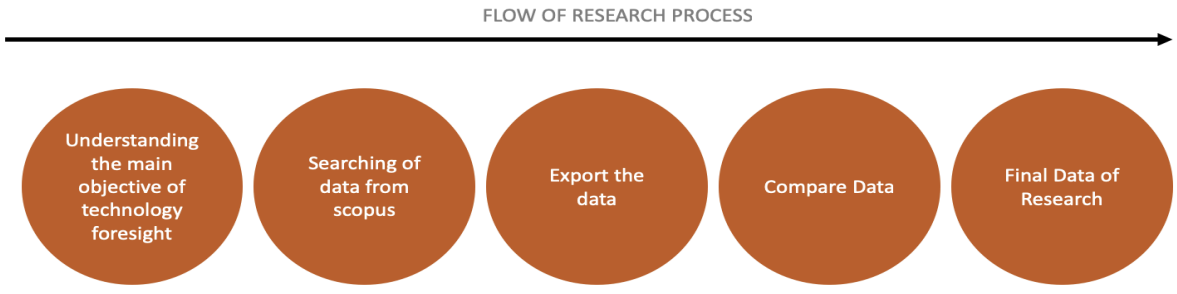

Figure 9: Flow of research process.

3.2.1 Data creation:

Based on the downloaded of journal the data base was created to further proceeding to our research. The data was divided in different segments.

- Author name
- Abstract
- Technology foresight topic in article (Yes/No)
- Definition of tool
- Tool used
- Positive review based on article
- Negative review based on article
- Rating based on tools
- Extra information about tools
- Determination of tools used, or no tools are used
-

3.2.2 Downloads of journals for further research:

The article was downloaded from Scopus website and journal was studied to determine the tools and method writer used to TF.

Note: Only the main journals were downloaded due to restricted number of access to download.

3.2.3 Segmentation of data:

Segmentation of data was done on the Microsoft excel software and the segmentation was done based on various topic like: -

- Count of journal published in that particular year
- Author based on number of journals published
- Count of source title used by writer
- Number of citations

Note: the above data is explained in descriptive analysis of data.

3.3 Descriptive Analysis:

Based on the 150 journals database descriptive analysis is done and further segmentation is done based on:

- Most citied paper's in the database
- Top authors in the database
- Top journals in the database
- Number of papers published per year
- Tools used in the journals

Further, we discuss on different segmentation mentioned above,

3.3.1 MOST CITIED PAPER'S IN THE DATABASE:

Based on the database out of 150 journals all authors were selected for our further understanding, it is distinguished between source title, number of citations, published year and Author of journal. Table 5 shows the sample of top 14 from database. Around 32% is about technology forecasting and social change title, furthermore 15% were of international journal of foresight and innovation policy and 8% covers of future topic. However, Martin B.R. and Johnston R authors is most cited author who described regarding technology forecasting and social change.

Authors	Title	Year	Source title	Citation
Martin B.R., Johnston R.	Technology foresight for wiring up the national innovation system: Experiences in Britain, Australia, and New Zealand	1999	Technological Forecasting and Social Change	149

Barker D., Smith D.J.H.	Technology foresight using roadmaps	1995	Long Range Planning	116
Grupp H., Linstone H.A.	National technology foresight activities around the globe: Resurrection and new paradigms	1999	Technological Forecasting and Social Change	107
Reger G.	Technology foresight in companies: From an indicator to a network and process perspective	2001	Technology Analysis and Strategic Management	93
Georghiou L.	The UK technology foresight programme	1996	Futures	86
Miles I.	The development of technology foresight: A review	2010	Technological Forecasting and Social Change	84
Eriksson E.A., Weber K.M.	Adaptive Foresight: Navigating the complex landscape of policy strategies	2008	Technological Forecasting and Social Change	72
Martin B.R.	The origins of the concept of 'foresight' in science and technology: An insider's perspective	2010	Technological Forecasting and Social Change	66
Rohrbeck R.	Harnessing a network of experts for competitive advantage:	2010	R and D Management	64

	Technology scouting in the ICT industry			
Salo A., Gustafsson T., Ramanathan R.	Multicriteria methods for technology foresight	2003	Journal of Forecasting	56
Czaplicka-Kolarz K., Stańczyk K., Kapusta K.	Technology foresight for a vision of energy sector development in Poland till 2030. Delphi survey as an element of technology foresighting	2009	Technological Forecasting and Social Change	53
Porter A.L.	QTIP: Quick technology intelligence processes	2005	Technological Forecasting and Social Change	52
Keenan M.	Identifying emerging generic technologies at the national level: The UK experience	2003	Journal of Forecasting	52
Kameoka A., Yokoo Y., Kuwahara T.	A challenge of integrating technology foresight and assessment in industrial strategy development and policymaking	2004	Technological Forecasting and Social Change	49
Linstone H.A.	Three eras of technology foresight	2011	Technovation	43
Breiner S., Cuhls K., Grupp H.	Technology foresight using a Delphi	1994	R&D Management	38

	approach: a Japanese-German co-operation			
Eto H.	The suitability of technology forecasting/foresight methods for decision systems and strategy: A Japanese view	2003	Technological Forecasting and Social Change	34
Jørgensen M.S., Jørgensen U., Clausen C.	The social shaping approach to technology foresight	2009	Futures	33
Banuls V.A., Salmeron J.L.	A Scenario-Based Assessment Model-SBAM	2007	Technological Forecasting and Social Change	32
Salmenkaita J.-P., Salo A.	Emergent foresight processes: Industrial activities in wireless communications	2004	Technological Forecasting and Social Change	32
Van Wyk R.J.	Strategic Technology Scanning	1997	Technological Forecasting and Social Change	32
Héraud J.-A., Cuhls K.	Current foresight activities in France, Spain, and Italy	1999	Technological Forecasting and Social Change	30
Saritas O., Taymaz E., Tumer T.	Vision 2023: Turkey's national Technology Foresight Program: A contextualist analysis and discussion	2007	Technological Forecasting and Social Change	29

Havas A.	Evolving foresight in a small transition economy	2003	Journal of Forecasting	29
Anderson J.	Technology Foresight for competitive advantage	1997	Long Range Planning	29
Durand T.	Twelve lessons from 'key technologies 2005': The French technology foresight exercise	2003	Journal of Forecasting	28
Salo A., Könnöiä T., Hjelt M.	Responsiveness in foresight management: reflections from the Finnish food and drink industry	2004	International Journal of Foresight and Innovation Policy	27
Salo A.A.	Incentives in technology foresight	2001	International Journal of Technology Management	27
Nedeva M., Georghiou L., Loveridge D., Cameron H.	The use of co-nomination to identify expert participants for Technology Foresight	1996	R and D Management	27
Bañuls V.A., Salmeron J.L.	Foresighting key areas in the Information Technology industry	2008	Technovation	26
Blind K., Cuhls K., Grupp H.	Current foresight activities in Central Europe	1999	Technological Forecasting and Social Change	26

Chan L., Daim T.	Exploring the impact of technology foresight studies on innovation: Case of BRIC countries	2012	Futures	25
Andersen P.D., Jørgensen B.H., Lading L., Rasmussen B.	Sensor foresight - Technology and market	2004	Technovation	25
Kuusi O., Meyer M.	Technological generalizations and leitbilder-the anticipation of technological opportunities	2002	Technological Forecasting and Social Change	25
Blind K., Cuhls K., Grupp H.	Current Foresight Activities in	1999	Technological Forecasting and Social Change	23
Stahl B.C., McBride N., Wakunuma K., Flick C.	The empathic care robot: A prototype of responsible research and innovation	2014	Technological Forecasting and Social Change	20
Borch K.	Emerging technologies in favour of sustainable agriculture	2007	Futures	20
Amcoff J., Westholm E.	Understanding rural change-demography as a key to the future	2007	Futures	20
Shin T., Hong S.-K., Grupp H.	Technology foresight activities in Korea and	1999	Technological Forecasting and Social Change	20

	in countries closing the technology gap			
Miles I.	Foresight and services: Closing the gap?	1999	Service Industries Journal	20
Loveridge D.	Foresight - Seven paradoxes	2001	International Journal of Technology Management	19
Salo A., Gustafsson T.	A group support system for foresight processes	2004	International Journal of Foresight and Innovation Policy	18
Porter A.L.	Technology foresight: Types and methods	2010	International Journal of Foresight and Innovation Policy	17
Jørgensen M.S., Jörgensen U.	Green technology foresight of high technology: A social shaping of technology approach to the analysis of hopes and hypes	2009	Technology Analysis and Strategic Management	16
Postma T.J.B.M., Alers J.C., Terpstra S., Zuurbier A.	Medical technology decisions in The Netherlands: How to solve the dilemma of technology foresight	2007	Technological Forecasting and Social Change	15

	versus market research?			
Chen H., Wakeland W., Yu J.	A two-stage technology foresight model with system dynamics simulation and its application in the Chinese ICT industry	2012	Technological Forecasting and Social Change	14
Brandes F.	The UK technology foresight programme: An assessment of expert estimates	2009	Technological Forecasting and Social Change	14
Boe-Lillegraven S., Monterde S.	Exploring the cognitive value of technology foresight: The case of the Cisco Technology Radar	2015	Technological Forecasting and Social Change	13
Kolominsky-Rabas P.L., Djanatliev A., Wahlster P., Gantner-Bär M., Hofmann B., German R., Sedlmayr M., Reinhardt E., Schüttler J., Kriza C., Niederländer C., Prokosch H.-U., Lenz R., Baumgärtel P., Schöffski O., Emmert M., Meier F., Aisenbrey A., Voigt W., Höllthaler J., Metzger A., Miethe M.	Technology foresight for medical device development through hybrid simulation: The ProHTA Project	2015	Technological Forecasting and Social Change	12
Hanney S., Henkel M., Walden Laing D.V.	Making and implementing	2001	Research Policy	12

	foresight policy to engage the academic community: Health and life scientists' involvement in, and response to, development of the UK's technology foresight programme			
Sanz-Menéndez L., Cabello C., García C.E.	Understanding technology foresight: The relevance of its S&T policy context	2001	International Journal of Technology Management	12
Uotila T., Melkas H.	Quality of data, information and knowledge in regional foresight processes	2007	Futures	11
Klusacek K.	Technology foresight in the Czech Republic	2004	International Journal of Foresight and Innovation Policy	11
Borch K., Rasmussen B.	Commercial use of GM crop technology: Identifying the drivers using life cycle methodology in a technology foresight framework	2002	Technological Forecasting and Social Change	11

Aichholzer G.	The Austrian foresight program: Organization and expert profile	2001	International Journal of Technology Management	11
Stelzer B., Meyer-Brötz F., Schiebel E., Brecht L.	Combining the scenario technique with bibliometrics for technology foresight: The case of personalized medicine	2015	Technological Forecasting and Social Change	10
Weinberger N., Jörissen J., Schippl J.	Foresight on environmental technologies: Options for the prioritisation of future research funding - Lessons learned from the project "Roadmap Environmental Technologies 2020+"	2012	Journal of Cleaner Production	10
Yuan B.J.C., Hsieh C.-H., Chang C.-C.	National technology foresight research: A literature review from 1984 to 2005	2010	International Journal of Foresight and Innovation Policy	10
Andersen P.D., Borup M., Krogh T.	Managing long-term environmental aspects of wind turbines: A prospective case study	2007	International Journal of Technology, Policy and Management	10

A Banuls V., Salmeron J.L.	Benchmarking the information society in the long range	2007	Futures	10
Lu L.Y.Y., Hsieh C.-H., Liu J.S.	Development trajectory and research themes of foresight	2016	Technological Forecasting and Social Change	9
Sokolov A., Chulok A.	Priorities for future innovation: Russian S&T Foresight 2030	2015	Futures	9
Castorena D.G., Rivera G.R., González A.V.	Technological foresight model for the identification of business opportunities (TEFMIBO)	2013	Foresight	9
Liu G.-F., Chen X.-L., Riedel R., Müller E.	Green technology foresight on automobile technology in China	2011	Technology Analysis and Strategic Management	9
Daim T., Basoglu N., Dursun O., Saritas O., Gerdsri P.	A comprehensive review of Turkish technology foresight project	2009	Foresight	9
Salo A., Gustafsson T., Mild P.	Prospective evaluation of a cluster program for finnish forestry and forest industries	2004	International Transactions in Operational Research	9
Martin G. M.	TRIZ-based technology-roadmapping	2004	International Journal of Technology Intelligence and Planning	9

Van Der Meulen B., Löhnberg A.	The use of foresight: Institutional constraints and conditions	2001	International Journal of Technology Management	9
Den Hond F., Groenewegen P.	Environmental technology foresight: New horizons for technology management	1996	Technology Analysis and Strategic Management	9
Iyer C.G.	Impact of entrepreneur on the sectoral system of innovation: Case study of the Indian crude oil refining industry	2016	Technological Forecasting and Social Change	8
Amankwah-Amoah J., Durugbo C.	The rise and fall of technology companies: The evolutional phase model of ST-Ericsson's dissolution	2016	Technological Forecasting and Social Change	8
Heidingsfelder M., Kimpel K., Best K., Schraudner M.	Shaping Future - Adapting design know-how to reorient innovation towards public preferences	2015	Technological Forecasting and Social Change	8
Hashemkhani Zolfani S., Salimi J., Maknoon R., Simona K.	Technology foresight about R&D projects selection; application of SWARA method at	2015	Engineering Economics	8

	the policy making level			
Piirainen K., Lindqvist A.	Enhancing business and technology foresight with electronically mediated scenario process	2010	Foresight	8
Yang Q.-Q., Gong Z.-M., Cheng J.-Y., Wang G.	Technology foresight and critical technology selection in China	2004	International Journal of Foresight and Innovation Policy	8
Tichy G.	The Decision Delphi as a tool of technology policy - The Austrian experience	2001	International Journal of Technology Management	8
Dickel S., Schrape J.-F.	The Logic of Digital Utopianism	2017	NanoEthics	7
Kanama D., Kondo A., Yokoo Y.	Development of technology foresight: Integration of technology roadmapping and the Delphi method	2008	International Journal of Technology Intelligence and Planning	7
Stout D.	Technology Foresight – a View from the Front	1995	Business Strategy Review	7
Förster B.	Technology foresight for sustainable production in the	2015	Technological Forecasting and Social Change	6

	German automotive supplier industry			
Lischka J.-M., Gemünden G.H.	Technology roadmapping in manufacturing: A case study at Siemens AG	2008	International Journal of Technology Intelligence and Planning	6
Belis-Bergouignan M.-C., Lung Y., Héraud J.-A.	Public foresight exercises at an intermediate level: The French national programs and the experience of Bordeaux	2001	International Journal of Technology Management	6
Bürgel H.D., Reger G., Ackel-Zakour R.	Technology foresight: Experiences from companies operating worldwide	2000	International Journal of Services, Technology and Management	6
Harrington J., Blagden J.	The neglected asset: Information management in the UK aerospace industry	1999	Business Information Review	6
Kaivo-oja J.	Towards better participatory processes in technology foresight: How to link participatory foresight research to the methodological	2017	Futures	5

	machinery of qualitative research and phenomenology?			
Pietrobelli, Puppato F.	Technology foresight and industrial strategy	2016	Technological Forecasting and Social Change	5
Chen H., Yu J., Wakeland W.	Generating technology development paths to the desired future through system dynamics modeling and simulation	2016	Futures	5
Ondrus J., Bui T., Pigneur Y.	A Foresight Support System Using MCDM Methods	2014	Group Decision and Negotiation	5
Brummer V., Salo A., Nissinen J., Liesiö J.	A methodology for the identification of prospective collaboration networks in international R&D programmes	2011	International Journal of Technology Management	5
Hwang J.H., Kim Y.J., Son S., Han J.	Technology foresight in Korea: A review of recent government exercises	2011	Competitiveness Review	5
Park B., Son S.-H.	Korean Technology Foresight for national S & T planning	2010	International Journal of Foresight and Innovation Policy	5

Arman H., Hodgson A., Gindy N.	Technologies watch exercise: Foresight approach enhanced with scientific publications and patents analysis	2009	International Journal of Technology Intelligence and Planning	5
Larsen K., Höjer M.	Technological innovation and transformation perspectives in environmental futures studies for transport and mobility	2007	International Journal of Foresight and Innovation Policy	5
Eto H.	Obstacles to the acceptance of technology foresight for decision makers	2004	International Journal of Foresight and Innovation Policy	5
Peterson J.W.	Leveraging technology foresight to create temporal advantage	2002	Technological Forecasting and Social Change	5
Nakahara T.	Technology strategy in a borderless economy	1999	International Journal of Technology Management	5
Gokhberg L., Sokolov A.	Technology foresight in Russia in historical evolutionary perspective	2017	Technological Forecasting and Social Change	4

Proskuryakova L.	Energy technology foresight in emerging economies	2017	Technological Forecasting and Social Change	4
Barnard-Wills D.	The technology foresight activities of European Union data protection authorities	2017	Technological Forecasting and Social Change	4
Featherston C.R., O'Sullivan E.	Enabling technologies, lifecycle transitions, and industrial systems in technology foresight: Insights from advanced materials FTA	2017	Technological Forecasting and Social Change	4
Choi M., Choi H.-L.	Foresight for science and technology priority setting in Korea	2015	Foresight and STI Governance	4
Lin H.-C., Luarn P., Maa R.-H., Chen C.-W.	Adaptive foresight modular design and dynamic adjustment mechanism: Framework and Taiwan case study	2012	Technological Forecasting and Social Change	4
Dursun O., Türe T.E., Daim T.U.	Post-evaluation of foresight studies:Turkish case	2011	International Journal of Foresight and Innovation Policy	4

Karasev O., Rudnik P., Sokolov A.	Emerging Technology-Related Markets in Russia: The Case of Nanotechnology	2011	Journal of East-West Business	4
Peissl W.	Technology foresight - More than fashion?	2001	International Journal of Technology Management	4
Walker W.E., Rahman S.A., Pöyhönen M., van der Lande R.W.I.	Technology foresight for the Netherlands: strategic technologies and the knowledge infrastructure to support them	2001	International Journal of Technology, Policy and Management	4
Hussain M., Tapinos E., Knight L.	Scenario-driven roadmapping for technology foresight	2017	Technological Forecasting and Social Change	3
Li M.	An exploration to visualise the emerging trends of technology foresight based on an improved technique of co-word analysis and relevant literature data of WOS	2017	Technology Analysis and Strategic Management	3
Li N., Chen K., Kou M.	Technology foresight in China: Academic studies, governmental practices and policy applications	2017	Technological Forecasting and Social Change	3

Iden J., Methlie L.B., Christensen G.E.	The nature of strategic foresight research: A systematic literature review	2017	Technological Forecasting and Social Change	3
Kim J., Park Y., Lee Y.	A visual scanning of potential disruptive signals for technology roadmapping: investigating keyword cluster, intensity, and relationship in futuristic data	2016	Technology Analysis and Strategic Management	3
Sacio-Szymańska A., Mazurkiewicz A., Poteralska B.	Corporate foresight at the strategic research institutes	2015	Business: Theory and Practice	3
Hassanzadeh A., Namdarian L., Majidpour M., Elahi S.	Developing a model to evaluate the impacts of science, technology and innovation foresight on policy-making	2015	Technology Analysis and Strategic Management	3
Apreda R., Bonaccorsi A., Fantoni G., Gabelloni D.	Functions and failures: how to manage technological promises for societal challenges	2014	Technology Analysis and Strategic Management	3
Celiktas M.S., Kocar G.	Telescopic drilling view for future: A geothermal foresight study in Turkey	2013	Technological Forecasting and Social Change	3

Kanama D.	A Japanese experience of a mission-oriented multi-methodology technology foresight process: an empirical trial of a new technology foresight process by integration of the Delphi method and scenario writing	2010	International Journal of Technology Intelligence and Planning	3
Martino J.P.	Some recent advances in technology foresight	2010	International Journal of Foresight and Innovation Policy	3
Li Z., Chen J.	National technology roadmapping of China: Practices and implications	2010	Journal of Science and Technology Policy in China	3
Feige D., Vonortas N.S.	Context appropriate technologies for development: Choosing for the future	2017	Technological Forecasting and Social Change	2
Kaivo-Oja J., Roth S., Westerlund L.	Futures of robotics. Human work in digital transformation	2017	International Journal of Technology Management	2
Intarakumnerd P., Chairatana P.-A., Kamondetdacha R.	Innovation system of the seafood industry in Thailand	2015	Asian Journal of Technology Innovation	2

Zweck A., Braun A., Rijkers-Defrasne S.	International foresight of the 2000s: Comparative analysis	2014	Foresight Russia	2
Tiits M., Kalvet T.	Intelligent piggybacking: A foresight policy tool for small catching-up economies	2013	International Journal of Foresight and Innovation Policy	2
Amanatidou E.	The greek national technology foresight programme: Success is in the eye of the beholder	2013	International Journal of Foresight and Innovation Policy	2
Haruvy N., Shalhevet S.	Integrating technology foresight methods with environmental life cycle assessment to promote sustainable agriculture	2012	International Journal of Foresight and Innovation Policy	2
Kim B.S.	A case of forecast-based technology evaluation and its implications	2010	International Journal of Technology Intelligence and Planning	2
Wilson I.	Technology foresight in an age of uncertainty	2004	International Journal of Foresight and Innovation Policy	2

