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# The Mutual Role of Scientometrics and Foresight – A Review

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**Foresight, a science and art, that helps human beings to know the future events, opportunities, and threats and to wisely choose the optimal futures from among possible (exploratory) ones and to consider future as an uncertain and instable setting. Foresight is the process of developing a range of views of possible ways in which the future could develop, and understand these sufficiently well to be able to decide what decisions can be taken today to create the best possible tomorrow. Scientometrics addresses science measurement in different areas and its overall objective is measuring the creation, distribution and consumption of science both quantitatively and qualitatively. Both scientometrics and foresight are interdisciplinary and are quite similar in observing scientific activities, analyzing the trends, scientific prospective and predictions. Indeed, making use of foresight means taking action for making policies in order to realize an optimal future through which a number of other helpful results would be obtained: developing new networks and communications, goal-setting and enhancing the sense of shared commitment, publishing the information, and prioritizing the options and actions. In this paper, the authors try to examine and elaborate the mutual relationship between scientometrics and futurology in different scientific texts then they will discuss the status and role of scientometrics as a tool for foresight-related studies.**

***Keywords:*** *Scientometrics, Foresight Study, Futurology, Information Sciences*

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## 1. Introduction

The contemporary world is preparing to growing, drastic and dynamic changes. The changes are so unpredictable and unexpected that even a minute amount of ignorance could lead to a vast strategic shock in all political, social,

and even cultural areas. In such a changing, unstable and uncertain setting, the only approach which might have more chance of success is attempting to build the future. Although making an attempt in this regard is always juxtaposed with high risk-taking, it seems to be more logical than merely observing the future changes.

The study aimed to examine the mutual role of scientometrics and futurology in designing the road maps for accomplishing the intended vision through using review of the related scientific texts. It also strived to determine the role of scientometrics as a tool in future studies.

## 2. Future Study



Foresight is a science and art which helps human beings to know the future events, opportunities, and threats and to wisely choose the optimal (possible) futures from among possible (exploratory) ones and to consider future as an uncertain and unstable setting. Foresight is the process of developing a range of views of possible ways in which the future could develop, and understanding the factors sufficiently well to be able to decide what decisions can be taken today to create the best possible tomorrow. The process of foresight involves assessing the future implications of present actions, assessing the present implications of possible future events and considering desired future states. The use of foresight as a tool in policy and strategic decision making increased especially in the last decade of the twentieth century in order to enhance competitiveness and innovation of nations, regions, corporations and even individuals. However, it was observed that none of these definitions were capable enough to represent an integrated and holistic view about the impact of foresight on the management of the future. Human beings have been always trying to know the future but scientific study of the future is a recent phenomenon. Fifty years ago, the well-known French futurist, De Jouvenel, who is called the Father of Future Study, founded an institute, Fotorible, which is now considered as a powerful centre of future study in Europe. Later, he published the Futurist journal which literally means orienting to the future or building future (Khazaii, 2009[29]). Futures have been known by several terms as Future Study, Futures, Future Field, Forecasting, Foresight, and Futurology which are commonly used in future studies. Future study is the systematic study of probable, possible, and preferable features and underlying attitudes, ideologies and myths of each future (Inayatullah, 2007[25]). However, each of these terms underlines various theories and presuppositions and has their own particular methods. The publication of two books, The Image of the Future (Polak, 1961[42]) and the Act of Conjecture (Jouvenel, 1967[27]), represent modern views toward future study. Polak used the concept of image of the future to analyze the ups and downs of different civilizations. He also codified a large number of principles of future study for the first time.

Foresight at national level first emerged in 1960 in defence sector of the U.S. First, no distinction was made between foresights and forecasting and it was done quantitatively. In addition to numerous organizations and activities which were contributing to future study, appropriate social structure (such as Jouvenel's science fiction stories, cultural con-

frontations (or conflicts), and the movement of environmental support in 1970s (Dater, 1979[8]) facilitated its development. A few years later, since the bestselling book Alvin Toffler's Future Shock was published, interest in future has become fashionable. Since early 1970s, the science and art of foresight was formally applied as a tool for policy making in a limited number of countries especially Japan. Later, it entered the field of technology and social study. Since the beginning of 1980s, foresight has been differentiated from forecasting and undergone a shift from quantitative methods to networking (European Commission, 2006[10]).