Cespedes Quiroga M., Martin D.P.	Technology foresight in traditional Bolivian sectors: Innovation traps and temporal unfit between ecosystems and institutions	2017	Technological Forecasting and Social Change	1
Santos C., Araújo M., Correia N.	A methodology for the identification of strategic technological competences: An application in the sheet metal equipment industry	2017	Futures	1
Temiz A.Ş., Özkan B.Y., Üçer A.Ş.	A Product-Based Strategic Technology Management Methodology for Developing Countries	2016	International Journal of Innovation and Technology Management	1
De Almeida M.F.L., De Moraes C.A.C., De Melo M.A.C.	Technology foresight on emerging technologies: Implications for a national innovation initiative in Brazil	2015	Journal of Technology Management and Innovation	1
Waite B.C.	A future's approach to enhanced television and governance	2012	Futures	1
Yokoo Y., Okuwada K.	Validity of foresight derived from the	2012	International Journal of Foresight and	1

	evaluation of past activities in Japan		Innovation Policy	
Yuan B.J.C., Chang C.-C., Hsieh C.-H.	Consensus building in participative foresight: Empirical cases of UK, Sweden and Germany	2010	International Journal of Foresight and Innovation Policy	1
Valadares Tavares L.	Foresight and governance: A problem-oriented methodology (GOVSIGHT)	2003	International Transactions in Operational Research	1
Hafezi R., Malekifar S., Akhavan A.	Analyzing Iran's science and technology foresight programs: recommendations for further practices	2018	Foresight	
Franceschini S., Borup M., Rosales-Carreón J.	Future indoor light and associated energy consumption based on professionals' visions: A practice- and network-oriented analysis	2018	Technological Forecasting and Social Change	
Kaivo-Oja J., Ahlqvist T., Kuusi O., Linturi R., Roth S.	New industrial platforms and radical technology foresight: The case of 3D printing in Finland and Europe	2018	International Journal of Manufacturing Technology and Management	

Esmaelian M., Tavana M., Di Caprio D., Ansari R.	A multiple correspondence analysis model for evaluating technology foresight methods	2017	Technological Forecasting and Social Change
Vishnevskiy K., Karasev O., Meissner D., Razheva A., Klubova M.	Technology foresight in asset intensive industries: The case of Russian shipbuilding	2017	Technological Forecasting and Social Change
Kuzminov I.F., Thurner T., Chulok A.	The technology foresight system of the Russian Federation: a systemic view	2017	Foresight
Ito Y., Kanama D.	Development of an integrated foresight process oriented toward social vision creation on ageing society in Japan	2013	International Journal of Foresight and Innovation Policy
de Almeida M.F.L., de Moraes C.A.C.	Diffusion of emerging technologies for sustainable development: Prospective assessment for public policies	2013	Journal of Technology Management and Innovation
Kanama D.	Objective, methodology and subject area of technology foresight	2013	International Journal of Foresight and Innovation Policy

	based on bibliometric analysis		
[No author name available]	A helping hand	2010	Twist
Yuan B.J.C., Kang T.H., Chang C.-C., Liu C.-Y., Li K.-P.	Technology foresight in Taiwan: developing internet foresight system	2010	International Journal of Foresight and Innovation Policy
Gong Z., Cheng J.	China's technology foresight: Aiming to 2006-2020	2010	International Journal of Foresight and Innovation Policy
Kobayashi S.-I., Kumeno F., Shirai Y., Inujima H.	A foresight methodology for exploring prior R & D topics in software field: Calculation and resolution of conflicts	2010	International Journal of Foresight and Innovation Policy

Table 5: Citied paper's in the database

3.3.2 TOP AUTHORS IN THE DATABASE:

Below table shows the top author from 321 different authors of 150 journals, which is chosen by number of journals wrote, Cuhls K, Salo A, Grupp H wrote around four journals and most one them wrote just once or twice as show in table 6.

JOURNALS COUNT	4	3	2
AUTHORS NAME	Cuhls K.	Salmeron J.L.	Yuan B.J.C.
	Salo A.	Kanama D.	Eto H.
	Grupp H.	Kaivo-Oja J.	Blind K.
		Chang C.-C.	Porter A.L.
		Hsieh C.-H.	Borup M.
		Gustafsson T.	Chen H.
			Chulok A.
			Martin B.R.
			De Moraes C.A.C.
			Andersen P.D.
			Rasmussen B.
			Borch K.
			Roth S.
			De Almeida M.F.L.
			Sokolov A.
			Jørgensen M.S.
			Wakeland W.
			Miles I.
			Yokoo Y.
			Yu J.
			Salo A.

Table 6: Top authors in the database

3.3.3 TOP JOURNALS IN THE DATABASE:

Here the table 7 shows the details study and list of the source title the author used for their journals, for the table we can see that the most of source title were of Technological Forecasting and Social Change which is titled 47 times from 150 journals dated from 1993 to 2018 followed by International Journal of Foresight and Innovation Policy, Futures and many more.

SOURCE TITLE	Count of Source title used
Technological Forecasting and Social Change	47
International Journal of Foresight and Innovation Policy	22
Futures	12
International Journal of Technology Management	11
Technology Analysis and Strategic Management	8
International Journal of Technology Intelligence and Planning	6
Foresight	5
Journal of Forecasting	4
Tech innovation	3
R and D Management	2
International Journal of Technology, Policy and Management	2
Journal of Technology Management and Innovation	2
Long Range Planning	2
International Transactions in Operational Research	2
Service Industries Journal	1
Nano Ethics	1
Twist	1
Engineering Economics	1
R&D Management	1
Asian Journal of Technology Innovation	1
International Journal of Innovation and Technology Management	1

Foresight and STI Governance	1
Group Decision and Negotiation	1
Competitiveness Review	1
Business Strategy Review	1
Journal of Cleaner Production	1
Research Policy	1
Journal of East-West Business	1
Business: Theory and Practice	1
Foresight Russia	1
International Journal of Manufacturing Technology and Management	1
Journal of Science and Technology Policy in China	1
International Journal of Services, Technology and Management	1
Business Information Review	1

Table 7: Top journals in the database

3.3.4 NUMBER OF PAPER PUBLISHED PER YEAR:

Number of papers published were determined to check the tread regarding the topic, surprisingly the technology foresight topic gain the momentum from 1993 to 2018 as shown in below table 8. This data was collected from the 150 journals which were downloaded and further analyzed to determine the trend and level of research paper written over the period of time.

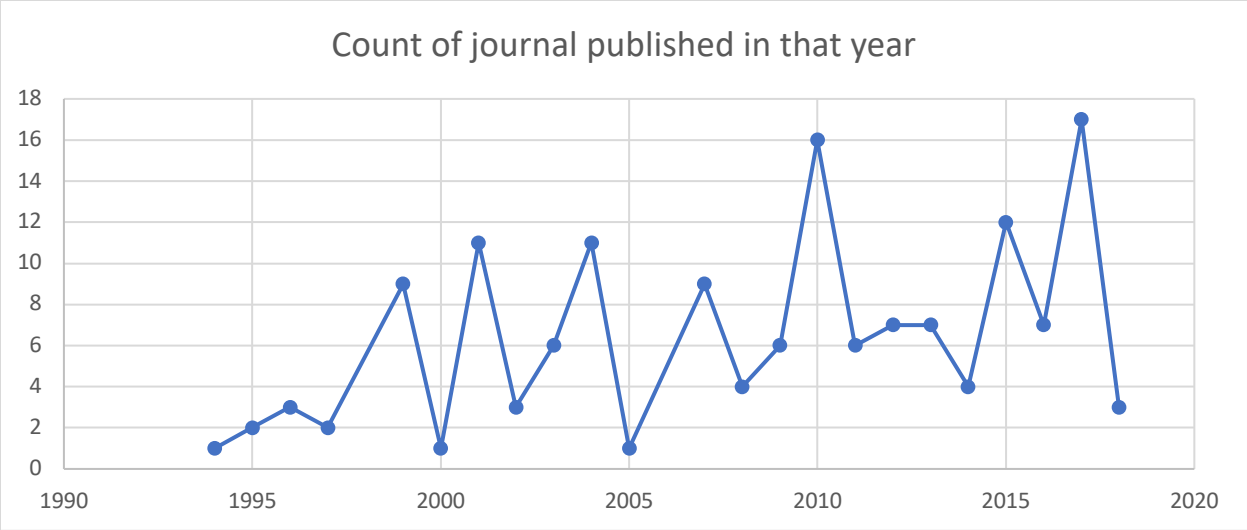

Table 8: Number of papers published in year.

3.3.5 TOOLS USED IN THE JOURNALS:

Furthermore, from journals different tools were segmented to determine which tools is used and how it was used for different papers. Based on which different tools were determined table 9 is described below.

TOOLS USED	NO. TIMES USED IN ABSTRACT
Delphi method	26
Road mapping	6
SWOT	3
Three phase method (Design/methodology/approach)	3
Expert advice	5
FURPS+ model	1
Grey model	1
Multiple correspondence analysis(MCA) model	2
Qualitative analysis	3
Trending on internet	3

Map	1
Linking	1
3rd generation Technology forecasting	3
Step-wise Weight Assessment Ratio Analysis (SWARA) method is one of the new MCDM methods	1
MENTALMODEL (experience, training, conditioning and education)	2
Technology forecasting (future predicting by mapping)	3
Radical technology foresight	1
Future oriented technology analysis (FTA)	1
Scenario- based assessment model (SBAM)	3
Cognitive value for technology Foresighting	1
Early warning system three main elements – scenarios, scanning, and monitoring	1

Table 9: Tools used in the journals

4.METHODOLOGY:

4.1 DESCRIPTIONS OF TOOLS USED:

4.1.1 Delphi method:

Delphi method focus on the time to reach upper limit, the factors to reach the present level, the expected year of realization, the measures that are required to catch up, the impacts and weights, as well as the present technology level and the technology level in the near future (in five years) stated by B.S.Kim in year 2010. Delphi method widely used for technology foresight, it consists of preliminary round, first round and third round, were the expert are chosen their own specialties for the selected technologies.

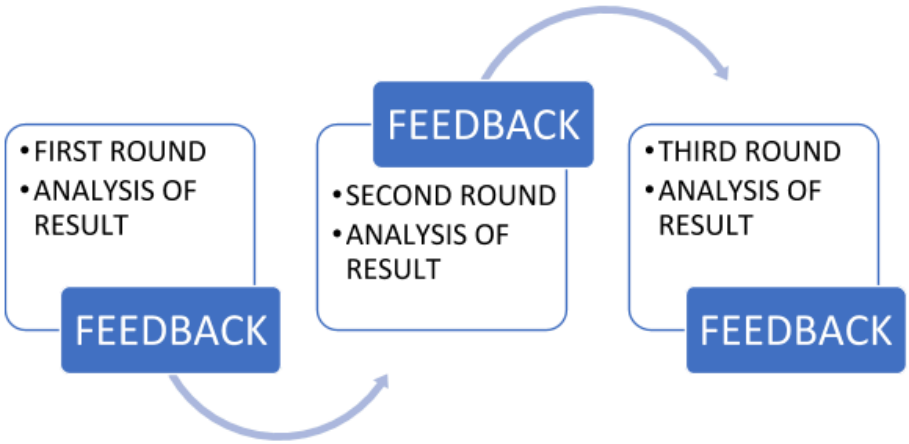

Figure 10: Delphi method process

The above figure is designed by (Al. & Escola Anna Nery - Revista de Enfermagem(2015), 2015) explaining how the Delphi tool works. At each round of process the results are analyzed based on the qualitative and quantitative analysis, obtained data are organized in form of simple statics and expert's participant are given feedback of their respective solution for technology foresight and in final round with the qualitative analyze the group forecasting are taken into consideration. In first and third quartile are proven as well as the median and interquartile

interval in order to provide the process with greater results.(Oliveira JSP, Costa MM, Wille MFC. and Wright JTC, n.d.) This method helps is knowing the feasibility, difficulty, competitiveness (Eto, 2003; Kuwahara, 2001). Delphi method methodology defines as the various expert are given the questionnaire's survey and repeated multiple respondent two or more times to obtain convergence in the expert opinions. This method differs completely from conventional method of questionnaires in that the second and subsequent questionnaires feedback previous responses to the respondents, enabling them to see the overall direction of opinions and to individually re-evaluate question topics. Views tend to meet because some respondent agree to the majority opinion.

Characters in Delphi method:

- Information flow: The initial phase contributions of experts are assembled in the form of question and answer with their comments. The committee handles the interactions among the participants by evaluating the information and removing out unrelated content.
- systematic review: Participants comment on their own finding, the responses of other participants as a whole. If possible, they can recall and revise their given statement. While in regular group meetings participants to stick to old stated comment.
- Anonymity of the participants: Usually all participants remained anonymous and the identity is being hidden after the survey is done. This will help in minimaxing the halo effect (the tendency for a reaction generated in one area to influence opinion in another area) and also the bandwagon effect (people follow blindly to other person). This helps participant to put their opinion very freely and due to which better results can be obtained.
- Role of the council: The jury coordinating the Delphi method can be known as a facilitator, and facilitates the comments of their panel of experts, who are selected based on the valid reason from different experts. The facilitator gives out questionnaires, surveys etc. and if the panel of experts accept and

present their views. Responses are collected and analyzed, then common and conflicting viewpoints are determined. If consent is not reached, the process continues through thesis and further studies, to gradually work towards making and building agreement.

4.1.2 Road mapping:

Roadmapping is defined as a very strategic tool for strategic planning method which integrate the creating and delivering strategy for technology foresight. It is expressed in graphical method which controls and show the alignment of tasks and function in firm with respect to time.
Technology Foresighting is a very old and efficient way of TF and it was first used in year 1970's by Motorola company, Road mapping is a strategic planning tool to determine the actions, steps, and resources need to achieve the goal. According to (Albright and Schaller, 1998) identified four kinds of technology foresight, those are:

1. Science and technology road mapping: planning on research and development based on which foresight is made.
2. Product technology foresight: planning of product which is starting of raw material to reaching to market.
3. Industry technology road mapping: planning and making the technology road mapping based on product life cycle and other uses of that technology.
4. Product/portfolio management road mapping: planning and releasing the product to market based on the proper timeline prepared by road mapping.

Below figure 11 explain the how the road mapping works it contains the multiple layers (consisting of bars and tables), single layers (consisting of bars and tables, pictorial (encompassing flow chart) and text format. Can we can observe that roadmapping is plotted with duration of time horizontally in case of below figure it is the quarterly 1, quarterly 2 and so on duration of timeline and different factors like milestone, sales, product and marketing etc. are plotted in vertical direction and bars and line are plotted with respect to duration and factors.

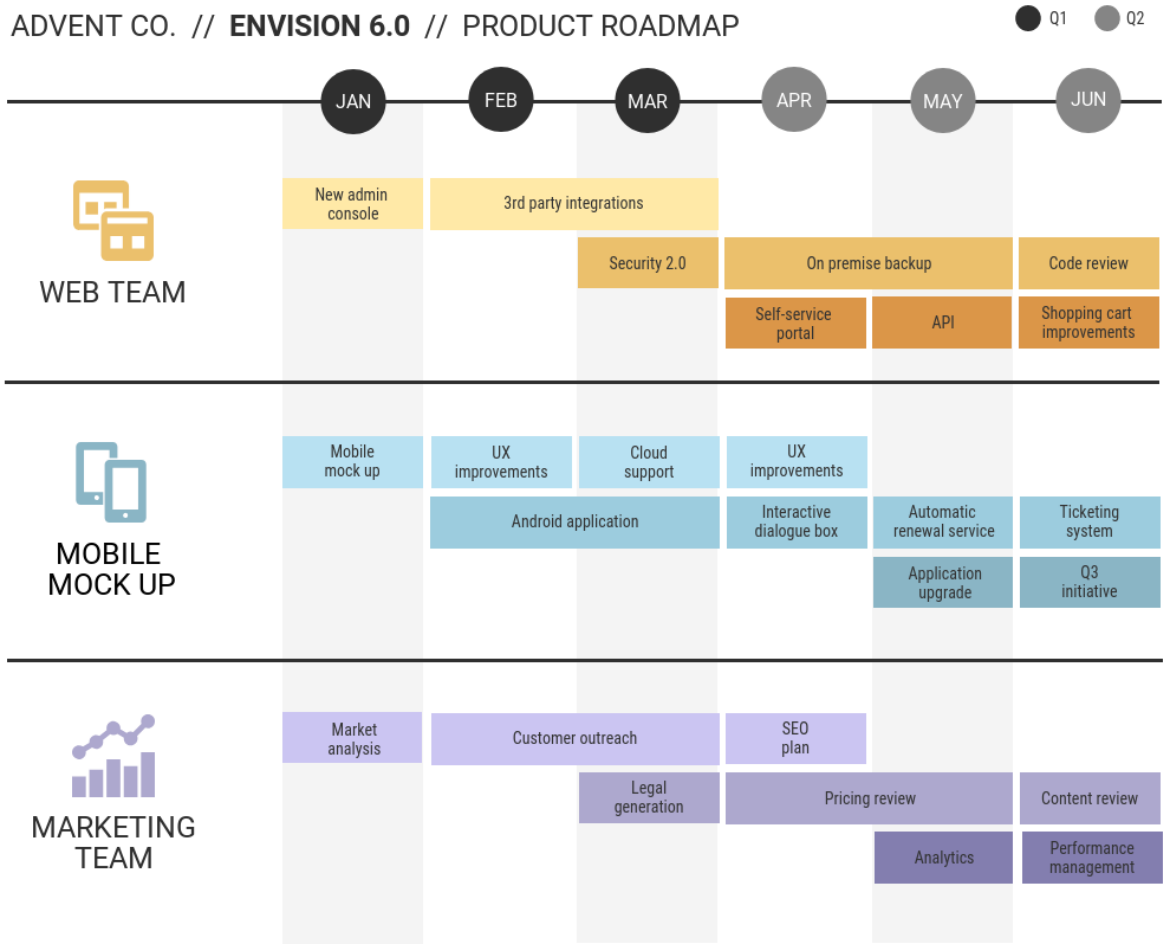

Figure 11: Example for Road-Mapping. Source: Venngage website

The architecture of technology foresight roadmapping This process was developed by Garcia and Bray in 1997, they explained that there are three phases preliminary activity, development technology roadmapping and follow up activity. It is divided into three phases namely(Garcia, M.L., Bray, 1997):

- Phase 1: preliminary activities focuses on Satisfy essentials condition of search data and information and Provide sponsorship/leadership for the further process of TF and finally Defining the scope and boundaries for technology roadmap.
- Phase 2: Development of technology roadmap by Identify the product which will be focused for TF and Identify critical system requirement and finding their target and

searching for Specify major technology area and Specify tech drivers and target to focus and Identify and recommend technology alternative and their target are plotted and technology roadmap report generated.

- Phase 3: Follow up Activity based on the information collected plotting of roadmapping is done.

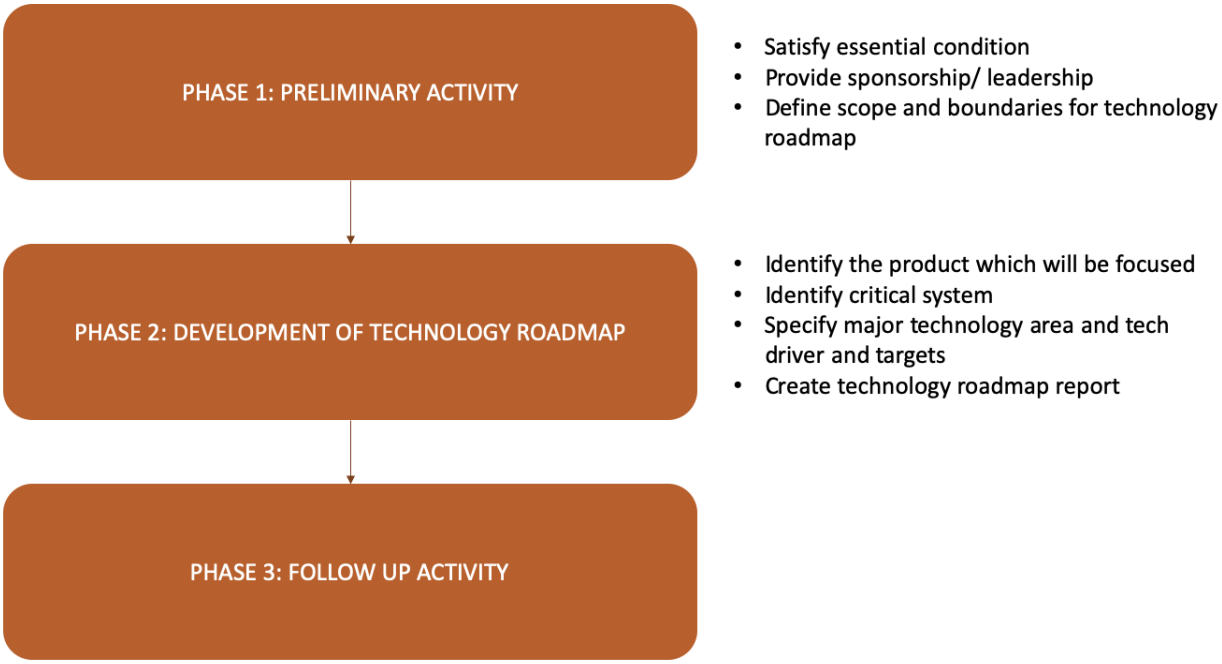

Figure 12: Different phases in roadmapping.

4.1.3 Delphi and roadmapping integration:

To overcome the demerits of Roadmapping and the Delphi Method, integration of both helps in reducing the demerits, before moving forward let's discuss and compare the brief advantages and disadvantage of the above tools, Delphi method gives a quantitative knowledge with consideration of importance of technology and time based on the experienced scientists and experts in that particular technology background(Daisuke Kanama*, 2008). However, it is difficult to get a proper connection with the future vision of the society for those technologies is created. Where at technology roadmapping it is easy to do. Coming to the biggest advantage of roadmapping over the Delphi method is research and development targets, change in society and concept based on the future vision. It gives a rough estimation to stakeholder to get enough info and project completion approximate dates and also predicts the technologies difficulties and the global competitiveness with respective technology. Moreover, it's difficult to measure quantitative and empirical items for development.

Even though predicting the proper technology is very difficult but blending in two more tools helps in getting the optimal results for future vision, however it is necessary to consider the three topics while conducting the technology foresight in near future.

1. Consideration not only technology but also social and economic elements in the process of technology foresight.

2. To gather more stakeholder in the process of TF because it's important to have a shared vision among different stakeholders helps in increase in technology uncertainties.
3. High flexibility in the result of TF helps in diversification and can engage in different fields. Increase in technology uncertainties implies an increase in the demand for future occurrences.

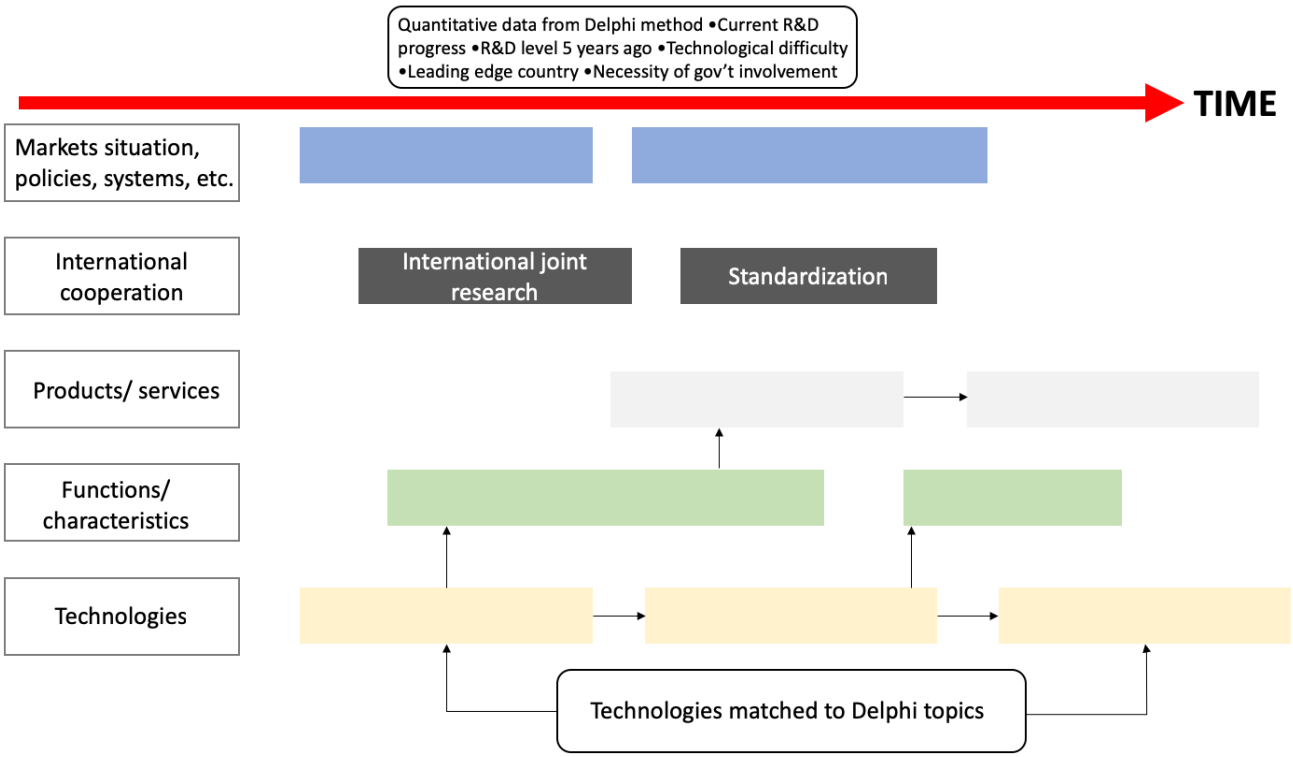

Figure 13: Integration of Delphi and road mapping by (Daisuke Kanama*, 2008)

Figure 13 explains technology roadmapping includes a combo pack of R&D and social vision, for example, it's being used in determining the road map of semiconductors, computers evolution and fuel energy etc. however, roadmapping doesn't provide detailed information about each technology specifically. This is the reason integration will help in filling the gap between two tools, where Delphi gives expert entities and quantitative details due to which the two-dimensional roadmapping can be converted into three-dimensional data. This is possible because the in Delphi method data is being reviewed by the expert in the technological area and it's an extreme and important part for the execution of the R&D part of roadmapping. The Delphi results also help in influencing the realization of the items and required service at which roadmapping aims.

4.1.4 SWOT analysis for technology foresight:

SWOT analysis is defined as strength, weakness, opportunity and threats, which are computed based on external/internal and helpful/harmful bases on each section. SWOT analysis are very easy to understand and easy to read map. This method is used in technology foresight for quick and effective result oriented where the strength, weakness, opportunity and threats can be determined by few experts and with this mind tool the result can be sometime quick and effective(Li, Z., & Chen, 2010.).

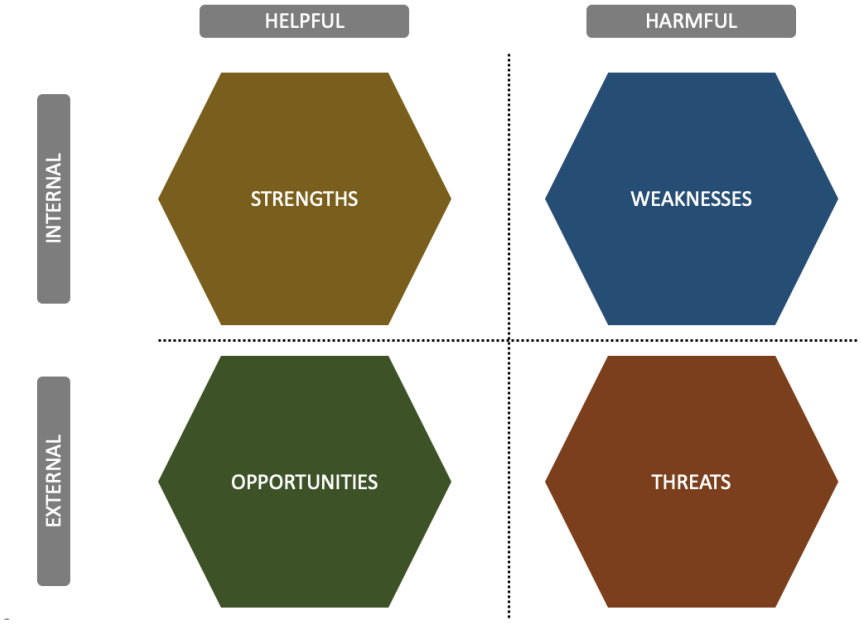

Figure 14: SWOT analysis.

The above figure 14 can be briefly explained by the below table 10, which gives a brief explanation about different variables of SWOT analysis.

SWOT ANALYSIS	HELPFUL	HARMFUL
INTERNAL	STRENGTHS: • Resource capability • Unique characteristics of the organization to fetch success	WEAKNESSES: • Absence of strength • Factors of past failure. • Loophole and bottle necks in the organization.
EXTERNAL	OPPORTUNITIES: • Environmental factors • Upcoming changes (election, government policies, social responsibilities and regulatory) • Unmet customer needs	THREATS: • Environmental factors that might prevent future successful outcome • Upcoming changes and external factors like government, policies or protest regarding the technology.

Table 10: Detail explanation of SWOT analysis.

4.1.5 Three phase methods:

Three stage methodology designed to:

- STUDY: It is understanding from the previous survey.
- ANALYZE: To diagnose and evaluate.
- DESIGN: Propose references to organize and implement extra efficient further foresight practices.

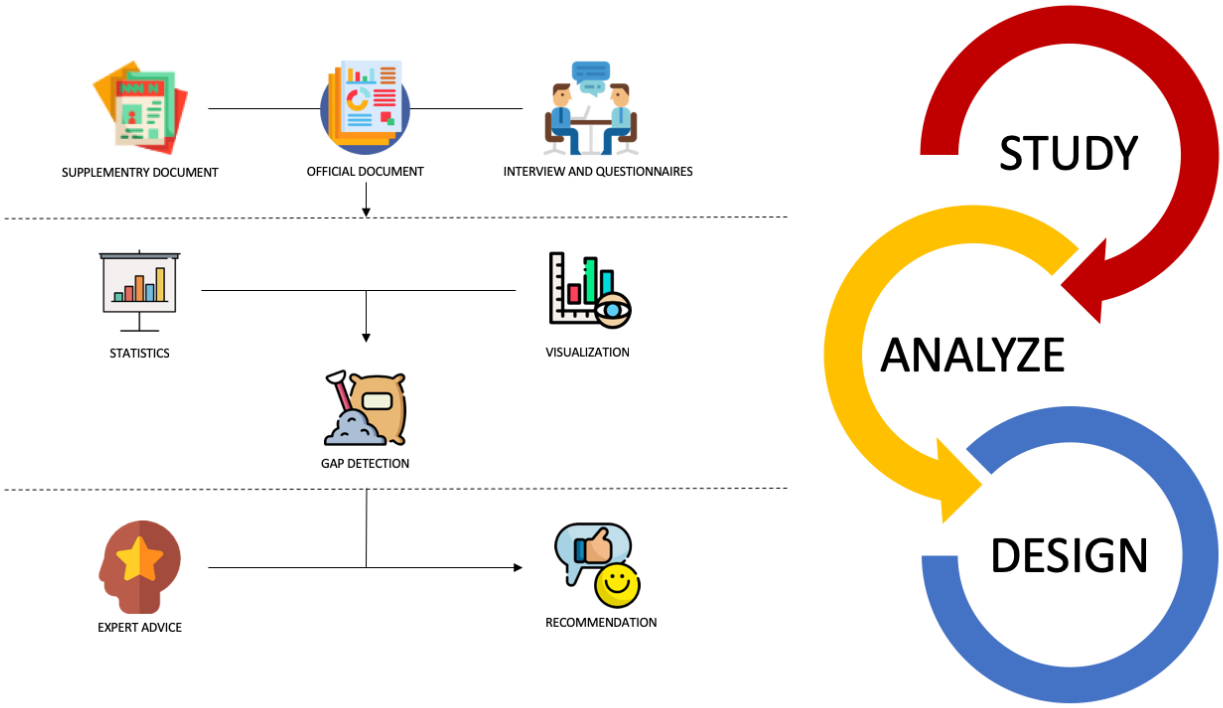

Figure 15: Flow of three stage methodology.

The above figure 15 explained in different phases(Hafezi, Malekifar, & Akhavan, 2018):

Phase 1: Study

In studies it covers the technology foresight dimensions and enhance better understanding of the analysis, raw data and questionnaire has been designed and experts were asked to review to response the obtained questionnaire and available supporting journals to start preliminary step of interview meeting with steering committee member for different foresight program. The method was used various tools like Delphi method (Expert advice, cross impact examination), SWOT analysis were done to get proper result.(Keenan, M. and Miles, 2008)

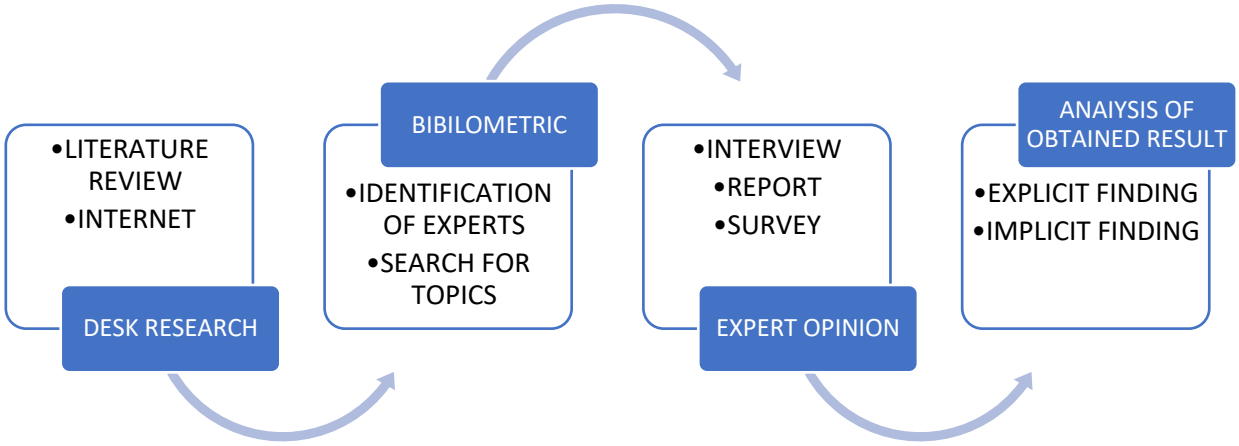

Figure 16: Flow of study and analyze part

Phase 2: Analyze

In this phase the study is made as reference and based on statics and figures ae provided in order to get a clear picture of the study, moreover to analyze there are two approaches can be used, i.e. Explicit result and Implicit result.

- Explicit result: these are the result which are obtained from solid organization like government survey or some reputed university.
- Implicit result: these are the result which helps in understanding the hidden and untold finding from the resource.

Phase 3: Design

Design phase is aimed at discovering new tactics and strategies to endorse the policymakers to organize the further foresight programs. All the results are obtained under the guidance and procedure of experts. Finally, certain proposals to support fruitful foresight efforts have been advised.

Henceforth by following the phase we can achieve the three-stage methodology by Study -> Analyze -> Design.

4.1.6 Expert Advice (technology scouting):

Author terms the technology scouting (Bodelle and Jablon, 1993; Brenner, 1996; Monteiro, 2006), "a systematic approach by companies where they assign their part of the staff or employ external consultant to collect the information regarding science and technology and through which they facilitate or execute the technology sourcing" the various aspect which are being covered in further stage.

Here the expert's network is created to build the TF practices by making the networks of scouts. The technology scout is the employee of companies or an external institution and assigned with full or part time scouting task similar to technology gate keeper, this assignment is given to those who has full knowledge about lateral thinking, science and technology, cross disciplinary and innovative mind.

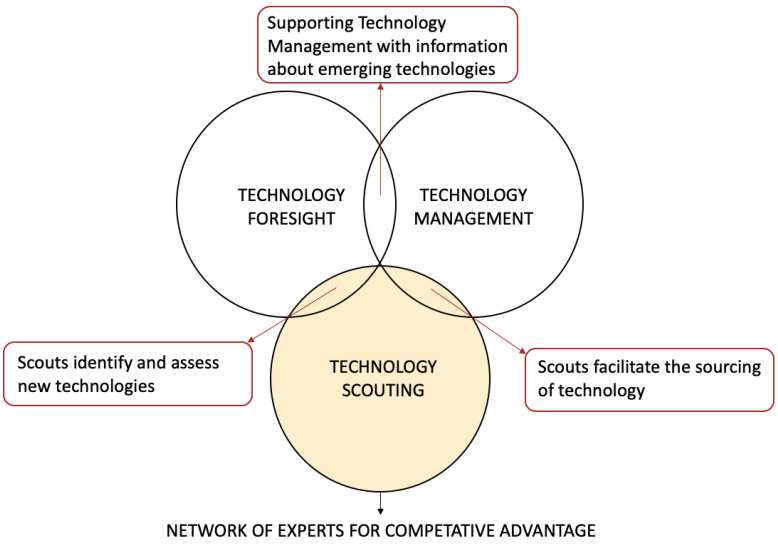

Figure 17: Contribution of technology scouting to technology foresight and technology management

The above figure 17 explains that how the technology scouting helps in merging the TF and technology management, the two aspect of technology scout are: 1. Identification, assessment and usage of data and 2. Sourcing of technology.

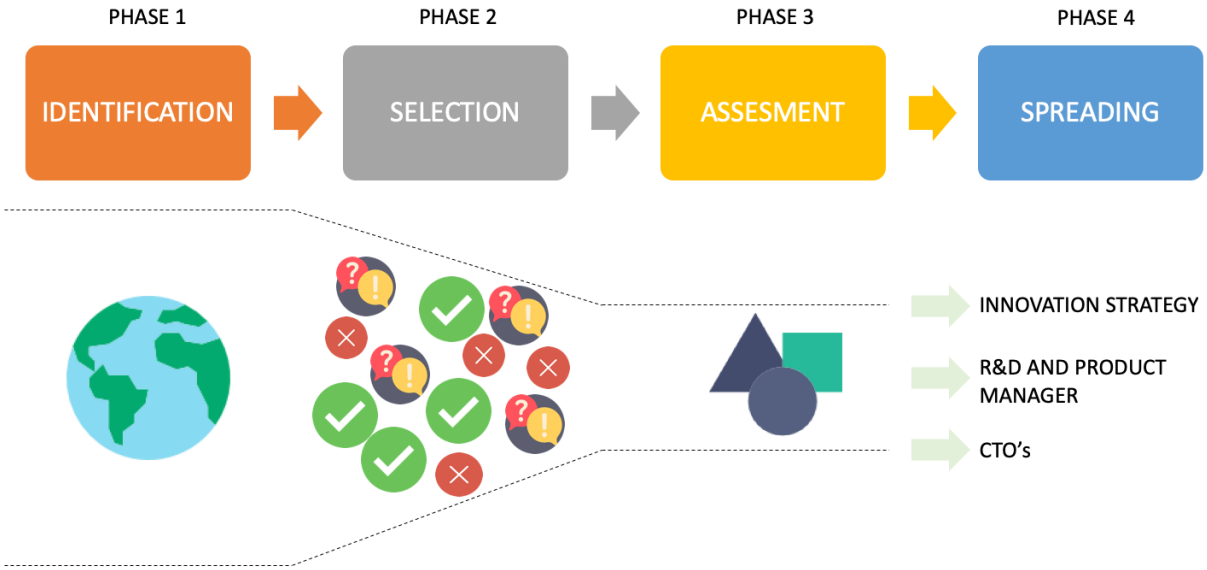

Figure 18: Different phases for technology foresight from technology scouting

The explanation of above figure 18 highlights, different phases as follows:

Phase1: Identification phase, the network of technology scout is activated across the globe to fetch the information regarding technology development and academia. Through which technology status, assessment and future potential of that technology is determined.

Phase 2: Selection phase, various data is being evaluated based on the required technology foresight and accept the required one for the further process and also ensure that the technology is never used.

Phase 3: Assessment phase, the technology is ranked according to market potential and technology realization complexity. The ranking is done by the technology scout.

Phase 4: Spreading phase, this is a final phase where name indicates that it spread the obtained knowledge, where research includes a description, research status, latest improvement and potential business value of TF.

4.1.7 FURPS+ model:

FURPS+ is a technique to give an authenticate solution after understanding clients demands and requirements. Acronym FURPS is functionality, usability, reliability, performance and supportability. FURFS gives the classification of TF in diverse aspects and also FURPS is good in segregating the technology independent and technology dependent aspect.

The brief meaning of FURPS explained as(Kobayashi, Kumeno, Shirai, & Inujima, 2010):

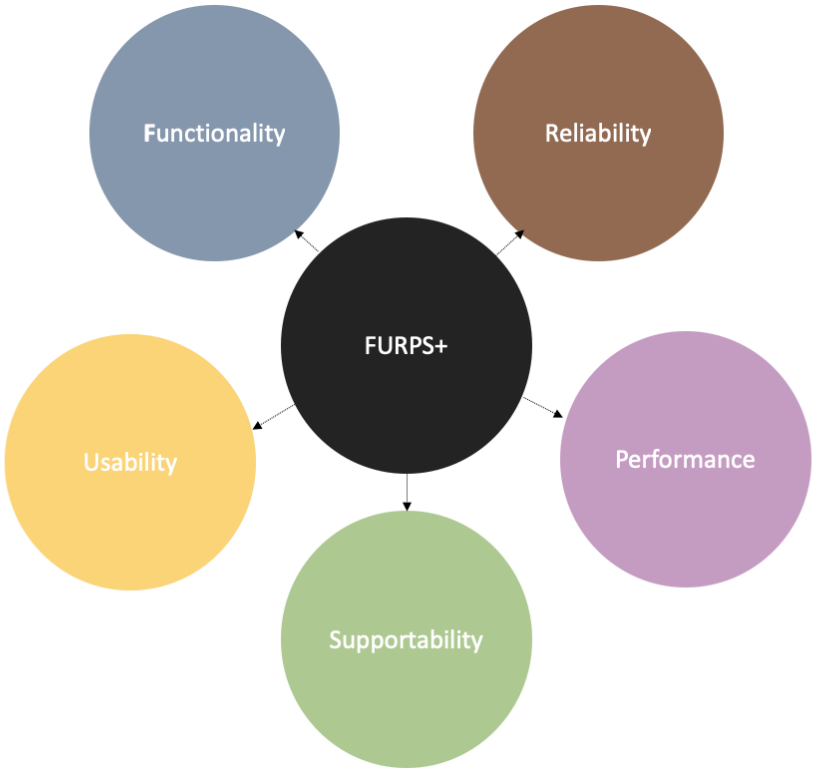

Figure 19: FURPS+ model

- **F**unctionality: the main technology feature which is available in particular business or institution, here the functionality can also vary upon technical oriented.