Scientometrics makes use of statistical and measurement methods to determine the development and growth criteria for science and its development level and influence on different human societies. This field first emerged in Soviet Union. In Eastern Europe and in Hungary in particular, it is used to measure sciences quantitatively at both national and international levels and for government and private institutes.



Scientometrics is an interdisciplinary area which examines a wide range of topics due to its broad scope and is conceived of as a dynamic issue which deals with all quantitative aspects of sciences and scientific research. Quantitative evaluation of scientific activities as a significant developmental factor could help the authorities and planners to make the most use of financial and human resources and positively contribute to enhancing the socio-economic structures of the society. It is neither merely a diagnostic tool nor a magic panacea, but it is one of the best tools in clarifying the scientific issues and proposing viable solutions for various problems considering the research-related activities. According to Moravcsik's theory, scientometrics is an interdisciplinary area which not only is related to the limited topic between two traditional problems but also entails numerous traditional topics due to its broad scope (Moravcsik, 1985[34](.Vinkler maintains that scientometrics is a science which deals with all quantitative aspects of science and scientific research(Vinkler, 2010[51]).

Nowadays, with the advent of digital environment, all these areas have undertaken wide changes and scientometrics has come to the force in academic and scientific settings. Accordingly, in the past decade, the application of scientometrics has undergone wide, quantitative and qualitative changes. Nowadays, scientometrics is applied to ranking people, universities, research and scientific centres, countries, etc. Moreover, a large number of databases such as ISI, ISC, Scopus, etc. have emerged. In recent years, scientometrics, has one of the main applications in foresighting, has received considerable attention.

Both scientometrics and foresight are interdisciplinary and are quite similar in observing scientific activities, analyzing the trends, scientific prospective and predictions. For instance, when we deal with strategic view toward scientific issue, three steps should be taken: first, we should map the optimal condition for us i.e. in near future, where we should reach between the duration and far future which is characterized by foresight (futurology). Second, we should consider the current condition and level. Third, the gap between the current condition and the optimal one should be examined which is done through scientometrics tools and techniques and the road map is formed accordingly. Indeed, making use of foresight means taking action for making policies in order to realize an optimal future

through which a number of other helpful results would be obtained: developing new networks and communications, goal-setting and enhancing the sense of shared commitment, publishing the information, and prioritizing the options and actions. In this article, the authors first present a brief historical overview of the formation of the term "foresight". Then, scientometrics and foresight are defined and the mutual relationship between these two terms in different scientific texts are examined and elaborated. Providing the related literature on scientometrics and foresight, the authors will discuss the status and role of scientometrics as a tool for foresight-related studies.

## 3. Foresight – Conceptual changes

The concept of foresight has been frequently changed since people hold different views based on their own area of knowledge and it has a short history and has undergone various experiences. This is why presenting a clear and precise definition of the concept seems difficult. Ben Martin, a pioneer in the field, presented the first generally accepted definition: "Foresight is a systematic attempt to look at long-term future of science, technology, environment, economics, and society, made to identify newly emerging technologies and enhance strategic research areas that seem to be of the most socio-economic benefits" (cited in Nazemi, 2006, p. 27[39]). Luke Georghion maintains that it is a systematic tool for evaluating those scientific technological advances which can make a huge impact on individual competition, wealth creation, and life quality (cited in Sahebinejad, 2006 p.2 [44]). Horton points to it as an extensive developmental process of attitudes regarding possible ways to develop future. Creating a complete understanding of these attitudes would lead to decisions which have the potential of creating the best possible future. Gavigan believes that it is a systematic and cooperative process entailing understandings of the future which provides a middle-term vision aiming at making up-to-date decisions and attracting shared actions" (cited in Nazemi, 2006 p.14 [39]).