- **U**sability: Looking for value adding resource to the particular technology foresight that might be anything like accessibility, consistency or the people working in institution.

- **R**eliability: it includes the aspects such as accuracy, recoverability and availability of the required source. This also include a part of reputation and loyal to the work.

- **P**erformance: In this section it includes the lead time, system response time, startup time which can enhance the work faster.

- **S**upportability: here it talks about how well testing is done, feasibility of product is determined, projection of TF is done, checking of compatibility is made, future maintenance is decided and so on.

- +: is used to specify the constrains including design, implementation and physical constrains.

FUNCTIONALITY	USABILITY	RELIABILITY	PERFORMANCE	SUPPORTABILITY
• Capabilities • Security • Sets and rules	• Human factors • Aesthetics • Consistency • Training • documentation	• Frequency • Severity of failure • Recoverability • Predictability • Accuracy • Mean time between failure	• Speed • Efficiency • Availability • Accuracy • Throughput time • Response time • Recover time • Resource usage	• Testability • Extensibility • Adaptability • Mentality • Computability • Configurability • Serviceability • Installability • localizability

Table 11: Explains the FURPS+ method

4.1.8 Grey model:

The Grey model has been used widely for technology foresight and analysis purpose, in Grey model the term “Grey” indicates the data used in model between “black” which is completely

unknown and “white” which indicates the known area data, grey model helps in smoothening of original data and reduce the effect of unwanted and discontinuities(Martino, 2010). Grey model was originally introduced by Deng in year 1982 and later on Lin and Yang and Hsu in year 2003 contributed more to the model (Lin and Yang, 2003; Hsu, 2003). A good presentation on the theory of Grey Models can be found in the paper by Lin et al. (2004).

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The Grey model (GM) as follows:

A time series of data respected as,

$X^{(0)} = (X^{(0)}(1), X^{(0)}(2), X^{(0)}(3),\ldots\ldots X^{(0)}(n))$

where the superscript (0) indicates that this is the original data, and the numbers 1, 2, …, n are the time indices of the individual data points. This is converted to a series

$X^{(1)} = (X^{(1)}(1), X^{(1)}(2), X^{(1)}(3),\ldots\ldots X^{(1)}(n))$

Where the superscript (1) indicates that the data have been converted by an ‘Accumulation Generating Operation (AGO)

$X^{(1)}(i) = \sum^{i(t=1)} X^{(0)}(t)$

Each element “i” of the series is formed by summing the element 1 through i of the original data. It can be shown that this function is equivalent to integrating the underlying process that produced the data. Whereas the accumulated generation operation (AGO) can be applied more than once or more if required and once the forecast is obtained we need to reverse the AGO applied in order to get original time series.

For improved grey forecasting model:

The research Deng also developed the residual modification to the present method, GM (1,1) model. The difference between the real value and the model predicted value i.e., $x^{(0)}(k)$ and $x'^{(0)}(k)$. are defined as the residual series and it is denoted by $q^{(0)}$:

$q^{(0)} = (q^{(0)}(2), q^{(0)}(3), q^{(0)}(4), \ldots\ldots q^{(0)}(n))$,

where

$q^{(0)}(k) = x^{(0)}(k) - x'^{(0)}(k)$

the residual GM(1,1) model helps in improving the predictive accuracy of the previous GM(1,1) model. The prediction value can be fetched from adding $x'^{(0)}(k)$ to the GM(1,1) model however the effectiveness value of the residual depend upon number of data points with the same sign. In this case the effectiveness with the same sign may not be more than four and a residual GM(1,1) model cannot be proven.

It is the modification of the sub-model that is the combination of residual GM(1,1) foresight which uses the absolute value with residual sign with an Artificial Neural Network (ANN) for residual sign estimation. The proper structure is showed in the below figure 20 and it is the detailed formulate of the improved foresight model(Li, Chen, & Kou, 2017)(Hsu & Chen, 2003).

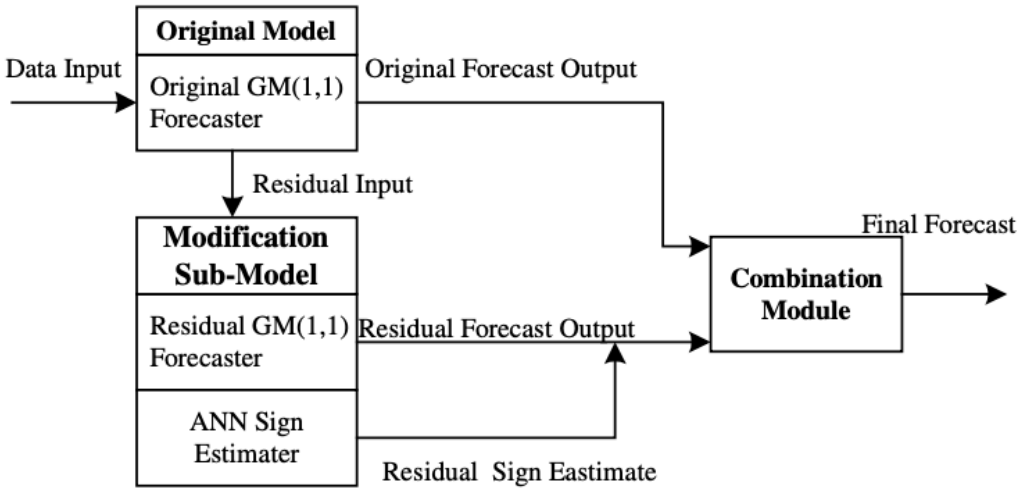

Figure 20: Foresight system flow

4.1.9 Multiple Correspondence Analysis (MCA) model:

Multiple Correspondence Analysis (MCA) is defined as to explore and envision the patters and relationship among the technology foresight methods and assessment measures. In quantitative phase MCA model combine the doubling data technique in order to reduce the diversification of dimension and perform the meaningful graphical representation of the technology foresight method(Esmaelian, Tavana, Di Caprio, & Ansari, 2017). However, on other side MCA used in quantitative method depends only on marginally on the characteristics of the organization. In fact, MCA helps in decreasing the subjectivity phase of the evaluation process. It has applied and can be used in various field like HR Management, Supplier selection and to check the complexity of the project.

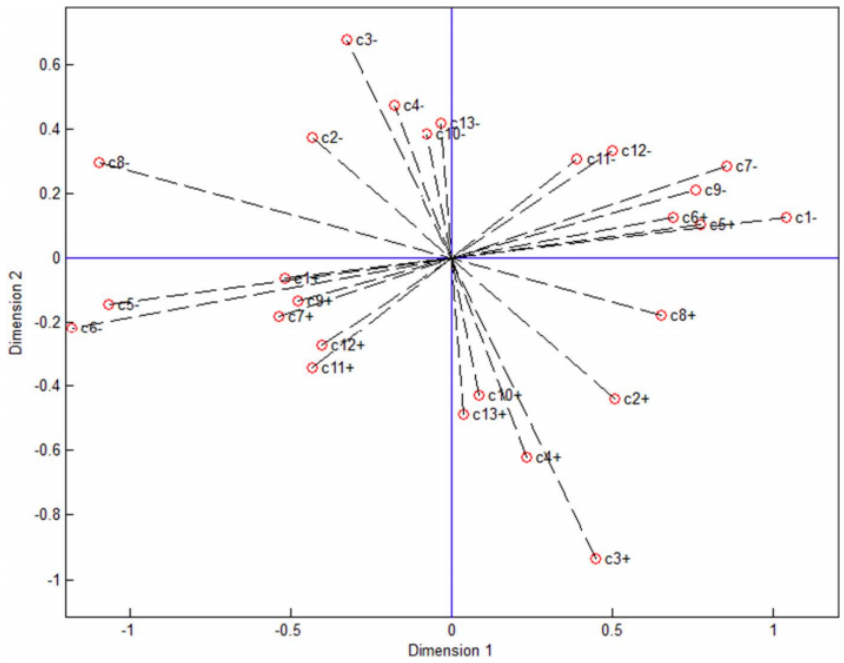

Figure 21: Example of MCA used in analysis

The above figure 21 shows the graphical illustration of MCA, MCA was a statically based visualization that allowed user to transform into a graphical representation among different dimension or variables. From the data we can build the cross-classification table contacting the different variables, through which MCA shoes the similarities and dissimilarities by placing on the different axis of table. MCA has a wide variety of application such as archeology,

psychology, sociology. Moreover, the MCA can be used for both quantitative and qualitative data input.

This method is either hard or soft, hard in terms of quantitative data consist of empirical and numerical and coming to soft it is qualitative data which evolves the judgmental data, expert knowledge. However as explained in most of the case both qualitative and quantitative data is being used to get a required outcome. The basic definition of quantitative and qualitative data can be said as Qualitative method is the preliminary part to understand the underlying motivations, belief and incentive. It provides the spur for the problem and helps in developing ideas to solve the problem. Qualitative research helps in exposure of the particular topic trend, thoughts and examine. Qualitative data may be structured or unstructured based on the topic, some of the common method used expert opinion, research paper, interview. Quantitative method main aim is to quantify the problem and research by collecting the data, stats and figures related to the topic of research. Quantitative research uses the measurable data to collect facts and uncover the pattern for the research work, the data collection methods include various form of survey like online survey, interview, paper survey, telephonic interview and online polls. However, the complete explanations of collecting data is explained in further part of the tool's methodology.

As it is defined that MCDM are good method to solve the complex problem, it implies a modeling activity which clarifies many qualities. Moreover, the research Salo et al. says that MCDM tool offer potential "in terms of lending accuracy and transparency to the foresight process".

Design propositions: towards an integrated multi-perspective approach helps us in understanding the nine-implementable design analysis in order to enhance the foresight activities. The main objective behind=d this process is to fill the gap between the multi stage, multi actor, and multi criteria, we can structure the proposition with the traditional input output relationship as shown in below table 12, main design proposition is to align design to this process and helps in enabling the computer support for each individual stage.

	INPUT	TOOL	OUTPUT
Multi-criteria	Collect data	Compute data	Visualize results
Multi-actor	Support scalability	Aggregate data	Compare results
Multi-stage	Allow flexibility	Analyze robustness	Store scenarios

Table 12: Prerequisite of an integrated multi-perspective approach.

The **input** comprises of main three important aspects the alternatives, the criteria and the decision maker preference (i.e., the evaluation and weights).

- The alternative is possible outcome or an action towards some particular problem in the process.
- The criteria are the different aspects under which the alternatives can be evaluated.
- The decision makers preferences are the one which are significant and more importance for the decision making. The weight is relative importance for decision making.

The **tool** (computation) is the compressed with the collection of methodology that need to analyst in order to use the MCDM methods. This methodology can be very experiential and dignified depending on the type of the problem.

The **output** is the outcome of obtained from the MCDM methods, this result can be expressed in various type such as, ranking, zero and one matric and graphs.

4.1.10 Internet of things (IoT) and data analysis:

The internet of things is architype where every day object is interconnected which identify, sense with the help of network and able to process by connecting with various devices. However, some call it as the next generation tool as it will enable ambient intelligence(Yuan B.J.C., Kang T.H., Chang C.-C., Liu C.-Y., 2010). Over last couple of decades there is constant evolution the field of internet which leads to further investigation of the IoT till now there is no universal definition for internet of things but basically it defined as “interconnection of different computing devices

through internet which helps in enabling in sending and receiving the data." These devices include computer, servers, desktop, mobile, tablets and various smart devices. From the below figure 22 shows in graph we can see that number of internet users increasing rapidly. Through which the huge amount of the data can be collected and engaged for building the fingerprint of the user.

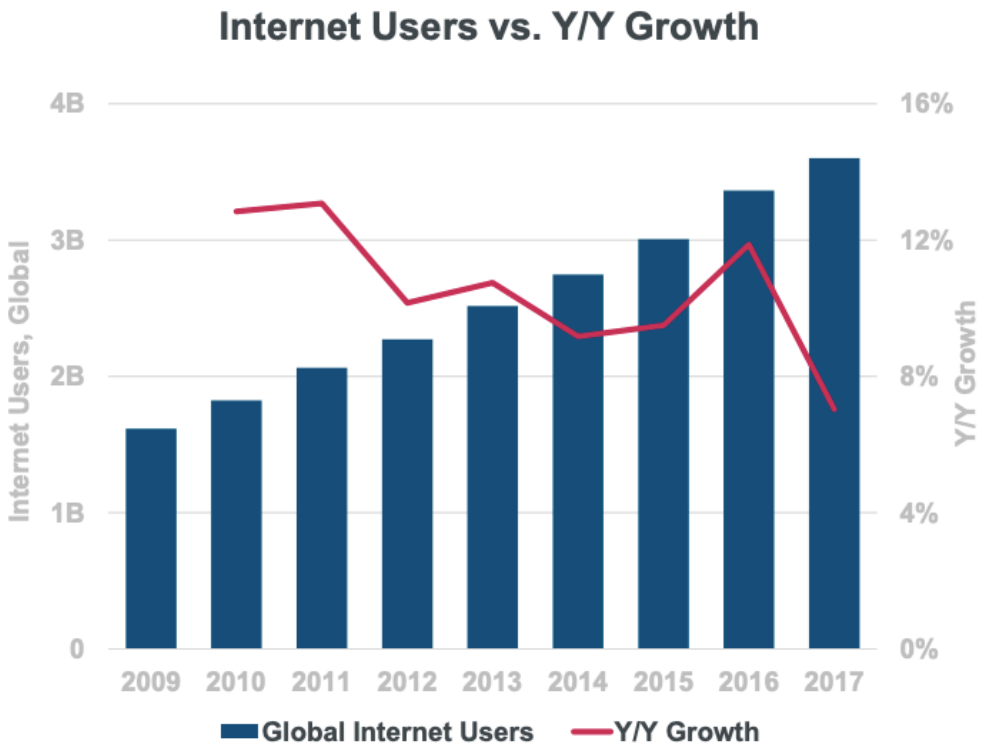

Figure 22: Explains about Global Internet Users = Slowing Growth @ +7% vs. +12% Y/Y

Source: United Nations / International Telecommunications Union, USA Census Bureau. Internet user data is as of mid-year. Internet user data: Pew Research (USA), China Internet Network Information Center (China), Islamic Republic News Agency / InternetWorldStats / KP estimates (Iran), KP estimates based on IAMAI data (India), & APJII (Indonesia). Note: Historical data (particularly in Sub-Saharan Africa) revised by ITU in 2017 to better account for dual-SIM subscriptions (i.e. two Internet subscriptions per single smartphone user)

IoT is also known as sixth generation of technology foresight, here in IoT the data and trends are being collected with the help of artificial intelligence AI and the next technology foresight is determined, it is very new, complex and very efficient for current scenario. IoT can be explained based on finding/ searching the key words and trend on internet regarding particular technology, where people are consciously or subconsciously liking it. Based the trend company will be heading and investing in that direction.

Figure 23: Internet of Things

Digitization has played a vital role in 21th century and it had also started for next social revolution and constantly technology is improving, and innovation will transform and bring them to new level and to make optimal business decisions, it is very critical for leaders to understand the trend and future needs based on the data analysis can open new doors for business and innovators.

4.1.11 Step-wise Weight Assessment Ratio Analysis (SWARA):

SWARA method is the evolved from MADM method (Multiple attribute decision making), and SWARA was introduced by Kersuliene in year 2010 and furthermore it got more improvement in recent year.

SWARA can be described as expert oriented method with an expert opinion is weighed more in evaluation and calculating the process. Expert determine the value of each criterion and rank in order which is in ascending to descending order based on experience, knowledge and information available to the expert(Hashemkhani Zolfani, Salimi, Maknoon, & Simona, 2015).

Figure 24 of SWARA model explains the process of determine the TF, the process starts from drawing a setting of criteria and rule set for finding the technology foresight based on it the survey is done and through which the listing of different criteria's are determined from which general list of criteria is being segmented for the further process and similar results are deleted and unrelated results are made in different criteria list based on the survey results the determination of rating and ranking is given and criteria is weighed based on importance of it.

The below figure explains the process of the SWARA methodology(Keršuliene & Turskis, 2011), it is applied to evaluate the searched criteria for the reason of prioritization, however the result can be very useful for the future technology foresight decision and relevant technology foresight investment.

The procedure for determining the relative weights of the criteria by applying the SWARA method based on Kersuliene et al. (2010) and Stanujkic et al. (2015) is shown by using the following steps:

Step 1. The criteria are sorted in a descending order, based on their expected significances.

Step 2. Preliminary from the second criterion, the respondent expresses the relative significance of the criterion j in relation to the previous (j-1) criterion and does so for each particular criterion. According to Kersulieneet al. (2010), this ratio is called the Comparative Importance of the Average Value, sj

Step 3. Determine the coefficient kj as follows:

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases}. \quad (1)$$

Step 4. Determine the recalculated weight qj as follows:

$$q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{cases}.$$

. (2)

Step 5. The relative weights of the assessment criteria are determined as follows:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k},$$

, (3)

Where wj, indicates the relative weight of the j-th criterion and n denotes the number of the criteria.

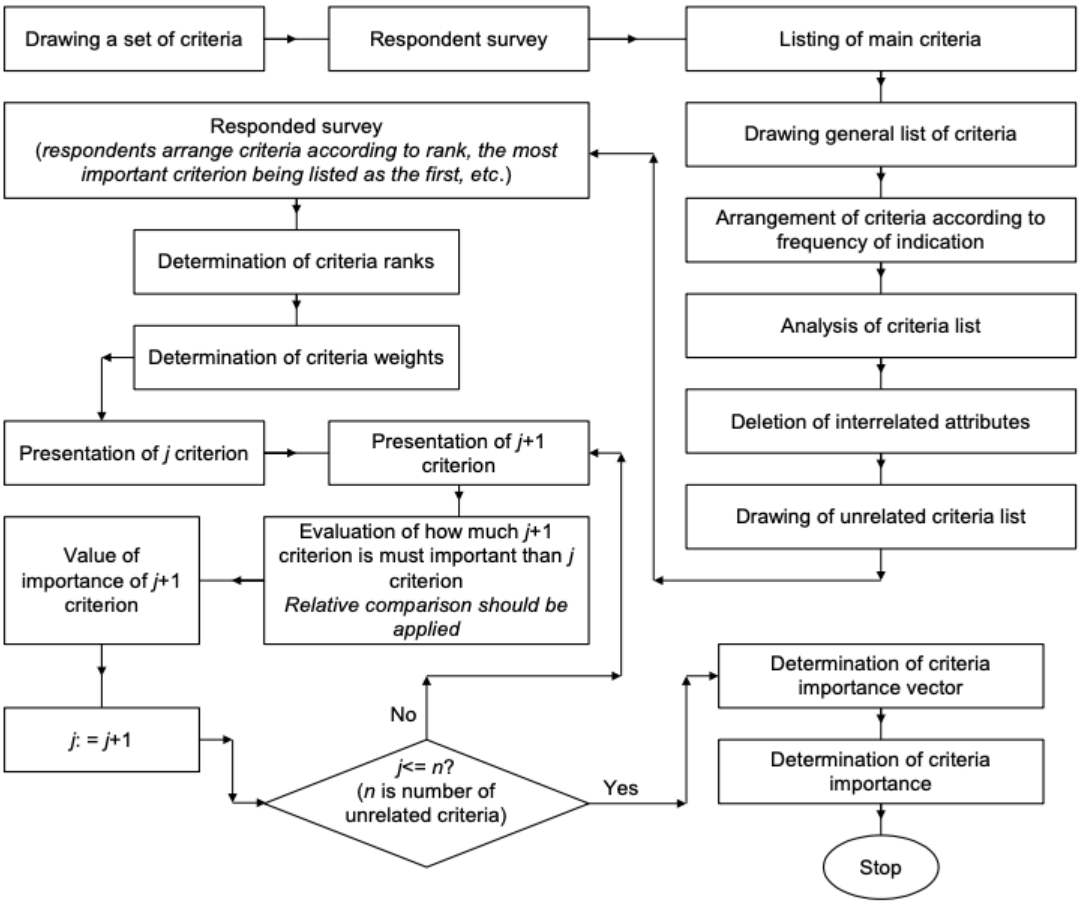

Figure 24: Determining of the criteria weights based on SWARA (Kersuliene & Turskis, 2011) flow chart.

4.1.12 Qualitative and Quantitative analysis:

Qualitative method is the preliminary part to understand the underlying motivations, belief and incentive(Zimmer, 2006). It provides the spur for the problem and helps in developing ideas to solve the problem. Qualitative research helps in exposure of the particular topic trend, thoughts and examine. Qualitative data may be structured or unstructured based on the topic, some of the common method used expert opinion, research paper, interview(Hassanzadeh, Namdarian, Majidpour, & Elahi, 2015).

Quantitative method main aim is to quantify the problem and research by collecting the data, stats and figures related to the topic of research. Quantitative research uses the measurable data to collect facts and uncover the pattern for the research work, the data collection methods include various form of survey like online survey, interview, paper survey, telephonic interview and online polls(Kaivo-oja, 2017).

However, the qualitative and quantitative analysis doesn't make black and white reality Actually there are many similarities between quantitative and qualitative research: (1) Data collection, (2) setting research questions, (3) the need to collect data in relation to the research literature, (4) concerns with difference, (5) foundation for analysis, (6) seeking to ensure that deliberate distortion does not occur, (7) importance of transparency, (8) the critical question of error, and (9) the claim that research methods should be appropriate to the research questions.(by Jari Kaivo-oja)

The below table 13 explains the prime difference between the qualitative and quantitative analysis, we can observe that qualitative on keywords, looks a point of view according to context as it goes very deep data mining. Whereas we can observe in quantitative analysis it's about numbers, theory testing, its more about generalization of data.

Qualitative	Quantitative
Words	Numbers
Point of views of participants	Point of view of researcher
Researcher close	Researcher distant
Theory emergent	Theory testing
Unstructured	Structured
Contextual understanding	Generalization
Rich, deep data	Hard, reliable data
Meaning	Behaviour
Tends to follow an inductive approach	Tends to follow a deductive approach

Source: Adapted from Hammersley (15), Bryman (16) and Halfpenny (17).

Table 13: Difference between qualitative and quantitative analysis.

However, for the Technology Foresight is done with help of both qualitative and quantitative analysis. The process as shown in figure 25 below: -

1. General research questions of foresight study: forming the question for survey and questionnaires.
2. Selecting relevant sites and subjects of the foresight study: searching the relevant websites for particular data gathering.
3. Collecting of relevant data: storing the data from the different website and journals for further process.
4. Interpretation of data: understanding the researched data and analyzing it.
5. Conceptual and theoretical work: based on the data gather making a proper abstract and applying different tools.
6. Final foresight research report: gathered data is collected and sorted and final report is developed.

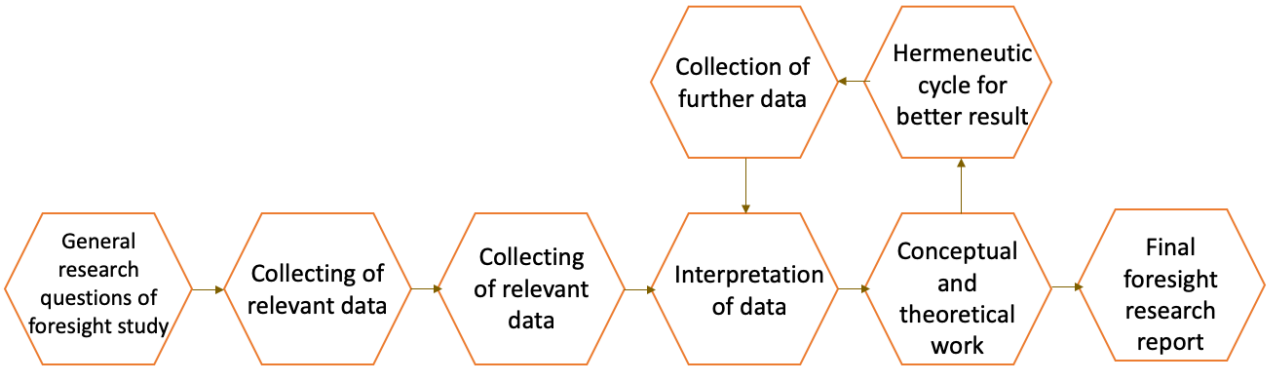

Figure 25: TF from the qualitative and quantitative analysis.

4.1.13 Linking:

Linking is all about connecting the edges between various clusters of techniques and path based on relevant research and paper published and from which network is being developed(Girvan, M., Newman, 2002). There are three stage of development of linkage as follows:

1. citation network is built in order to determine the major research groups and the citation is being linked.
2. key route is being applied to analyze the overall knowledge diffusion on the particular technology foresight and the exabit relationship is determined among various research group.
3. furthermore, using of global main path on the three-medium sized segment to determine their development trajectory.

As we described a brief idea of edge between clustering and main path analysis. the first main path analysis was introduced by Hummon and Doreian in the year 1989. he also explained the procedure of main path analysis as follows(Hummon & Dereian, 1989):

1. construct network using the citation by using relevant papers with related technology foresight.
2. “Transversal count” for each link of citation network is counted.
3. from above steps it searches the main path based on the traversal count.

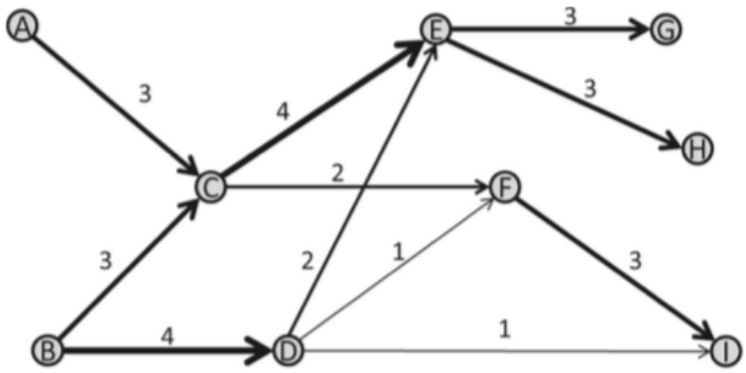

Figure 26a: Illustrate the example of citation network to describe the idea of main path analysis.

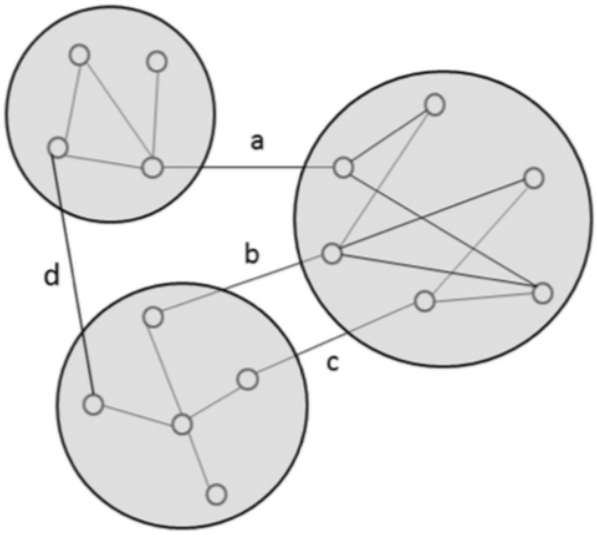

Figure 27b: Clustering of similar nodes

Each node is represented as a paper and link between two nodes signals the relationship with citation. Whereas the sink node are one which are not citied(Hsu & Chen, 2003)(Newman, 2004). As it can be seen in figure a. based on connecting nodes the clustering is done as shown in figure 27 b. Conclusively, select the optimal network division with the largest modularity for better outcome. Foresight has a various meaning moreover, many papers concurrently discuss about all three topics of foresight, forecasting, and futures studies simultaneously. Furthermore, a word method may belong to more than one topic for instance where method can be used for both foresight and forecasting. Therefore, it is problematic to cluster papers according to keywords. The

edge-betweenness clustering is a citation-based approach in order to divide groups based on the citation network within which the network links are dense but between which the network connections are thin. A citation-based on the clustering is extra appropriate for grouping the extensive foresight information than a keyword based one.

4.1.14 Construction of Map by co-nomination:

It is a survey based technique, which is also known as co-nomination the technique used here to make mapping pattern with the help of experts where the respondent were asked to identify fitting participate and at the same time they are asked to outline their own expertise.(Nedeva, Georghiou, Loveridge, & Cameron, 1996) the process have four main activities are included in the concept were:

- around the world the consultative seminars were held with respective topic of foresight, where they express the view regarding the topic and how should be implemented.
- Development of different technique which includes the prioritization of different ideas and recommending it.
- Identification of the membership of the panels.
- Briefing and training the panelist.

The procedure of main forecasting phase by considering all the panel's recommendation and giving them a generic priorities and recommendation (Ost, 1995).

- The *context* was to study about the research before reaching the members where they use the Delphi method for initial stage of development the main objective is to use the co-nomination in the technology foresight program: to build the database of experts who could be consulted to the panels and to identify key figures who could serve the panelist in the particular area of foresight.
- *Design of the survey form* it is designed on two factors, one on the name, contact details of the potential panelist and pool member and second is based on the respondent area of expertise.
- *Implementation of the study* it's an important part of the process. Names of the

participant came from three main source which are:

1. Active search is taken by the team of experts to compile the list of names against the expected responsibility of that area.
2. Interest and involvement are selected.
3. Nomination received from the organization position to identify the key individual in particular field.

- *Conduct of the survey* based on the foresight program where the participating is asked to respond, and the deadline will be set, and correction of database are done.
- Further, *response rates* are being collected within the date of deadline however the rate figures provided which doesn't include the duplicated forms filled by the respondent who were not are not added to database to prevent the biasing of the response.

  This is the small procedure to conduct and create the mapping from the group of experts by co-nomination.

4.1.15 Third generation technology foresight:

In the third generation tool of technology foresight is integration of strategic management, process oriented, need & value driven and network dominated is done.(Reger, 2001) Much of the ground-breaking effort in technology foresight at international level and at national level was done in the USA (especially in the defense sector) in the 1950s and 1960s. Large think tanks, such as Rand and Hudson, made many technological forecasts.(Van Den Ende, Mulder, Knot, Moors, & Vergragt, 1998) previously the study was only intended to only government policy purposes slowly western Europe and other developing countries followed it in investing the technology foresight program.(K. Blind, Cuhls, & Grupp, 1999), it is a conceptual model of the technology foresight for various multi-national companies and also reflects the evolution of the technology foresight, it was developed with help of 26 multinational company (MNC) and also with the help of scientific literature. The below fig (Reger, 2001) explain about the third-generation tool for Foresighting

Model for the technology foresight:

- Describing technology foresight: here the broad explanation about the technology monitoring, technology watch, technology forecasting and technology scouting is being discussed it is being evaluated which tool will be suitable for the further process, after selecting the technology foresight the phases of technology analysis is done in which analyzation of particulate technology is done with respective to the other industry in that area and then there is the process of technology monitoring in which observation of technology done by searching and finding from research papers which are already existing then the technology prognosis is done to develop the statement on the future value and trend in field of science and technology. Then the final process of technology scanning will be done to identify, observe and analysis of new technology outside the existing company.
- Main results of the interviews: strengths and weakness: the strengths and weakness of the particular technology is being evaluated with the help of the experts and researchers and the rating is done.
- Phases and the players of the technology foresight: here the process of the phase is designed which starts from the determining the information needed to be selecting the required information then to collecting the relevant data and then to filtering, analyzing and interpreting the gathered data and moving to preparing decisions to evaluating an decision making and then to final phase of implementing and carrying out.

The third generation is based on the integration of indicators based concept into the strategic firm(Krystek & Müller-Stewens, 2006) whereas the TF is integrated part of decision making at the managerial level and also regarded as the core strategy formulation. In order to improve technology foresight, the company had to establish systematic organizational process with in the company.
Foresight is no longer a technology driven but includes the vital information about the user and environment. Therefore, technology foresight in more need and also value drive. for third generation TF the internal and external network as well as the informal and inform network is taken into consideration. Furthermore, the third-generation tool includes the social, economic, environmental and legal trends of technology foresight as the obligatory framework in foresight exercise and also the information and communication technology I/C, which includes database, internet, software. As shown in below figure 28.

Figure 28: Three generation of technology foresight

4.1.16 MENTALMODEL (experience, training, conditioning and education):

This tool was created by organization which are Management of Accelerated Technology and Innovation project (MATI), through its relationship with the Center for Technology and Innovation Management (CTIM) at Northwestern University, is currently establishment assessment of how to create information dominance. This tool is very much focused towards the information technology (IT), the tools helps in executing the team effectively and manage the technology concentrated business within the framework of multiple new and different “event horizon”. Every follow-on

model is unique and company specific, built and evolved upon the interactions of the separate concept of technology and business value network, whereas the skill can be nourished, acquire and arranged. This is how it can improve the capitalization of particular firm. (J. W. Peterson, 2002). This tool focusses on the experience, training, conditioning and education.

This tool created to get solution regarding the cultural acceptance for the nonlinear thinking and nontraditional approaches to solve the complex problem before they befall. The positive culture is developed over a period of time by engaging the health decision for the future process. This tool helps is familiarize the individual exclusive. It helps in enabling the risk taking under pressure at obvious signals of pending disruption.

The futures and foresight activities are those which will create the multiple new event of horizon that force into John Boyd's "OODA" loops, they must engage in observe(O), orient(O), Decide(D) and act(A), (C.W. Richards, 1998). He gives the example of the piolet where he needs to observe(O), orient(O), Decide(D) and act(A) during his combat mode, the successful pilot not only outlasts, but also mentally creates the conditions that allow faster responses and future survival in the next series of next engagements. the organization also creates virtual spaces that can generates both threats and opportunities in unacquainted context.

MATI dubbed the concept of Horizon Mission Methodology (HMM) which was first developed by NASA by the late John Anderson. The process consists of five steps for creating and thinking within entire new frame of reference based on a postulated but achievable future. So, this concept was used for the business purpose. New Event Horizon starting point, 10–50 years into the future, pre-empts linear, extrapolative thinking and forces nonlinear intuitive thinking well beyond the bounds of current plans and expectations.(J. Peterson, 2001) the five steps of new event horizon activities are:

Step 1: *make an intuitive leap* are creating and thinking beyond the extraordinary, mind-blowing and impossible for the alternative future. Each new event horizon should be strategically relevant and conceivable, but it should be overtaken estimable solution.

Step 2: *construct a new frame work of reference* by defining the new horizon in terms of unique, innovative which should be driving force. Which it should include the things like STEEP (social, technological, environmental, economic and political aspects), assumption, drives and attributes.

Step 3: think within this new frame of reference to identify the disruptive innovation in both activities and the technologies that can be achieved in coming future, it requires the proper

discipline to stay on the track to think at first in higher level than simply driving to right technology answer.

Step 4: *begin the return back from future to present*. The higher-level functions can then be clustered into vision-inspiring categories. In this effort, evocative metaphors are extremely fruitful and integrative at this stage of the process. High leverage categories such as solely new capabilities, new common technologies, infrastructure changes, new uses, applications, and dramatic potential payoffs can then be acknowledged and investigated.

Step 5: *Transform the high leverage concepts back into the present* by identifying and working through the business and technology value chains and relating selected technologies to functional and virtual functional activities. Issues such as new products, new markets, new capabilities, investment and required technological breakthroughs, are then explored. Strategic activities in these areas can then be identified, time phased, and integrated into the innovation portfolio.

Following the above five step procedure the tool was developed which is more inclined towards the mystical relationship between the technology ecology, human nature, decision cycles, information technologies, and the speed and veracity of their interactions.

4.1.17 Radical technology foresight:

It was first experimental case which discussed about the technology foresight of 100 emerging technological solution and it was realized back in 2013(Linturi R, Kuusi O, and Ahlqvist, 2014)(Linturi, R., Kuusi, O. and Ahlqvist, 2013). The study focused on radical technologies that would impact and necessity in the present society. The study of radical technology foresight was based on the visionary assessment procedure grasped through multi criteria tool (Kaivo-oja & Roth, 2014). "There were 48 experts in the panel, who commented the findings on the Facebook. Most panelists made several comments on the preliminary ideas drafted by the writers. The results were also crowd-sourced more openly in different Interne- based fora. This process resulted in over 200 hundred comments ad insights" (Linturi et al. 2013, Linturi et al. 2014). The resulted into list of more than hundred technological solution that were to evaluate through multi-criteria tool created in the process. The data collected from assed based on most ubiquitous and wide range impacts to the society, the list was as follows:

- Big data and open data

- Freely organizing the distance work
- Instrument of enhanced reality
- Gamification of cooperation and society
- Quantum processors
- Autonomous car
- Biosensors and chip
- 3d printing of physical object

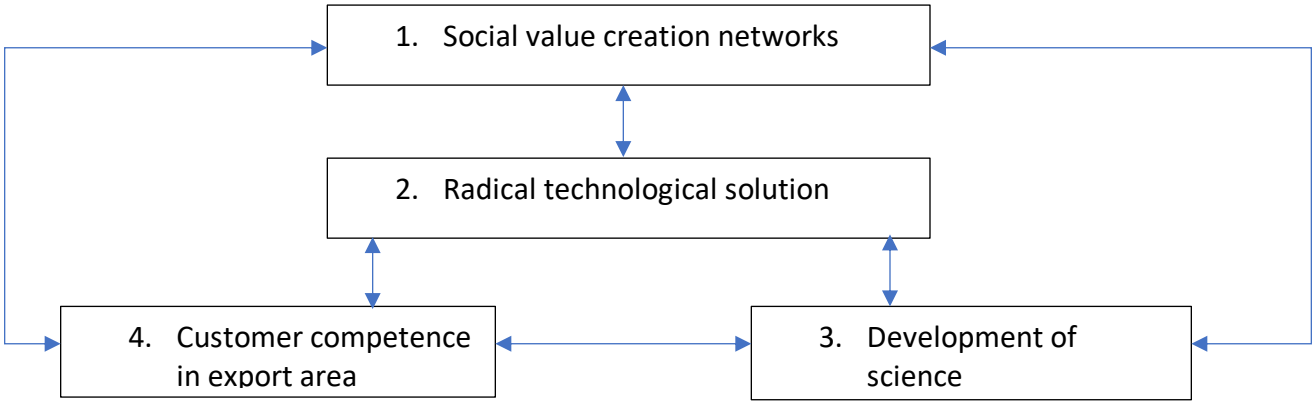

Figure 29: Four level model for radical technology foresight (Linturi, R., Kuusi, O. and Ahlqvist, 2013)

The above figure 29 explains the different level model for technology foresight:

At the level one: social value creation networks- it is defined as configuration that covers the most important transformation dynamic in the present structure of society. The survey defines the social value creation as follows: they are sorts of bundles of communal needs that can be integrated in several fields of private and collective, public and market angled action that can increase or decrease the comfort of the citizen.

At the level two: Radical technological solution- the radical idea of technology foresight is being ranked from high to low which might be least important or crucial technological solution in the

future. This is why continuous updating of the formed list is very important part of the process. The experts use the multi-criteria decision-making framework where the decision is made based on the priorities.

At the level three: customer competence in export area- every technology discovery could be important to everyone or small niches, but these respective segments could have its own importance from the export perspective.

At the level four: development of science- this section of level discusses regarding the unraveled possibilities by scientific development.

However, all the level is interlinked and interconnected to for continuous correction and multiple criteria and multiple decision can be taken place in effective and efficient way.

4.1.18 strategic technology foresight with cognitive mapping:

In this tool the with the help of cognitive mapping, technology foresight is being done, here the cognitive can be defined as based on the reasoning of particular technology foresight obtained from interviews, survey or from any database and linking them to create a valuable map based of different variables.(Franceschini, Borup, & Rosales-Carreón, 2018) building on the tradition of foresight and scenario methods (Amer, Daim, & Jetter, 2013; Biloslavo & Dolinšek, 2010) this study suggest a future-oriented approach for analyzing different technology foresight and rebound dynamics. The approach is centered on the cognitive mapping. (Downs and Stea, 1973) that describes the element between element of practice and network prospective. When the foresight is being interviewed with professional experts and producers' individual cognitive maps represents the future vision of particular technology. Here tool also include the rebound effects which are very fruitful which helps in creating the systematic perspective on innovation and technology.

The main aim of this technology foresight is not to determine the future but to make very systematic and qualified analysis of that going to happen in future by interconnection, development and with assessment of present availability of opportunities (Piirainen and Gonzalez, 2015). In this

connective mapping technique (Tolman, 1948) is used to determine the proper investigation and expectation and view of that technology by different experts and to illuminate the relations between the element in future terms. Previous this connncetion has applied by (Amer et al., 2016; Biloslavo and Dolinšek, 2010; Boe-Lillegraven and Monterde, 2014; Bootz, 2010; Kaplan and Tripsas, 2008; Swan, 1997). Kaplan and Tripsas (2008) they argued who cognitive approach is important to understand the dynamics of technology modification and that models of technology progress. E.g. economic, organization and behavioral models that don't include the cognitive factors which may result in unauthentic conclusion.

The initial stage the interview with the experts and researcher take place which would last approximately around 1hour to 2hour, where the audio is recorded for future reference and further analysis. Then directive proposed by Wolcott (1990) is followed to guarantee the validity of the answer by following the different process: i) elaborate an interview guide, ii) pre-test the interview guide, iii) avoid the modification of the interview guide structure during the interviews, iv) listen carefully, v) produce annotations that are as precise as possible, vi) write early, vii) employ a unique format to transcript the interview, and viii) corroborate the information with the interviewee. Each interview included four phases.

- First phase: the interview is started with brain storming session where the experts are asked to write the sticky notes and focus to the answers regarding the mentioned question.

- Second phase: the interviews is given the A2 sheet and asked them to stick the notes and draw the arrows representing relationship between them. Where the direction indicates the relation between to sticky notes.

- Third phase: the interviewees assessed based on two dimensions of an element, which are 1) potential: is to determine usefulness in the future and 2) feasibility: is to possibility to attain that particular technology foresight and cost factors also comes in picture.

- Fourth phase: the interview reported the sticky notes on a cartesian coordinate system in which two-dimensional were represented in scale of low, medium, high, and also asked to give a general explanation about the overall map.