According to Bell (1996) [4] the purposes of Futures Studies are to discover or invent, examine, evaluate, and propose possible, probable and preferable futures. Foresight is neither prophecy nor prediction. It does not aim to predict the future but to help us build it (European Commission, 2006[10]). In Webster dictionary, it is defined as "an organized and goal-oriented process which takes into account expectations of different actors about technology and codifies strategic vision of the future to support and confirm the extensive socio-economic development" (cited in Nazemi, 2006[39]). Loveridge (2009) [31] views foresight as a description of a set of solutions for improving decision-building and decision-making methods in order to develop a strategic vision and intelligent forecasting. Richard Slaughter, the author of the book "The Foresight Principle", also presented various definitions but the following definition is mostly cited: "the ability to create and keep a practical, cohesive and qualitative vision, looking forward and taking advantage of understandings resulting from helpful organizational methods e.g. identifying improper conditions, guiding policy, the strategy of forming and examining new markets, products and services" (Slaughter, 2007[47]).

FOREN describes it as a systematic, cooperative process, intelligent community, and building middle-term and long-term vision which aims at forming decisions in order to set up the future activities (cited in Miles, 2004 p.39 [33]). A futurology theoretician briefly defined it as knowing future and studying probable and desirable futures for a society (Mansouri, 1998[32]). Accordingly, future is the reason behind the existence of the past and present and is a way for all to control their own future. In other words, the aim of vision-based thinking is clarifying the choices of our past and present in light of probable futures (Ghodeh, 1996[18]). Joseph Kootez describes foresight as a process in which an individual strives to reach a more comprehensive understanding of the powers forming the long-term future which can be incorporated in formulating politics, planning and making decisions. Foresight entails both quantitative and qualitative instruments for studying growing signs and indicators. Being in direct relationship with analyzing political events is considered as its optimal state. It is also more useful than other fields. It prepares us for meeting the needs and future opportunities (Khazaee & ElahiDehaqi, 2013[28]).

Foresight tries to create a futuristic thinking style and understanding in business, governmental sectors and knowledge institutes in order to allow them to understand the probable opportunities and threats within the next 10 to 20 years in the realm of market and technologies. Then, it brings about and fosters cooperation among these three sectors and directs their activities to create competitive assets, to improve the quality of life, and to provide stable development (Sajjadipour, 2006[45]). The main functions of foresight are as follows: orientation, recognizing newly developed trends, adapting objective to fulfil needs, supporting and promoting decisions and policies serving the preferences of the interested, promoting external relationships with those who benefit from the research or education, and determining priorities (Khazaee & ElahiDehaqi, 2013[28]).

Table 1 provides a comparative account of several definitions of futurology. In order to compare the definitions, relevant text to futurology were compiled from valid databases including Emerald, Scopus, and Science direct. Then, the collected literature was scrutinized and several definitions were extracted. Scrutinizing the definitions through content analysis provided nine dimensions implied in definitions including: Process, Being organized and systematic, Cooperative, Constructing the vision, Long-term future, Gathering the operations, Gathering perceptions, Making decisions, Making wise predictions. Some of the definitions cover more common dimensions and some reveal less common dimensions. Different definitions and viewpoints toward foresight indicate the wide scope of experts considering it. According to the indices presented in table 1, it may be inferred that being organized and systematic, constructing the vision and long-term future are the only commonalities of these definitions. Nevertheless, some scholars have pointed to it as a process and some others have considered it as unimportant.