All phases are kept separated and also any material used in previous phase is not showed during any phase, it is done in order to avoid the contamination between the interviewer and interviewees. That the reason the cognitive map is showed in the fourth phase of the process(Franceschini et al., 2018).

After the evaluation of the different phases the report is generated and with cognitive map by the interviewer. Interviewees are asked to evaluate the agreements and disagreements using the 4-point Likert scale: 1. Total disagreement; 2. Disagreement superior than agreement; 3. Agreement superior than disagreement; 4. Total agreement. Where the frank answer was collected, and honest responses are collected. Later the whole process is evaluated.

4.1.19 Technology foresight with future oriented technology analysis (FTA):

In this type of technology foresight tool, the future oriented technology analysis is done, FTA has its own potential to analyze the complex innovation journey of science-based technologies as they follow the rule of developed, diffused and deployed in evolving market and industries. FTA main focus on the innovation system policy making and the development of national strategies for key emerging technologies (Featherston & O'Sullivan, 2017). However the FTA has been proven it's a valuable tool in science, technology, and innovation(STI) field can important for government technology strategy, policy and program development(Keenan, Barré, & Cagnin, 2008). They can key in order to explore impediment places and also this insight can be significant value in defining program objectives and prioritizing the future opportunities and challenges. By using the FTA we can draw a concept of technology operations management are related to more carefully characterize: (1) 'technical infrastructure' which may be required to construct the emergent technologies; (2) key phases of emergence lifecycles, as technologies diffuse into new application areas and ever larger, more mature markets; and (3) key stages of industrial value chains into which the technologies may get deployed (Featherston & O'Sullivan, 2017).

This section helps us in understanding the recent evolution and helps in motivating to deeper in the research and we also drew different categories, dimensions and structure provide by different authors, Innovation system foresight has contributed as the next generation of technology foresight (Andersen and Andersen, 2014). The FTA draws number of useful and important concept from innovation system literature to understand the nature of the technology and technological innovation. such as the classification construction into actors, linkages, and institutions (see Edquist, 2005) and concepts that help define how innovation systems function (see Bergek et al., 2010; Hekkert et al., 2007; Johnson, 2001). These insights have been applied to technology foresight and innovation policy (e.g., Alkemade et al., 2007; Bergek et al., 2008).

This section helps us to understand about exploration of potential to more methodical structure of FTA exercise for key emerging technologies.

Model 1: The below figure 30 explains about characterization of the classifications of technological knowledge and varying public (dark shading) and private(white) good content (source: Tassey, 2007,p.115, 2005,p.92)

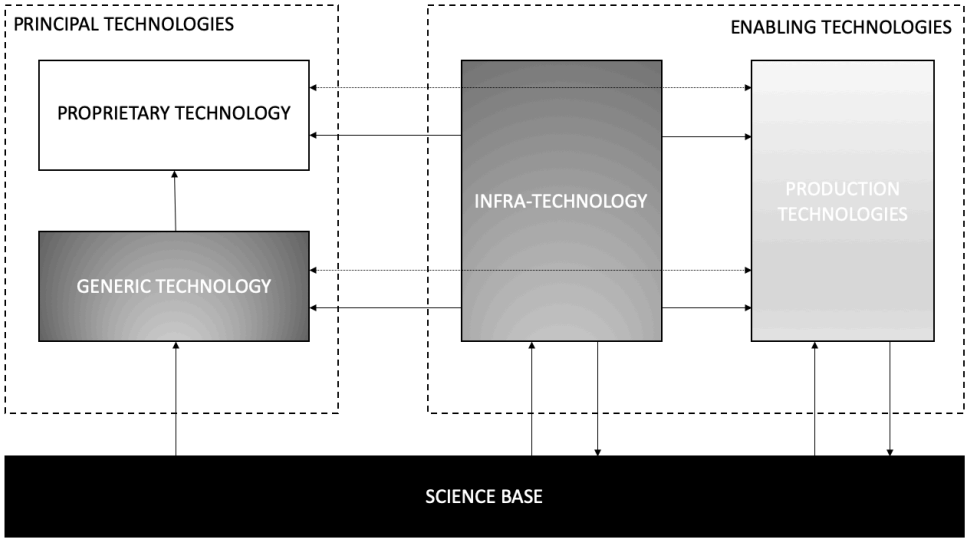

Figure 30: Characterization of the classifications of technological knowledge and varying public (dark shading) and private(white) good content (source: Tassey, 2007,p.115, 2005,p.92)

The figure explains how the theoretical construction and useful categories can be integrated to create a shape for the FTA and considering building the technologies innovation and infrastructure of technologies.

- The science base signifies to scientific phenomena which are discovered and explored in technology possibilities which are convinced. Where the research is based on science, life-sciences, engineering, physics, chemistry and mathematics and so on.
- Generic technology is one which are become a platform which other technologies can be built on that platform and can be configured.
- Proprietary technology is the technology which are under the surveillance of institution or any organization with help of technical or design patents or rights, basically anything which are recognized, registered or acquired.

Whereas the generic technologies and proprietary technologies comes under the umbrella of "principal technologies", that can be combined to create commercial technology and later can be deployed to market. However, the pathway between for progression is supported by enabling technologies infra-technologies and production technologies.

- Infra-technology is used to support the development of principal technology and production technology, these includes testing, modelling, simulation tool and technique and infra-technologies is important because they enable and accelerate the development, commercialization of product and manufacturing.
- Production technologies are the tool related to support the fabrication of an innovative technology. The factors like cost, yield and price-performance comes into picture. production technologies a complex mix of public, quasi-public, and private good physiognomies and warranting investigation as a separate category of enabling technology.

Model 2: Technology lifecycle emergence phases and transitions (accelerating innovation) with the help of STAM framework which explains about emerging phase, transitions phases, demonstrators and trajectories to new markets(Phaal, O'Sullivan, Routley, Ford, & Probert, 2011)

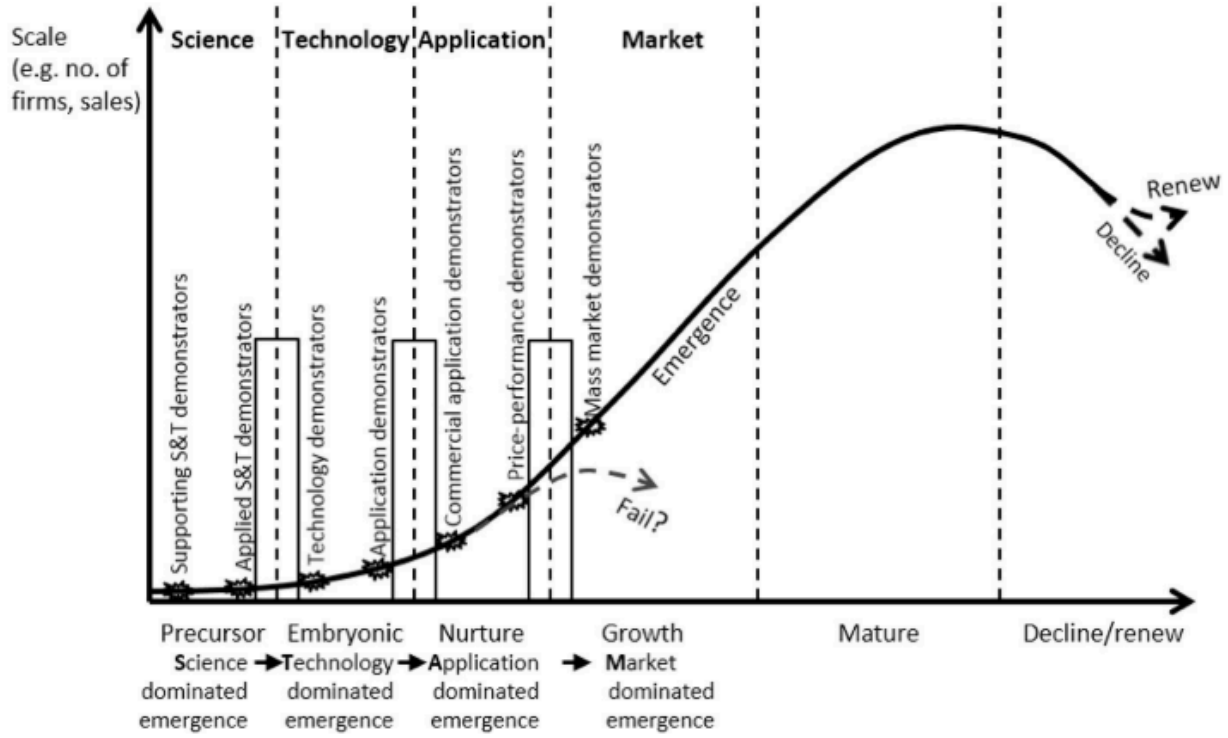

Figure 31: STAM framework which explains about emerging phase, transitions phases, demonstrators and trajectories to new markets(Phaal et al., 2011)

The science-technology-application-market (STAM) is the framework divides the industrial life cycle into four distinct factors like science, technology, application and market as illustrated inn above figure 31 and the STAM model could be boost in exploration in the key transition of technology development for FTA. The above figure explain the lifecycle chart which is carried out with time and growth on axis's, it also describes at what phase what emergency can be used for example at the beginning the *supporting* and applied science and *technology demonstration* is required to show the foundation from moving to the further phase of *developing stage* of technology and then to *nourishing stage* with help of commercial help and pricing factors comes in consideration and finally *entering to the market*.

Model 3: Industrial system structure elements:

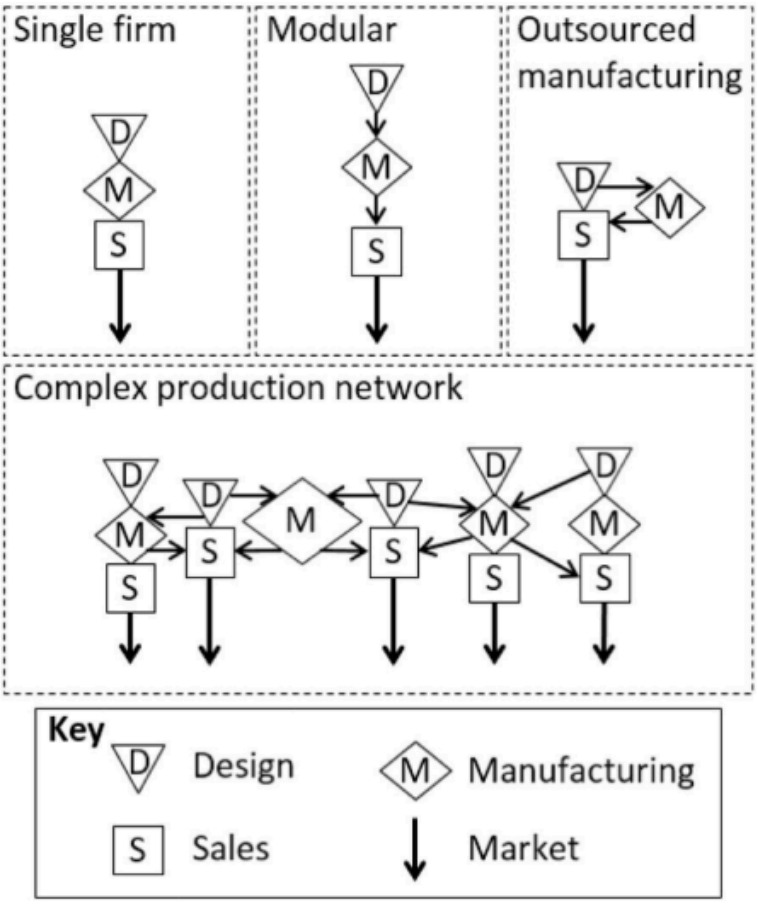

Figure 32: Industrial system structure elements(Sturgeon, 2002)

This document was added to different example of model for FTA method because it focuses on the different categories of industrial activities and the main mechanism for worth capturing, knowledge about of market.

- Design: the influence on the new material on the design of new product and process and development of that product.
- Manufacturing: it is about the production of devices, components or material to make a final product.
- Sales: activities required to trade the product which are being manufactured to the market, it might be focused on particular segment or particular customer.
- Market: it deals with how to penetrate the product to the market, forecasting the market opportunity and to creating the market for that particular product.

In doing this, we draw on concepts from technology and maneuvers management and related literatures to more wisely differentiate the: (1) 'technical infrastructure' required to develop emerging technologies; (2) key technology transitions involved in diffusion; and (3) complex industrial value networks into which they may eventually get deployed.

4.1.20 Scenario Based Assessment Model (SBAM)

This tool (Banuls & Salmeron, 2007) is constructed based on the experts judgement for judgements for :

(1) assessment of the future impact of a technology portfolio

(2) support for shaping technological policies by means of its determination and assessment.

SBAM approach is associated to the other technology assessment which aims to assess the technology portfolio as a whole. The SBAM is combination of different tools such as multicriteria and scenario methods. Specifically, it's a mixture of Delphi Method, Analytic Hierarchy Process, and Cross-Impact Method.

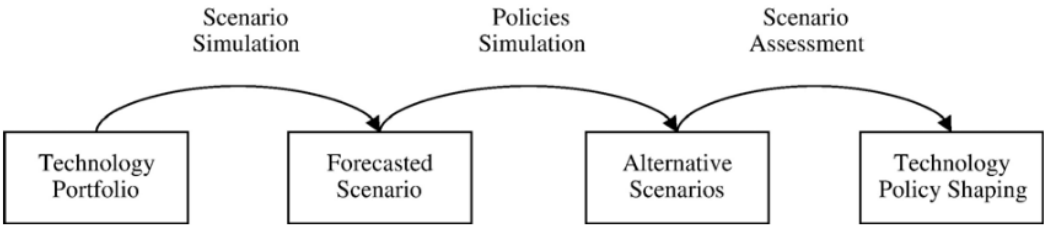

Figure 33: SBAM elements

The above figure 33 is the detailed process of SBAM, it explains that technology collection are the sets of interconnected technologies that can be assessed. The most apparent flow of technology portfolio is the forecasted scenario as displayed in figure, and it is simulated by expert advice which results in forming the alternative scenario and it further flow to the impact and effect of technology polices on the forecasted technology. The final outcome of the process helps in making technology policies. The scenario planning and foresight approaches are shared both elements.

The uniqueness of the SBAM approach is that all elements are integrated into operational framework.

The methodological framework table 14 of the SBAM is a mix of the Analytic Hierarchy Process (AHP), Cross-Impact Method (CIM) and Delphi Method. Each method has a specific functionality in the SBAM as displayed in below table

Methodological framework

Method	Function	Results
Delphi Method	Managing experts' feedback	Inputs
CIM	Controlling interactions between events	Scenario and technology policies simulation
AHP	Structuring assessment model	Scenario and technology policies assessment

Table 14: Methodology of SBAM.

The main motto is to integrate and interlink together to the strong points of each method, and also to prevent the insufficiency of each tool used:

- Delphi method: it is used to get an individual expert advice in order to solve the complex problem. The list of questionaries' is asked and judgement and summery are sent to further process analysis, it is difficult to obtain scenario with causal relationship among possible future events(Turoff, 1971) then this is where Cross-Impact Method(CIM) includes technique that facilitate this problem.

- Cross-Impact Method(CIM): from the paper (Gordon & Hayward, 1968) states that CIM has been applied to various problem to solve like scenario generation, information technology diffusion estimation and simulation of business environments (A. Duval, E. Fontela, A. Gabus,J.C. Dupperin, M. Godet, B. Sapio, Banuls, S. Enzer, Interax, 1974). Even though there are many approaches to the CIM but there are seven major steps. Which are: displayed in the table 15 below,

Steps in the use of the CIM	
Step 1	Defining the events
Step 2	Estimating the initial probability of each event
Step 3	Defining the cross-impact probability matrix
Step 4	Calibration run of the cross-impact matrix
Step 5	Defining the sensitivity test to be run with the matrix
Step 6	Performing the cross-impact calculations for sensitivity test
Step 7	Evaluating results

Table 15: Steps to use CIM(Gordon, 1969)

- Analytic Hierarchy Process (AHP): the AHP model was introduced by Saaty(Olson, 2012) which is used to solve the complex decision making problem with help of involving multiple criteria. It is used because it's simple, flexible, more intuitive appeal and ability to deal with quantitative and qualitative criteria in the same framework. Moreover AHP is used for the cross-impact events scenario approach.(Cho & Kwon, 2004)

- The AHP works by developing both importance of criteria used to judge and alternatives. Henceforth priorities are derived for the criteria to achieve the goal. To find that priorities the AHP method is based on decision problem formulated into hierarchical structure. In the second level it includes the criteria as (Cx) which is further used to judge alternatives in the hierarchy, the priorities are being set and weighed with help of quantified numerical weight (Wx), which can be obtained overall priorates for alternative (Ay) this is how the goal is accomplished.

Hence this is the systematical methodology fir SBAM proposal tool which is being used for technology foresight.

4.1.21 Cognitive value for technology Foresighting:

Before understanding the cognitive tool, let us try to understand what is cognitive, the word cognitive, it is defined as basic use of metal activities and performing the skill on particular task by reasoning, understanding, learning, remembering, paying attention, solving and so on to ability to solve. In the following we are going to see the theoretical part consider not only the final outcome of the foresight, but it also its very potential for affecting the mindsets and conducts of

individuals and thus creating valve by enabling the organizational changes and rejuvenation.(Boe-Lillegraven & Monterde, 2015) there are three research gap in this particular regards, those are as follow:

- Most of the fresh research contemplating the value of foresight does it on the organizational level, which means they are focusing of the value observed by individual stakeholders are less accounted for, particular in cognitive perspective.

- It is slightly open whether the connection between mental model and foresight model change can be established also for activities that don't include scenario for instance technology foresight.

- Also, there are few arguments that why foresight can change a mindset, there is a very less solid theoretical foundation from the cognitive perspective. For a better understanding of cognitive process of foresight what happens and when happens come together as contribute in the system needed.

(Whetten, 1989) refers to concept development experts such as (Dubin, 1978) he is listed four main elements, which contains four important elements like: what, why, how and who/where/when as shown in below figure 34. The main aim is to focus on "why" related to the cognitive model for foresight. As shown in below figure,

The main intention behind this theory is to focus on how and why, for the technology foresight. Which explains as follows:

Why: it focusses on the fundamental psychological, economic or social dynamics that helps in choosing the foresight, during the process logical replaces the data as the basic evaluation.

How: the factors effecting to the system and causality is introduced- regardless of ability to test the links.

Furthermore, they use MENTAL MODEL to foresight the further process in order to fetch and depend on cognitive aspects. Mental model tool was created by organization which are Management of Accelerated Technology and Innovation project (MATI), through its relationship with the Center for Technology and Innovation Management (CTIM) at Northwestern University, is currently establishment assessment of how to create information dominance. This tool is very much focused towards the information technology (IT), the tools helps in executing the team effectively and manage the technology concentrated business within the framework of multiple new and different "event horizon". Every follow-on model is unique and company specific, built and evolved upon the interactions of the separate concept of technology and business value network, whereas the skill can be nourished, acquire and arranged. This is how it can improve the capitalization of particular firm. (J. W. Peterson, 2002). This tool focusses on the experience, training, conditioning and education.

This tool created to get solution regarding the cultural acceptance for the nonlinear thinking and nontraditional approaches to solve the complex problem before they befall. The positive culture is developed over a period of time by engaging the health decision for the future process. This tool helps is familiarize the individual exclusive. It helps in enabling the risk taking under pressure at obvious signals of pending disruption. (the model is being explain in previous tools.).

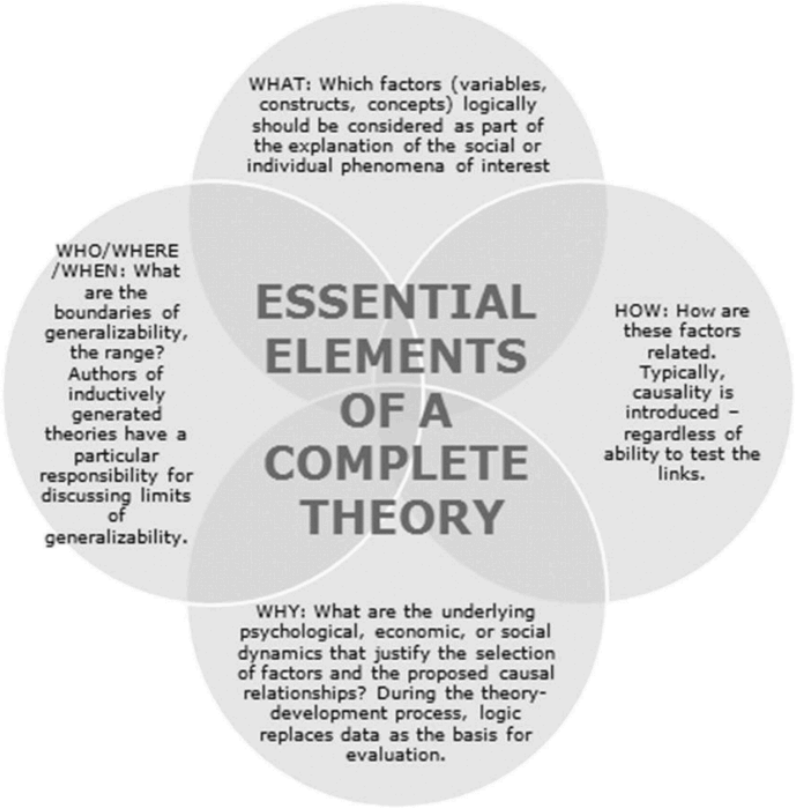

Figure 34: the elements in engaging the technology foresight to use the cognitive model, which aims on how and why to solve the problem.

4.1.22 Technology foresight by using: monitoring, Scenarios and Scanning

This foresight had been built under the umbrella of three things which are scenarios, monitoring and scanning. (Wilson, 2005) describe as in the wall of ambiguity, technology foresight is not feasible. Because in technology foresight they are not using scenarios, monitoring and scanning three elements for planning the foresight. Let's us enlighten these three elements'(Wilson, 2005):

- Scenarios: in the simple term the scenario can be defined as the "stories of possibilities" where stories in the sense to picturize the dynamic of interacting forces for future and the future can be descried as the possible of occurrence, which are reasonable.

  In order to further enlighten the scenario, we can choose to the following abbreviated table16:

Scenario are not:	*Rather they are:*
Predictions	Descriptions of alternative plausible futures
Variations around a mid-point base case	Significantly, often structurally, different views of the future
'Snapshots' of end-points (e.g., the market in 2010)	'Movies' of the evolving dynamics of the future
Generalised views of feared or desired futures	Specific decision-focused views of the future
Product of outside futurists	Result of management insight and perceptions

Table 16: Abbreviation for scenario.

In the context of this tool, scenario plays an important role in construction of technology foresight, it is created to explore for particular future strategy to deal with. This element should be strong and tight to give discipline, coherence and relevance to the final foresight product at the same time it should embrace the creativity, unconventional situation, insight of the executives and planners who will use this tool. However, scenario highlight four main issues which are as follows:

- They help in providing the strategic standpoint in handling long development cycles and large cycle commitment of resource.
- Wrapping of technology uncertainty and so this enables strategy to deal with critical problem.
- Across-the-board view for the future environment so that it can used to evaluate the impact of business strategy and external variable in technology.
- Help in developing the blue print for developing and evaluating a resilient strategy and its ability to deal the problems in future.

o Monitoring: monitoring helps in maintain the track of actual present courses of event or to explain in simple way would be "scenarios, explain about what might be? but monitoring, helps in understanding what it is?".

However, ever organization use the monitoring because it helps in detecting the problem and it also act as a signaling emanating from the external environment. Thus, marketing personal always monitor trends of customer preference, economic changes in sector, eye on competitor's strategies, R&D and latest development in technological sector. For a well-integrated technology foresight ask for ample "sensing mechanism". This coordination of insight inputs is very important for tech strategy.

- Scanning: it is often confused between scanning and monitoring but they are very distinct in various area. Monitor tracks the movement of particular trend whereas the scanning seeks in establishing an “early warning mechanism” those are sensitive enough affecting the force of technology. Vital changes don’t grow up spontaneously, they start as an idea and further those idea grows and expressed in the required area.

  Scanning is one of the straightforward and widely used methodology specially in the media content, but the scanning should be comprehensive enough to look for early warning signals.

There is give-and-take relationship between all three element which are explained above to give and take strength for foresight activities for any technology. The foresight system thus has the stability of tripod which is formed by interlocking with these three methodologies.

5.RESULTS:

In order to identify the proper upshot, different clustering tools researched and studied thoroughly. We applied the iterative approach to fetch the data based on it then we analyzed each and every tools and also with the scrutinizing of tools we also formed the cluster by using the similarity characteristics matrix and foresight diamond (Popper, 2008), mentioned model will help in to get the valuable data to this literature review process. All the technology foresight tools can be used for specific purposes and this is one of the outcomes of the above research.

However, this research was concentrated towards the qualitative methodology because they were no completely numerical form of tools to find the quantitively approach. That the reason based on the collected data qualitative analysis clustering and similarity type matrix were performed and some interesting result were obtained.

Before heading further the concept clustering can be defined as from the obtained database creating the pattern on similarities and dissimilarities in order to get some essential data out of research finding. In this research we used the qualitative approach to analyze the tools. Here we also used the unconventional method to find the clustering which is foresight diamond which is in diamond shape and with four edges each edge denotes different attributes, in our case we used evidence, creativity, interaction and expertise as our main edges, here evidence denotes as the availability of the proof of the statement or research, any reliable documents with stats and figures regarding some findings, these is very helpful in understanding actual state of development of project and the second edge is creativity, it explains about mixture of originality with the imaginative thinking and which is non-traditional method, basically one who use it we call them Tech-gurus. Interaction focuses on exchange of view and idea with the other experts and solve the problem together. And the last edge which is expertise which indicates how knowledgeable about that particular technology or subject. (see also Ansoff, 1975; Cassingena Harper and Pace, 2004) (see also Kuusi, 1999; Scapolo and Miles, 2006) (see also Andersen and Jæger, 1999; Cuhls, 2003; Brummer et al., 2007) (see also Porter et al., 1980; Armstrong, 2006)

The other which is being used is similarities-based matrix, developing the matrix is more about the theoretical exercise which helps in understanding different view about the tools and identify the research needs.

5.1 Analysis performed on various tool:

In this part, all the tools were analyzed on the various comparable and distinctive technique, this process of result will help us in understanding the selection of tools based on the expected outcome, for example it helps it answering which tools can be used for qualitative or quantitively approach.

Since more then 23 tools are being used out of 150 survey which was obtained from Scopus website were studied individually and tool literature review was conducted. Below figure 35 helps us in understanding which tool was being used more frequently and we can see that the Delphi method used more than 25 times which is followed by roadmapping, SWOT analysis and three phase method.

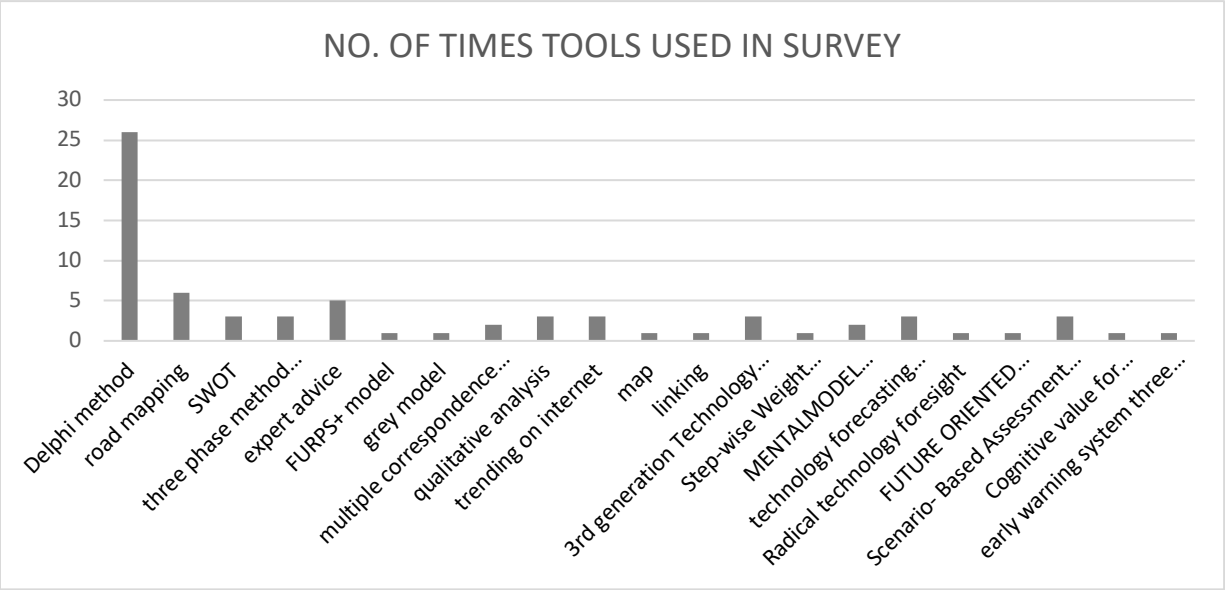

Figure 35: Different tool used and obtained from survey.

All the above tools were constructed based on different approach. Such as qualitative, quantitative, requirement of expert, use of questionnaire and survey, type of analysis, graphical or statistics

generation, mathematical equations, computational, cognitive, just based on citation and literature review. Let us discuss one by one,

Qualitative approach: this approach is being used to understand that, any tool which can be used for the theoretical kind of technology foresight. This kind of approach only focus on the non-numerical data in order to conduct foresight of technology.

Quantitative approach: this kind of approach is used to solve the numerical kind of problem for technology foresight, where further several arithmetical formulas is used to foresight the technology this approach is very good to get the precise data of particular research.

Experts: it is being used to understand whether that tool require the expert intervention for the process of technology foresight. How they are contributing to the tool.

Use of questionnaire and survey: it is to determine is it mandatory to have a questionaries' or survey with the experts for the further process of the technology foresight, not all tool require the survey for the finding the TF.

Graphical or statistics generation: it aims to understand is it possible to generate the graphical illustration through that technology foresight tool, note that not all tool can form or construct the graphical representation of the foresight. This kind of tools are very complex and very precise and better to understand context.

Mathematical equations: there are many tools which use the mathematical equation to solve the complex problem, however not all foresight require the formula to solve the problem but, the tool which helps in solving the problem by equation helps in creating the better graphical and better outcome of technology foresight.

Computational: some of the tools use the computer in order to solve the technology foresight problem, for example internet of things, which use computer to learn and further data is generated for foresight. This is new and very efficient way to generate the technology foresight.

Cognitive: some tools are very much focused on the personal instincts and personal knowledge to solve the problem by using basic metal activities and performing the skill on particular task by reasoning, understanding, learning, remembering, paying attention, solving and so on to ability to solve.

Citation: some tools are very much dependent on the citation for example in linking tool the technology foresight is done based on help of similar citation and linking up based on similarities and getting the solution.

Use of journals: however most of the tools uses journals for the reference of tool methods but there is few tool which don't use journal for reference also.

Type of tool used: there are two type of tools can be segmented in this research 1) independent tool and 2) dependent tool. The independent tool is one which doesn't depend on any tool which are used for technology foresight and they are unique in terms of method of foresight and the dependent tool are one which are directly and indirectly related to other tools or use them for technology foresight.

5.2 Different tools characteristics:

Based on the various approach applied on the tools as shown in above table 17 it helps us in better understanding the distinctive characteristics of the different tools, however we know that all the above-mentioned tools are being used for the technology foresight but each and every tool has its own specialties and sector of operation. We can choose the tools based on the type of the survey as shown in below figure we want to create for technology foresight. In this section of the result we would be discussing regarding the different potentials of different tools:

Table 17: Comparison of different tools.

The table 17 help in better understanding the concept of which tool uses what approaches. Based on it the further tool enlightenment was generated.

Delphi method: Delphi method methodology defines as the various expert are given the questionnaire's survey and repeated multiple respondent two or more times to obtain convergence in the expert opinions. This method differs completely from conventional method of questionnaires in that the second and subsequent questionnaires feedback previous responses to the respondents, enabling them to see the overall direction of opinions and to individually re-evaluate question topics.

Delphi method is very old tool and the experts are mandatory for the foresight purpose and the survey takes place in the process, and it is a qualitative approach tool according most of the research but, there are few journals states that Delphi can be used as both qualitative and quantitative but for our research purpose we are going to stick for majority side. where it analyzes the theoretical technology foresight. However, it is an independent tool and it is widely used in another tool also and Delphi is more feasible and accurate. Particular time is not considered because the process can be repeated again and again until the interviewer gets the suitable solution for the technology foresight. However, it more reliable and deep-rooted method to find technological foresight

Roadmapping: Roadmapping is defined as a very strategic tool for strategic planning method which integrate the creating and delivering strategy for technology foresight. It is expressed in graphical method which controls and show the alignment of tasks and function in firm with respect to time. Road mapping is a strategic planning tool to determine the actions, steps, and resources need to achieve the goal.

This tool is an independent and can be used when time is more important part of the technology foresight, as it only performs on qualitative analysis and it need only few experts are required to construct the process with respect to time.

Delphi and roadmapping: To overcome the demerits of Roadmapping and the Delphi Method, integration of both helps in reducing the demerits and also increases the merits for technology foresight.

This tool is dependent on individual tool i.e. delphi+roadmapping, and it only perform on qualitative approaches. Here time and different expert knowledge is used to tackle the problem of technology foresight.

SWOT method: SWOT analysis is defined as strength, weakness, opportunity and threats, which are computed based on external/internal and helpful/harmful bases on each section. SWOT analysis are very easy to understand and easy to read map. This method is used in technology foresight for quick and effective result oriented where the strength, weakness, opportunity and threats can be determined by few experts and with this mind tool the result can be sometime quick and effective

This tool is independent and only qualitative analysis can be performed, here no need of many experts is required, the few expert can analyze the technology foresight based on the strength, weakness, opportunity and threat and plotting of technology foresight can be done.

Three phase methods: "Three stage methodology designed to:

- STUDY: It is understanding from the previous survey.
- ANALYZE: To diagnose and evaluate.
- DESIGN: Propose references to organize and implement extra efficient further foresight practices."

This tool uses the expert advices to solve the foresight problem it can be used for both qualitative and quantitative research, where survey is a part of its process. There are very few tools which can perform both task of qualitative and quantitative approaches and it is one of the them. This tool uses other independent tool to solve the problem of this tool like Delphi, STEEP analysis is done.

Expert Advice (technology scouting): “it’s a systematic approach by companies where they assign their part of the staff or employ external consultant to collect the information regarding science and technology and through which they facilitate or execute the technology sourcing”

This is very distinctive tool with respect to studied tool, it can be used for both qualitative and quantitative approaches and it is independent tool which don’t rely on any other type of tool. However, it takes reference from the various journals to build up its technology foresight.

FURPS+ model: FURPS+ is a technique to give an authenticate solution after understanding clients demands and requirements. Acronym FURPS is functionality, usability, reliability, performance and supportability. FURFS gives the classification of TF in diverse aspects and also FURPS is good in segregating the technology independent and technology dependent aspect.
Unlike other tool here no many experts are required, where it is new tool and solve the problem of both qualitative and quantitative approaches and it is independent tool. The tool is very detailed and focus on diversified topic which are required for the technology foresight.

Grey model: The Grey model has been used widely for technology foresight and analysis purpose, in Grey model the term "Grey" indicates the data used in model between "black" which is completely unknown and "white" which indicates the known area data, grey model helps in smoothening of original data and reduce the effect of unwanted and discontinuities
This model is an independent tool which helps in determining the quantitative approach, here many formulas are used in order to find the required foresight. It is little bit complex but helps in getting more valuable data in terms of graphs and figures, the expert knowledge and research are very important part of the research.

Multiple Correspondence Analysis (MCA) model: Multiple Correspondence Analysis (MCA) is defined as to explore and envision the patters and relationship among the technology foresight methods and assessment measures. In quantitative phase MCA model combine the doubling data technique in order to reduce the diversification of dimension and perform the meaningful graphical representation of the technology foresight method.
MCA is an independent tool which uses the expert opinion to solve the problem, however it uses the quantitative data to determine the technology foresight, this tool helps in getting the proper graphical representation of the research and it is very effective and efficient way of research and to determine the technology foresight.

Internet of things (IoT) and data analysis: The internet of things is architype where every day object is interconnected which identify, sense with the help of network and able to process by connecting with various devices. However, some call it as the next generation tool as it will enable ambient intelligence for technology foresight.

This tool is very new and emerging tool in field of technology foresight, due high data penetration and smart devices, this is very independent tool where it requires just a programming language for creating the systematic algorithm and more over it does not depends on research papers or journals, it can solve both qualitative and quantitative data for the technology foresight.

Step-wise Weight Assessment Ratio Analysis (SWARA): SWARA can be described as expert oriented method with an expert opinion is weighed more in evaluation and calculating the process. Expert determine the value of each criterion and rank in order which is in ascending to descending order based on experience, knowledge and information available to the expert

This method is can be used for both qualitative and quantitative approaches and however it is dependent tool where it uses tools like Delphi and MCA for the process of the technology foresight. This method uses the simple calculation method to find the required output and experts play a vital role in this tool and this tool can help in getting the graphical representation of the different aspects of technology.

Qualitative and Quantitative analysis: "Qualitative method is the preliminary part to understand the underlying motivations, belief and incentive (Zimmer, 2006). It provides the spur for the problem and helps in developing ideas to solve the problem. Qualitative research helps in exposure of the particular topic trend, thoughts and examine. Qualitative data may be structured or unstructured based on the topic, some of the common method used expert opinion, research paper, interview (Hassanzadeh, Namdarian, Majidpour, & Elahi, 2015).

Quantitative method main aim is to quantify the problem and research by collecting the data, stats and figures related to the topic of research. Quantitative research uses the measurable data to collect facts and uncover the pattern for the research work, the data collection methods include various form of survey like online survey, interview, paper survey, telephonic interview and online polls (Kaivo-oja, 2017)."

This tool was constructed to overcome the problem of qualitative and quantitative approaches of research and hence it solves that problem, this tool is dependent on another tool. By using this tool, we can get the graphical as well and statistical data of foresight.

Linking: "Linking is all about connecting the edges between various clusters of techniques and path based on relevant research and paper published and from which network is being developed by (Girvan, M., Newman, 2002). There are three stage of development of linkage as follows:

1.citation network is built in order to determine the major research groups and the citation is being linked.

2.key route is being applied to analyze the overall knowledge diffusion on the particular technology foresight and the exabit relationship is determined among various research group.

3.furthermore, using of global main path on the three-medium sized segment to determine their development trajectory. "

This tool is very different because it uses the citation in order to find the link of foresight and it is effective and however it is an independent tool, but good experts are required. This tool more focused on evidence in the research.

Construction of Map by co-nomination: It is a survey-based technique, which is also known as co-nomination the technique used here to make mapping pattern with the help of experts where the respondent is asked to identify fitting participate and at the same time they are asked to outline their own expertise.

This tool can be used for both qualitative and quantitative approaches of research and it is completely focused on the survey material and questionnaires for the technology foresight and it's a dependent tool where we use other tool complete the process.

Third generation technology foresight: third-generation tool includes the social, economic, environmental and legal trends of technology foresight as the obligatory framework in foresight exercise and also the information and communication technology I/C, which includes database, internet, software.

This tool can compute qualitative analysis and expert are basic pillar of this tool and it uses the computation to analysis the data and solve the problem. This tool focus technology foresight with equal importance and effect on social, economic, environmental and legal trends. This focuses and unearth resolution.

MENTALMODEL (experience, training, conditioning and education): This tool is very much focused towards the information technology (IT), the tools help in executing the team effectively and manage the technology concentrated business within the framework of multiple new and different "event horizon". Every follow-on model is unique and company specific, built and evolved upon the interactions of the separate concept of technology and business value network, whereas the skill can be nourished, acquire and arranged.
This tool can only compute qualitative analysis and expert are required to guide this tool and it uses for computation and analysis the data and solve the problem. Here the cognitive of the various experts comes into picture which focuses on experience, training, conditioning and education.

Radical technology foresight: In this tool the with the help of cognitive mapping, technology foresight is being done, here the cognitive can be defined as based on the reasoning of particular technology foresight obtained from interviews, survey or from any database and linking them to create a valuable map based of different variables
This tool is based on the cognitive reasoning method which craft the map from experts, questionnaire's other search and try to link them. However, it is a dependent tool, can solve both qualitative and quantitative approach.

Technology foresight with future oriented technology analysis (FTA): FTA has its own potential to analyze the complex innovation journey of science-based technologies as they follow the rule of developed, diffused and deployed in evolving market and industries. FTA main focus on the innovation system policy making and the development of national strategies for key emerging technologies
This tool is very famous in field of construction of government policy, however this tool is dependent with other tool solve the problem. And this tool uses qualitative data and tool answer by graphical representation and this is new tool compared to another tool.

Scenario Based Assessment Model (SBAM): SBAM approach is associated to the other technology assessment which aims to assess the technology portfolio as a whole. The SBAM is combination of different tools such as multicriteria and scenario methods.

This tool is dependent to different tool specifically, Delphi Method, Analytic Hierarchy Process, and Cross-Impact Method. Where it can solve the complex problem of both qualitative and quantitative approaches. It uses the basic mathematical equation to solve the problem. This tool is very effective in assessing the technology foresight.

Cognitive value for technology Foresighting: It is defined as basic use of metal activities and performing the skill on particular task by reasoning, understanding, learning, remembering, paying attention, solving and so on to ability to solve. In the following we are going to see the theoretical part consider not only the final outcome of the foresight, but it also its very potential for affecting the mindsets and conducts of individuals and thus creating valve by enabling the organizational changes and rejuvenation.
This tool is dependent on other tool like MENTAL model and expert's knowledge plays an important role to frame the foresight problem, this tool can solve qualitative approach. This tool completely based on the experience, training, conditioning and education of an expert.

Technology foresight by using: monitoring, Scenarios and Scanning: This foresight had been built under the umbrella of three things which are scenarios, monitoring and scanning. (Wilson, 2005) describe as in the wall of ambiguity, technology foresight is not feasible. Because in technology foresight they are not using scenarios, monitoring and scanning three elements for planning the foresight.
This too is new and constructed to focus on monitoring, Scenarios and Scanning, here experts are key players and it's an independent tool which does not depend on any other tool and can solve the problem of qualitative and quantitative problem for technology foresight.