**Table 1**

**Comparison of the definitions posed by nine various aspects**

| Theoreticians | Process | Being organized and systematic | Cooperative | Constructing the vision | Long-term future | Gathering the operations | Gathering perceptions | Making decisions | Making wise predictions |
|---|---|---|---|---|---|---|---|---|---|
| Webster | * | * | * | * | * | * | | | |
| FOREN | * | * | * | * | * | * | * | * | |
| Martin | * | * | * | * | * | | | | |
| Georghion | | * | * | * | * | | | | |
| Horton | * | * | * | * | * | * | * | * | |
| Gavigan | * | * | * | * | * | * | * | * | |
| Slaughter | | * | | * | * | | * | * | * |
| Loveridge | | * | | * | * | | * | * | * |
| Foundation of Future Development | | * | | | * | * | | * | |
| Kootez | * | | | | * | | * | * | |
| Tagavi Gilani & Ghofrani | * | | | | * | | | | * |
| Ghodeh | | | | * | | | | | |

## 4. Scientometrics

There is a wide consensus that the emergence of the term scientometrics coincided with coining the term bibliometrics by Alan Perichard for the first time in 1969 which was used by Vasili, Namilov and Mulchenko in Soviet Union in order to study all aspects of existing written sources related to science and technology (Hood & Wilson, 2001[24]; Wouters, 2003[57]; Glanzel, 2003[19]). The term Scientometrics is made up of two words: sciento which means science, and metrics which is derived from measuring (Ganji, 2004[14]). With the publication of Scientometrics Journal in 1978 by Braun in Hungary, this field has witnessed many advances. Some of the works which contributed to the formation of the field of Scientometrics are as follows: Nalimov (1970) [37], Nalimov and Mulchenko (1971) [36], Nalimov *et al.* (1971) [38].

Brooks (1999) [5] asserted that the term was first emerged in a FID publication in 1969. The Scientometrics Journal was not that old but the term scientometrics was totally acknowledged in English (Garfield, 2007[15]). After the publication of the aforementioned journal, Braun established the scientometrics department in the Information and Scientometrics Research section of the library of Hungarian faculty of sciences. It was his attempts that led to the evolution of scientometrics and changed it to a wider area with more scientific communications in socio-economic studies.

There are many definitions for the term "Scientometrics" in the literature. Scientometrics is the quantitative study of the disciplines of science based on published literature and communication. This could include identifying emerging areas of scientific research, examining the development of research over time, or geographic and organizational distributions of research (Glossary of Thompson, 2008[20]). In a brief but general definition, Wilson (1999) [55] defines scientometrics as the study of all quantitative aspects of science, related communications and scientific policies. Osareh cites Bookstein (1995) and provides a clear and brief definition of scientometrics and calls it "the knowledge of measuring science" (Osareh, 1997[40]). Eom (2009) [9] describes it as the application of quantitative instruments to study scientific communications. International Encyclopaedia of Library and Information Sciences (2003) [26] defines it as follows: "Scientometrics is a sub-discipline of Sociology of Science which is mostly related to scientific policies. It is concerned with quantitative study of scientific activities in general and publications in particular". In an elaborate definition, Van Raan (1997)[50] asserts that "scientometrics studies deal with quantitative study of science and technology which aims at knowledge development related to the developments of science and technology and questions considering scientific and social policies. The scientometrics studies are basically problem-oriented and interdisciplinary which take advantage of methods of Social and Behavioral Sciences, e.g. mathematical methods and statistics, models from Social Sciences, observation and survey from Psychology, computer sciences and so forth".

Nalimov and Mulchenko define it as "the application of quantitative methods which is concerned with analyzing science as an information process" (cited in Glanzel, 2003[19]). Since Nalimov's coinage of the Russian equivalent of the term 'Scientometrics'

(naukometriya) in 1969, this term has grown in popularity and is used to describe the study of science: growth, structure, interrelationships and productivity (Hood & Wilson, 2001[24]). San Gupta (1993) [46] refers to the underling purpose of scientometrics as "evaluating the recent developments of any fundamental, scientific content and the effective factors in constant development of research activities in a particular area after World War II". It is nowadays one of the most frequent methods for evaluating scientific activities and managing research. It entails quantitative examination of scientific products, scientific policies, and scientific communications, planning the scientific map of several areas of knowledge and drawing the science map. In scientometrics, scientific communications, methods of producing, distributing and taking advantage of scientific information are measured and evaluated. As a result, it is called the science of measuring science. It determines the achievements of a thinking area and predicts the probable lines for future developments through examining and exploring the underlying structure and system of a scientific area quantitatively. The underlying purpose of any activity in this field is providing the required information for technological, research, and scientific policy making and planning. This information, especially regarding scientific policy making at national level, has received considerable attention and enjoys several economic, social, political, and cultural dimensions (Osareh, 2009 p.44 [41]).

## 5. Mutual relationship between futurology and scientometrics

Nouroozi-chakoli maintains that "scientometrics and futurology were presented when the discussion of Science (with capital S) arose. Science gave rise to the emergence of these fields. In science (with small s), pursuing science was a personal tendency. Before World War II, science was more personal than under the pressure of organizations. In Science, organizations and even a country are in charge. Accordingly, it may disadvantage a country in the case of any loss. As a result, science generated a number of considerations one of which was future studies and science-studying (General Book of the Month, 2013[16]).

One of the main principles of futurology is choosing a model and an appropriate method for gathering the data and information about several topics related to areas under the study and finding an efficient model and method to analyze the data in order to reach a better understanding of the future and facilitate the decision-making procedure (Abdollahkhani, 2011[1]). There are various methods to depict future and foresight (Tabatabaiiyan, 2010[48]). According to conducted research (World Future Society, 2004[56]) there are over 33 methods to carry out futurology studies (Popper, 2008[43]) see Figure 1.

To clarify them more, Vinnari (2014) [52] divides these methods into five categories in terms of the instruments and concepts used in futurology studies:

1. Methods for data collection (for example expert methods, Delphi, questionnaires),
2. Analysis methods (SWOT, trend analysis and cross impact analysis),
3. Tools for data organization (STEEPV and futures tables),

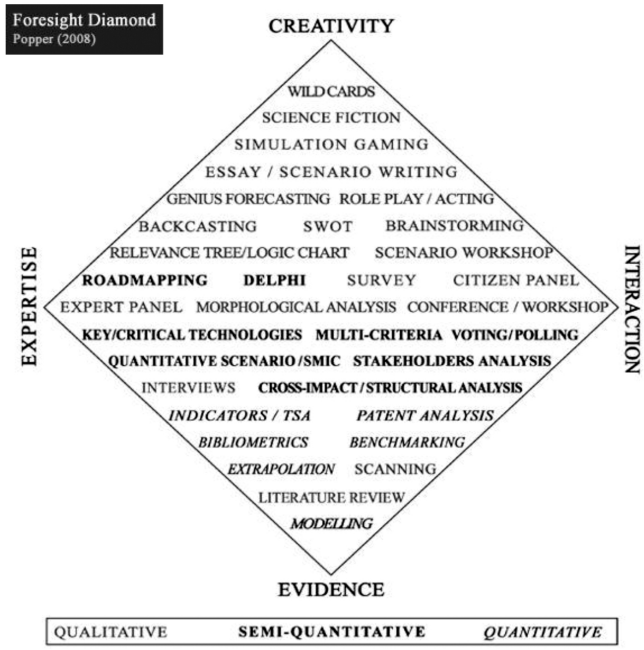


**Figure 1**

**33 methods to carry out futurology studies (Popper, 2008[43])**

4. Tools for representing results (scenarios, back casting and futures images), and
5. Concepts for interpreting futures information (weak signals, megatrends and wild cards).

It should be noted that information is the key element in all of these methods. To analyze the obtained information, all methods make use of scientometrics instruments in one way or another. We have analyzed both the status quo and the future in scientometrics. It should be noted that both futurology studies and scientometrics studies are somehow interdisciplinary. Futurology has a special characteristic, i.e. being at large-scale which does not consider the details. However, it has a number of instruments; one of the most important instruments is scientometrics. Which road we should take and what we need for our purposes come from futurology studies which are achieved through small-scale studies in which scientometrics is involved. Scientometrics instruments can provide the futurologists with these types of information; otherwise, they would not be able to draw the appropriate map clearly (General Book of the Month, 2013[16]).