5.3 Brief Clustering analysis summary:

The tools for technology foresight share the common personalities, and it is very important to cluster based on its characteristics, due to qualitative data it was little difficult to cluster with the traditional method. So, the diamond foresight comes into picture,
The framework of foresight diamond figure 36 can be explained as follows:

Figure 36: foresight diamond.

Based on the characteristics of tool, it is being placed in the different dimension of the edge of diamond foresight, behavior of tool can be explained in matrix by using the similar pattern of diamond foresight, developing the matrix is more about the theoretical exercise which helps in understanding different view about the tools and identify the research needs. Furthermore, diamond foresight can also be explained in the form of scenario matrix containing the different axis of variables, as shown in below figure 37. However, for the further process of discussion we would be sticking to the diamond foresight method, which is much cleaner and adjustable to our research.

Figure 37: similar to above foresight diamond but plotted in axis matrix.

Figure 38 is generated based on characteristics of tool analysis and level of involvement of experts in the process characteristics of the tool this cluster was generated and it contains two axes, x-axis is single tool for analysis called as independent tool and other pole is dependent tool which use multiple tool for analysis, and other y-axis indicates level of expert involvement in the particular tool purpose. Independent tool is one which are created or derived without the help of any other tool or any foresight tool. Dependent tool is one which is derived from directly or indirectly with the help of different tool in order solve the technology foresight problem. The level of expert required to solve the problem in whole process of technology foresight is varies based on the different tools, experts are required to conduct the foresight process, some tools use very high

expert guidance, and some take very less, as shown in figure 38 and in detailed study is presented in discussion part.

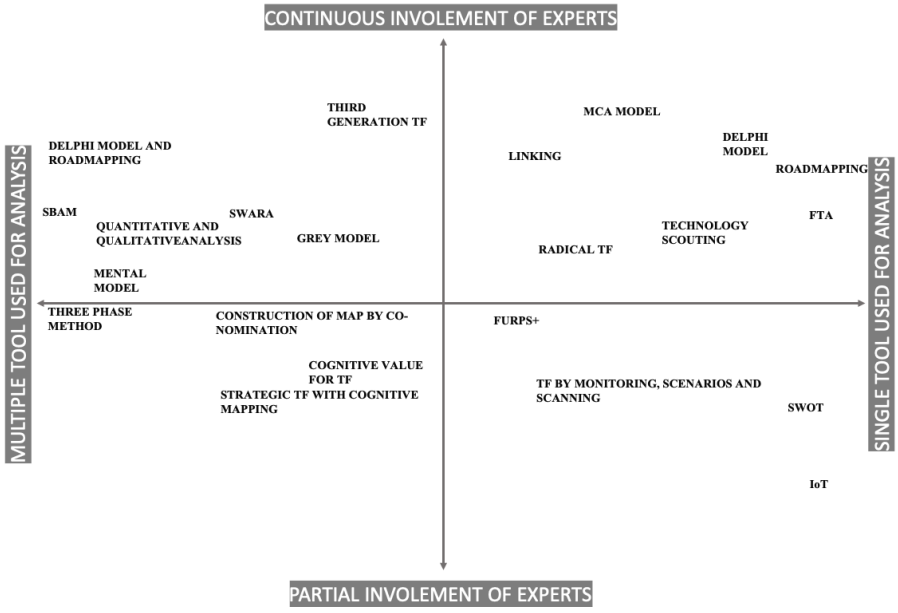

Figure 38: differentiating tools based on characteristics

6.DISCUSSION:

In order to get the picture of different tool methodology and characteristics of tools which can be used on the requirement, tentative research have been directed. The technology foresight tool was arranged based on the similarities so that clustering task can be done. The clustering can be defined as from the obtained database creating the pattern on similarities and dissimilarities in order to get some essential data out of research finding. In this research we used the qualitative approach to analyze all tools.

6.1 Clustering 1:

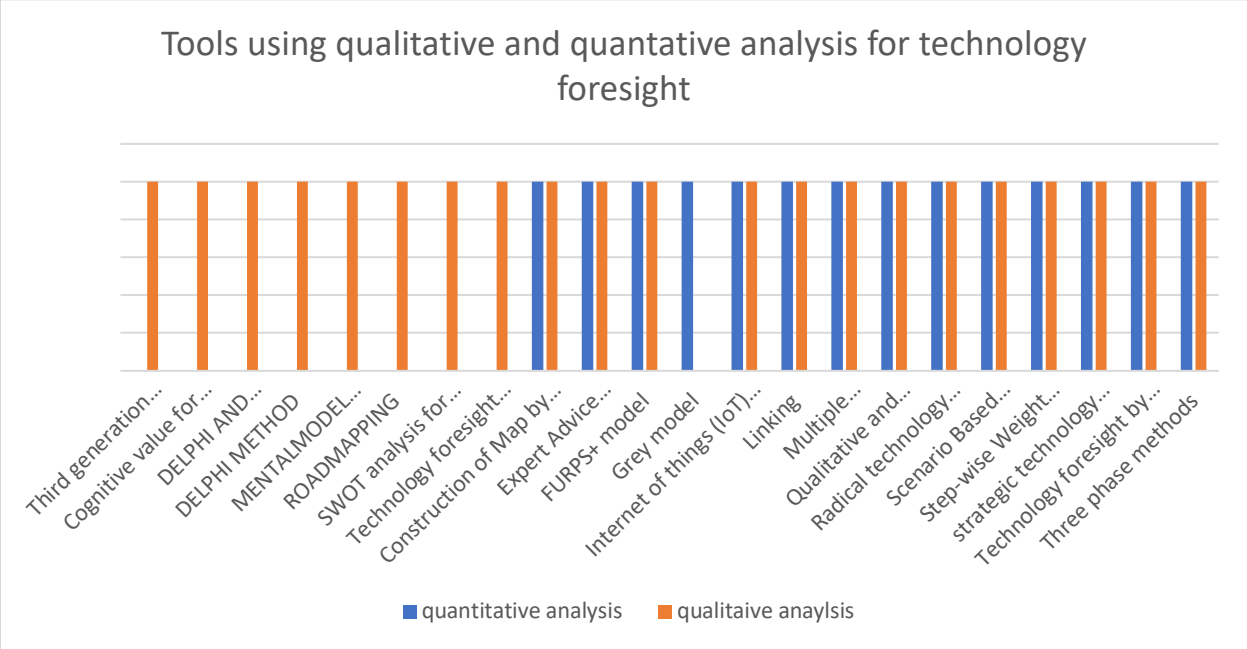

Table 18: tools using qualitative and quantitative approaches.

Graphical representation: as we seen previously that all tools have unique features, here the above graph explains in table 18 the qualitative and quantitative approach's for different tools. Before selecting any tools for the technology foresight, it is important to known what kind of survey has to take place or how? this constructed survey can be used to apply on different tool. There are three segment which was formed after the carefully examining the tools. which are qualitative,

quantitative and both qualitative and quantitative. Qualitative helps in examining the thoughts and idea it can be structured based on similarities, exert opinion or some research in our case almost all tools use the qualitative research excluding the grey model, and quantitative analysis are sometimes intuitive. In quantitative analysis it talks about collecting, data, facts and figure, the data can be used to solve the problem, however this approach is very complicated by result oriented, the tools like grey model which is completely dependent on quantitative type of approach. Coming to the both qualitative and quantitative are more effective way to technology foresight they use the qualities of each other approaches and hide their drawbacks in order to get a valuable data of foresight as you can see in below table. In all cases of approach, the data is collected through survey, questionnaires', interview, online polls etc.

6.2 Clustering 2:

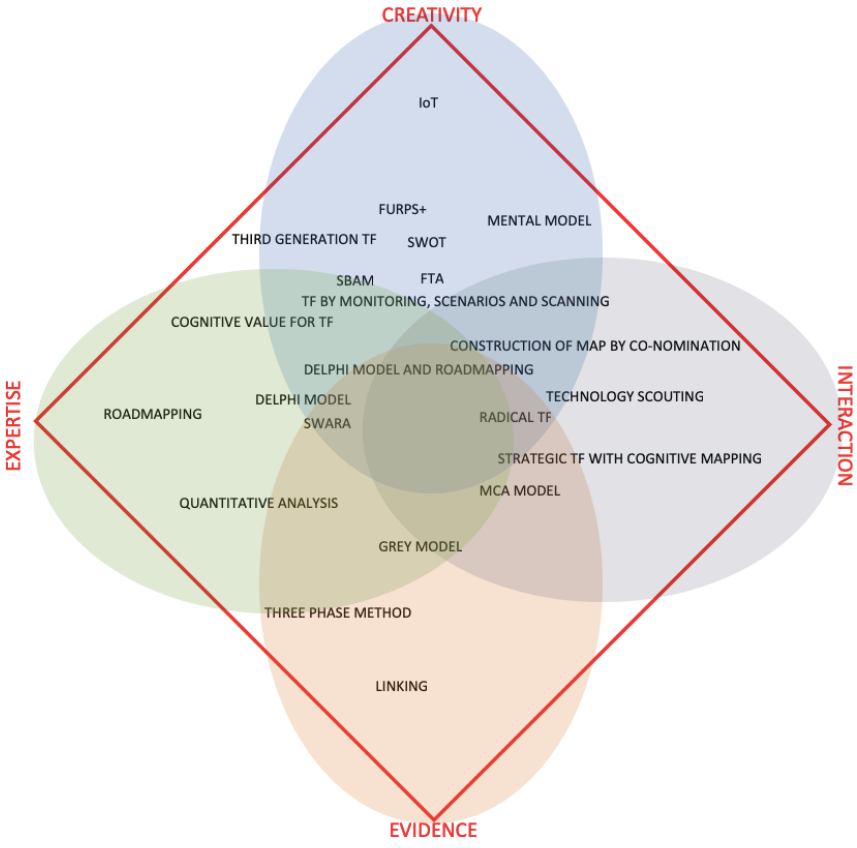

Figure 39: Diamond foresight.

Here we also used the unconventional method to find the clustering which is foresight diamond, which is in diamond shape and with four edges each edge denotes different attributes. It was

introduced by the popper in the handbook of technology foresight of (Georghiou, 2008), in our case we used evidence, creativity, interaction and expertise as our main edges, here evidence denotes as the availability of the proof of the statement or research, any reliable documents with stats and figures regarding some findings, these is very helpful in understanding actual state of development of project and the second edge is creativity, it explains about mixture of originality with the imaginative thinking and which is non-traditional method, basically one who use it we call them Tech-gurus. Interaction focuses on exchange of view and idea with the other experts and solve the problem together. And the last edge which is expertise which indicates how knowledgeable about that particular technology or subject. (see also Ansoff, 1975; Cassingena Harper and Pace, 2004) (see also Kuusi, 1999; Scapolo and Miles, 2006) (see also Andersen and Jæger, 1999; Cuhls, 2003; Brummer et al., 2007) (see also Porter et al., 1980; Armstrong, 2006)

In this type clustering main focus was differentiate different tools based on four characteristics which they use to process the technology foresight, in our case we used expertise, evidence, interaction and creativity (each characteristic is explained above):

Each tool was placed in different zone based on the methodology and tool near to any edge assumed their characteristics in technology foresight process. The clustering helps in understanding the different tools with focusing factors based on which tools can used, to summarize this proposed clustering can help organization to select the tool with based on their requirement. The above clustering information was obtained and analyzed by looking into various factors such as qualitative, quantitative, requirement of expert, use of questionnaire and survey, type of analysis, graphical or statistics generation, mathematical equations, computational, cognitive, just based on citation and literature review. Based on its placement of tools were engaged.

The shaded reflects to the overall ability to gather information based on evidence, expertise, interaction or creativity. Here it is worth noting that the interaction dimension is first ‘‘touched’’ by methods like futures workshops and brainstorming (although some types of expert panels are designed to promote participation and interaction between groups of stakeholders). The mapped foresight work is aligned with concepts accepted by the community of practitioners, where foresight is seen as a way to encourage more structured debate with wider participation leading to the shared understanding of long-term issues (Georghiou et al., 2008). The reader should also note that there are no commonly used more methods near the top vertex of creativity. Expect the IoT,

this may be a consequence of the lack of guidance on how to apply techniques such as gaming and other creative methods like wild cards or weak signals.(Popper, 2008)

However, the influence of the capabilities of this method is high but not balance and at the same time it would be unrealistic to expect all the foresight tools to give an equal weightage to all four vertices of the diamond.

6.3 Clustering 3:

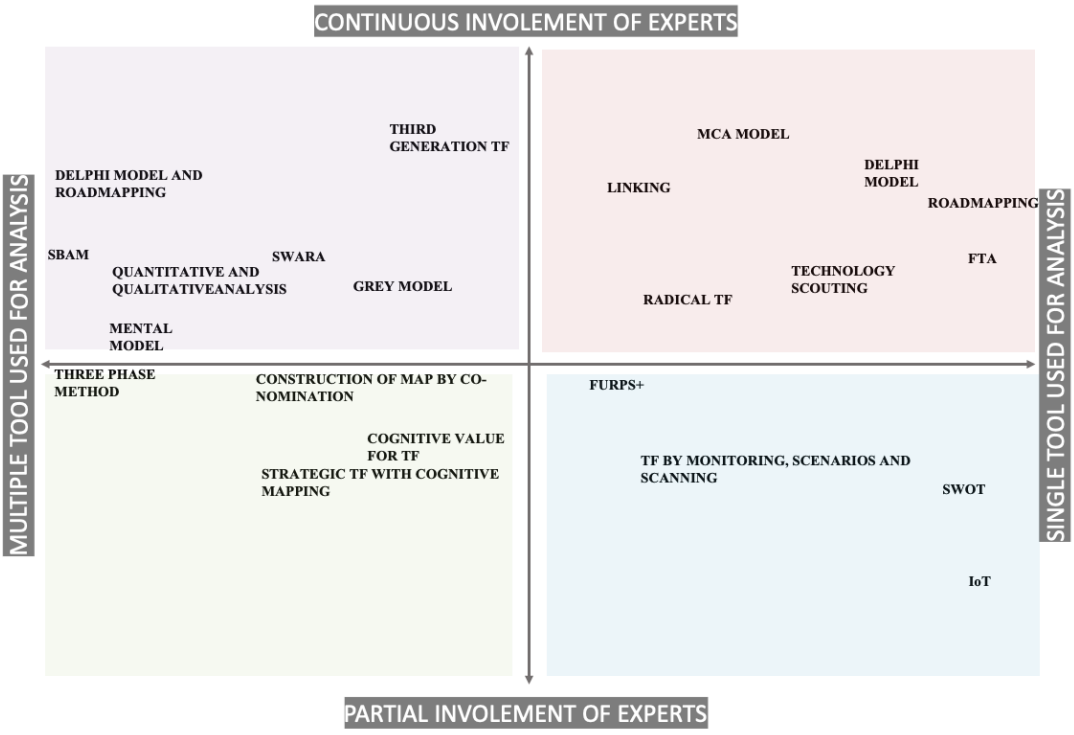

Figure 40: differentiating tools based on characteristics

The clustering of all tool is done based on tool properties and expert involvement in order to learn whole process of technology foresight, this cluster contains two axes, x-axis contains independent tool and other one is dependent tool with the level of expert involvement in the particular tool for the whole process indicator.

Single tool for analysis can be called as Independent tool is one which are created or derived without the help of any other tool or any foresight tool.

Multiple tool used in analysis can be called as Dependent tool is one which is derived directly or indirectly with the help of other Foresighting tool, in order solve the technology foresight problem. The level of expert required to solve the problem in whole process of technology foresight is varies based on the different tools, there are two poles which are continuous involvement and partial involvement of experts are required to conduct the foresight process, this explains that some tools use very high expert guidance and some not. This is considered based on the whole process of foresighting from the starting research to the ending of the process.

From the about figure 40, However, tool are placed based on the level of experts and tool properties required in complete process, so we can see that tools like Delphi, roadmapping, FTA, MCA model uses the high expert involvement and they are independent tools. But, tool like IoT which requires very less involvement of experts, the experts are required only at beginning of the process of coding and later stage a skilled worker can understand the trends and foresight from the output data. Furthermore, tools like mental model and three phase model uses the methods like Delphi method, STEEP method and other tools to uncover technology foresight.
From the above figure 40 we can see that there are four quadrats constructed based on the two axes, namely based on the characteristics of tool for analysis and the other axis on the level of the expert involvement in the whole process of the technology foresight.

First quadrant: Here, single tool used for analysis and continuous involvement of experts in the process of technology Foresighting section, it explains that, the nature of tool is very independent, and it does not take any help from other tools in order to do foresight and the expert are strictly required in each and every step of the process. The tool like MCA model, Delphi, Road-mapping, FTA, linking, Radical TF, Technology scouting comes in this category of quadrants.

Second quadrant: Here, single tool used for analysis and partial involvement of experts takes place in the process of technology Foresighting section, it explains that, the nature of tool is very independent, and it does not take any help from other tools in order to do foresight and the partial intervein of expert required in different step of the process. In this quadrant tool like FURPS+, TF by monitoring, scenarios and scanning takes place, SWOT and IoT comes under.

Third quadrant: Here, multiple tool used for analysis and partial involvement of experts takes place in the process of technology Foresighting section, it explains that, the nature of tool is very dependent, and it does take help from other tools in order to do foresight and the partial intervein of expert required in different step of the process. In this quadrant tool like three phase method, cognitive value, construction of map by co-nomination and strategic TF with cognitive mapping come under.

Fourth quadrant: Here, multiple tool used for analysis and continuous involvement of experts in the process of technology Foresighting section, it explains that, the nature of tool is very dependent, and it does take help from other tools in order to do foresight and the expert are strictly required in each and every step of the process. The tool like third generation TF, grey model, SWARA, SBAM, Mental mode, Delphi+Raodmapping, qualitative and qualitative analysis comes in this category of quadrants.

7.CONCLUSION:

This research helps in understanding the value concealed in tools and help in construct the appreciated technology foresight of particular technology.

This literature review is very much engrossed on technology foresight, this research can help in explain about construction of tool, comprehensive clarifications about tool and when to use of particular tool for technology foresight.

Moreover, the different literature indicates that how technology foresight is being used in various aspects to determine the estimate value of particular technology. During the research period it is observed that many universities and companies were very much concerned, and technology foresight is being used in various field of innovation.

7.1 Research objective and question:

The main objective represents an integration of different studies and researches to deeply understand how companies and policy makers can detect early or existing technologies by using a technology navigation process. The main purpose of our work is to create a methodology to integrate and manage tools based on the behavior during the technology foresight by using the help of technology foresight.

Research question 1: What all the different methods used to determine the TF?

Answer: Different data was collected from 150 journals on the Scopus website and systematic literature review was conducted to understand different tools used in different journal for the technology.

Research question 2: Clustering tools based on the characteristics?

Answer: Each and every tool carries some similarity and dissimilarities with respect to their characteristics and way of solving the foresight problem. Based on the nature three cluster were generated.

Research question 3: How the characteristics of different tools can be identified?

Answer: To carry out the systematic clustering understanding the nature of tool was main focus of this question, where each and every tool was thoroughly studied, classified and segmented for this process.

7.2 Limitations:

There are few limitations for technology foresight which can be considered for future improvements in its methodology of tools and when attempting to extract conclusions using the offered results.

- Quality of the experts: Quality of the experts involved in the process of technology foresight may vary the outcome and it also depends upon the cognitive value.
- Resources availability: The availability of resource in order to get the required outcome of technology foresight is difficult sometimes.
- To identity "unusual" is often difficult: It is impossible to identify, when you don't know what and where to ask or start.
- Difficult to evaluate: Foresighting is one of the classifications of "predicting the future", therefore no one can be sure, what is going to happen because of serval factors "like future change in government, policy changes, environmental factors, cost factors, change in segmented customer behavior.

7.3 Industrial implication:

Technology foresight and industrial development strategy need to be taken very seriously in order to shape the technology changes and economic growth. It is also said that technology foresight and industrial work are the different faces of the same coin, they need to logically design and implement for the better economical outcome, based on several research paper it is being stated that the industries which are using technology foresight that would more successful (Pietrobelli,2016).

Due to globalization the competition and technology change in different sectors are very rapid, specialization on learning the technology changes can make a front-runner in particular sector of technology. Technology foresight has been proved that it is very valuable in developing countries in field of science and technology policy. The experience we can explore from the countries like Brazil, Chile and South Korea, where this coherence has been sought successfully, provide preliminary support to our argument.

7.4 Government implication:

It is evident base that for the innovation and related policy foresight activity is limited, but wide range of countries USA, Australia, South Korea, UK, Germany, France, among others as well as at European level are investing on technology foresight in S&T sector. Most of the policy are being used for the technology foresight in defense, but however many research are done on infrastructure, health, Argo, food security to name few. (Knut Blind, Cuhls, & Grupp, 1999). Moreover, small and developing countries investing on the foresight. This research tool characteristics can help in choosing the right foresight method.

7.5 Academic implication:

From the research in technology foresight in university and institution level, many universities are considering the research on different technology foresight and in some reputed institution there is particular courses regarding technology foresight.

The main intention is overcome the traditional method of technology foresight and replace it with the proper technology foresight tool for different research focused on technology.

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Simone Franceschini is a PostDoc researcher at University of Sassary (It). His work is focused on eco-innovation dynamics in the energy sector, with a specific interest in wide- systemic consumptions impact of eco-efficiency innovations, and participatory processes in policy- and decision-making processes. He holds a PhD from the Technical University of Sassary. He is also senior consultant for urban mobility projects.

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