In recent years, many researchers have conducted scientometric analysis in different subject fields (Wen *et al.* (2007[53]), Mukherjee (2008[35]), Tian, Wen & Hong (2008[49]), Arruda *et al.* (2009[2]). A brief review of the related literature encompasses a number of evidence indicating the involvement of scientometrics in futurology. The available literature

and comparing it with the nature of the studies (Georghiou and Keenan, 2008[17]; Popper, 2008[43]; FOREN network, 2001[12]; Cassingena Harper, 2010[7]; Calof and Smith, 2010[6]; Havas *et al.*, 2010[23]) in the field of futurology indicate that the reports of scientometrics studies can be applied to futurology and contribute to drawing the road map of a country and achieving several visions regarding scientific, political, social, economical, and cultural issues. These studies significantly contribute to the growth and development of new technologies and inventions which the society requires (WMA, 2006[54]).

Diagram 1 displays the results for searching in the aforementioned databases. The articles in which scientometrics were used or highlighted as a tool in futurology studies from 1990 to 2014 were included. According to the diagram, the use of scientometrics as a tool in futurology studies has gained prominence within the last years. On the other hand, futurology studies enjoy a fundamental and basis status in scientometrics. If we separate them, part of the scientometrics studies aiming to making policies and long-term planning would not be possible. As a result, futurology studies should be incorporated into scientometrics studies and scientometrics is at the service of futurology instead. Moreover, the results of a simultaneous searching for the terms "futurology" and "scientometrics" or "Bibliometrics" by the researchers suggests the growing increase in the number of published articles since 1990 till now which might point to more application of scientometrics instruments in futurology studies (Diagram 1).



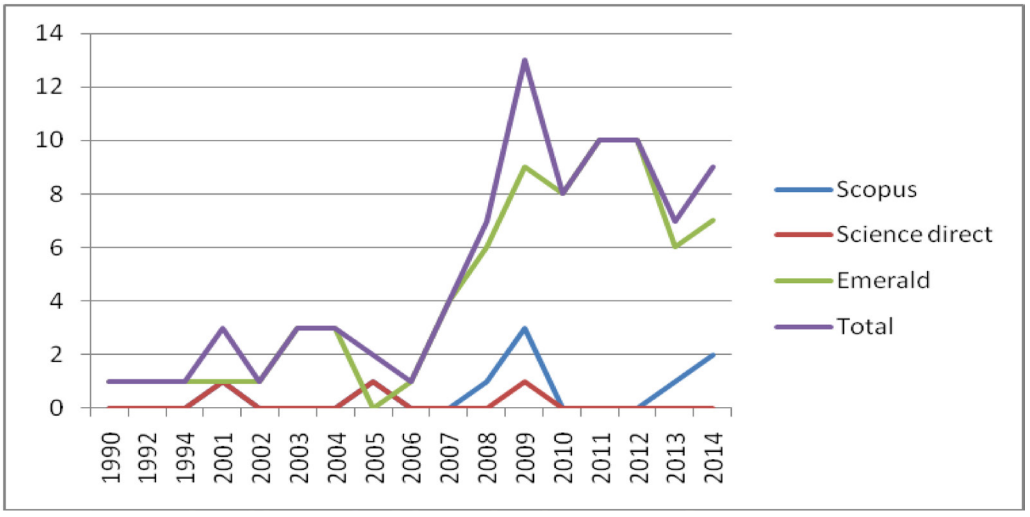


**Diagram 1**

**The results of the terms "futurology" and "scientometrics" or "Bibliometrics" in Scopus, Science Direct, and Emerald since 1990 till 2014**

## 6. The role of scientometrics and futurology in drawing the road map

The real independence and development of the countries is directly associated with their abilities in scientific production and research-scientific development. In other words, the development of the countries relies on predicting future and revising the performance and purposes, explaining the status quo and drawing the future development map in order to meet the local, regional, national and global needs. To this end, obtaining information regarding the scientific and research performance of the countries are essential. Acquiring this information is possible through conducting scientometrics studies (Fadaei & Hasanzadeh, 2010[11]).

According to Kostoff *et al.* (1998) [30] "The relationships among science and technology fields, and the temporal evolution of these relationships, have been of long-term interest to many organizations. The 'roadmaps' of these relationships have been used for science and technology marketing; science and technology management; enhancing communications among researchers, technologists, managers, users, and stakeholders; identifying gaps and opportunities in science and technology programs; technical intelligence; and identifying obstacles to rapid and low-cost product development. The generalized roadmap relates science and technology performed at some point in time to: its science and technology heritage; other relevant science and technology being performed at the same time; and future relevant science and technology and eventual end products".

Observing the scientific issues is included in topics of information sciences. Observation is employed in futurology and scientometrics. It is used to identify both the strengths and weaknesses and to enhance the former and to remove the latter ones. Indeed, it is of utmost significance in reaching the optimal status in scientific map of the country. In order to prepare the best road map, the issues should be observed in practice. It is considered as a key point in scientometrics and futurology in order to reach the optimal future. We have a vision for future which is a precise picture of what we strive to reach. The mutual understanding between future and us is called vision in which our goals are precisely determined. In fact, to reach an optimal status, detailed objectives, competitive goals, modelling, taking models, etc. should be precisely done in scientometrics and futurology (General Book of the Month, 2013[16]). In order to determine the status quo and optimal status, scientometrics methods and content analysis are used. For instance, the number of recorded inventions, research and development expenses, the number of engineers and scientists, and the number of scientific articles in relevant areas, etc. are determined to achieve an understanding of the status quo and the optimal status (Tabatabaiiyan, 2010[48]).

## 7. Conclusion

Scientometrics has received considerable attention as a useful instrument in decision-making areas in scientifically developed societies within the last decades (Georghiou and Keenan, 2008[17]; Popper, 2008[43]; FOREN network, 2001[12]; Cassingena Harper, 2010[7]; Calof and Smith, 2010[6]; Havas et al., 2010[23]). Nowadays, scientometrics instruments

are used not only for contributing to large-scale decision-making and strategic areas but also for enhancing the quality of analytical data especially in universities (Ball & Tunger, 2004[3]; Gorraiz et al., 2010[21]). The number of institutes which are established to meet the ends of scientometrics is growingly increasing (Gumpenberger, Wieland, & Gorraiz, 2012[22]). In this article, the history and definitions of scientometrics and futurology were presented briefly. Moreover, the mutual relationship between these two fields was examined in various texts and their role in drawing the vision and road maps of the countries in different fields was elaborated. It was tried to deal with the role of scientometrics instruments and techniques in screening and determining the existing gap between the optimal status and the status quo and drawing the road map in futurology studies. It should be noted that scientometrics instruments are too limited to evaluate the complete status of an area in a system since the scientometrics instruments are focused on explicit knowledge and research and we have no instrument for implicit parts; what is done in that area cannot be observed since numerous scientific products are the result of unpublished researches. Having access to a well-defined vision requires operational, timely and integrative planning at different levels. This planning should take advantage of a set of resources, facilities, and talents so that it starts from status quo and moves toward the defined status in vision document (optimal status) through an organized and steady movement in a specified time. This is exactly futurology. Realizing this process requires drawing an accurate road map in which taking the road, predicting resources and facilities, dividing labour at national level and the way of participating and considerations are precisely and clearly specified. In this way, the vision is developed in detail and at smaller and more operational scales. This requires drawing a precise road map based on scientometrics instruments. Codifying the documents of scientific developments of the country and the comprehensive scientific map of the countries are in line with scientometrics studies. To put in a nutshell, futurology of any area should be based on accurate methodology and observation of the status quo through accurate scientometrics instruments and methods in order to see how many ways are available and to spot the problems. Moreover, metadata and instruments for analyzing them are needed in order to reach the minimum amount of information. Information sciences play a mediating role and set the required informational scenes. Through using appropriate information settings and using scientometrics instruments, accurate futurology in relevant areas would be possible in different countries. All in all, it is inferred that scientometrics and futurology topics are closely interwoven. Using scientometrics instruments in periodical screening of the road map and future road of various areas is both effective and inevitable.

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