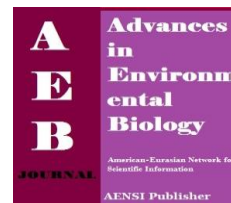




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The Impact of Earthquakes on Scientific Production in the Field of Seismology in the Earthquake-Prone Countries

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ABSTRACT

The purpose of this study is to investigate the relationship between the occurrence of earthquakes and the production of science in this field. Analysis of seismic records using scientometric methods based on the science citation index in this article is an attempt in testing the hypothesis of effects of earthquakes on the scientific production in the earthquake-prone countries. Data were extracted from the Web of Science database during 1990-2011. The research findings showed that 21,357 related documents are produced in the field of seismology, of which more than 70% of them fit the purposes of this article. The calculated scientific production rates indicate an upward trend of 39% in this field. This study examined the relationships among the authors in this field regarding the scientific productions, and the results demonstrated high level of correlation with cooperation coefficient of 85%. The results also showed that 84% of the scientific productions have been produced in three sub-fields of earthquake engineering, geology and geophysics. Similarly, the results showed that there is a significant relationship with the occurrences of earthquakes and the levels of scientific production in the earthquake-prone countries with the P value of 0.05.

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INTRODUCTION

Amongst all natural phenomena, earthquake causes the most unfortunate developments than any other, and every year produces numerous injuries and causes financial burden all around the world. Despite their painful results, these events are per se a testament to preserve human's strength against them, to a point that in a verse stated in the Holly Quran "it qualifies as without a doubt in God's trial over fear, hunger, reduction in earthly possessions, loss of lives and products, and the gospel of those patients" (Baqra, verse 155). The meaning of Holly Quran verse points to human trial against hardship and adversity. Earthquakes, volcanoes, and floods are such examples of human plagues. From the year 1900 to 2011, some 46 major earthquakes measuring between 6 and 9 degrees, or more, on the Richter scale have occurred. The stated statistics from these occurrences indicate a loss of life exceeding 2 million people and untold and incalculable damages [1].

According to Fig. 1, 31 countries and two American States are located on the major fault lines which are known as earthquake-prone countries. These countries are Armenia, Afghanistan, Indonesia, Italy, Iran, Azerbaijan, Argentina, Pakistan, Peru, Tajikistan, Thailand, Taiwan, Turkey, China, Japan, Chile, Fiji, Kyrgyzstan, State of California in USA, Colombia, Cuba, Guatemala, Guinea, Morocco, Macedonia, Mexico, Nepal, New Zealand, Haiti, India, and Greece [2].

Natural phenomena such as earthquakes, floods, volcanoes, and other destructive forces have always demanded human attention due to their disparaging natures. However, they have also forced us to invent equipment and methods to combat them. Governments and organizations have employed many through research centers, universities, scientists and researchers to combat these plagues with scientific methods, and for years have produced many scientific products through various information databanks from researchers and scientists throughout the world in the field of seismology for the purposes of identification and scientific combat against them which have been produced and published by the scientific communities. The studies of scientific activities in this field in the earthquake-prone countries and regions have also attracted the attention of journalists resulting in this general inquiry as to what is the scientific behavior of these countries in regards to this issue.

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Fig. 1: Earthquake-prone regions world

1.1. Research objectives:

The basic objective of this study is to investigate the scientific status of countries located in the earthquake-prone zones on the earthquake scientific productions over a period of 22 years (1990-2011) as stated in the Web of Science website, with the objectives related to the occurrence of earthquakes and production of science in this field.

In order to obtain this goal the following questions must be explored:

1. What are the types, languages, and scientific productions in the field of seismology?
2. What are the leading countries in scientific production and related science?
3. Who are the leading authors in the field of seismology?
4. What is the publication growth rate in the field of seismology?
5. What are the leading universities and scientific research centers in the field of seismology?
6. What is the coefficient of cooperation and how is co-authorship relation in the production of seismological papers?
7. How is depicting of co-authorship relationship in the earthquake-prone zone countries?
8. What is the proportion of scientific production amongst the earthquake-prone zone countries?
9. What is the relationship between the occurrence of earthquakes in the earthquake-prone zone countries and the scientific production?

1.2. Research background:

Scattered research papers in journals and online sources indicate designated earthquake-prone zones in the world. The earthquake-prone regions on the earth have established zones. The research conducted by the researchers in this field on the published mediums such as in paper and electronically show that there has only been one conducted direct research on the effects of earthquakes. Other researches are indirectly connected with this current research. Citation analysis of geophysical evidence by the Geophysical Institute of University of Texas in the US shows that 1,128 documents related to the earthquake engineering have been published by the researchers from this institute [3].

Also, the results of another research conducted in 51 universities and institutions around the globe with the aim of finding influential researcher in ISI regarding earthquake engineering field, show that the number of earthquake engineer researchers in ISI are few and even fewer indexed documents are filled in this field. The findings of this study also indicate that fewer researchers work independently in the field of earthquake engineering [4].

In another research, the effects of earthquake in the Sea of Marmara along the Gulf of İzmit, Turkey was studied by the researchers during the years from 1990 to 2009. The findings of this research showed that the number of published documents by the Turkish scientists after the said earthquake in 1999 increased significantly and the country of Turkey is currently holding the 11th ranking in this field [5].

In Iran, there has not been any independent seismic study in this field. Emami *et al.* conducted a research on the geological scientific production of Iran published in the ISI database in the years between 2005 and 2009. The results of their study show that in Iran the field enjoys a progressive scientific move, and some 270 articles have been published in the English language. From these totals, some 32 articles concentrated on fault lines and earthquakes [6].

In reviewing the background studies, while finding similarities of this research with the previously used methods, this research emphasizes the measurement of effects of natural phenomenon on the progression of one science. Perhaps it is based on this view that the study seems to be unique in itself and the least is that this research offers a new classification and attempts to look at the issue with a new approach.

1.3. Research methodology:

The current research is conducted using an applied methodology and for answering the proposed research questions, a scientific survey method and other similar methods were used. Based on this goal, the required documents were extracted from the general scientific documents in the spring of 2012. For collecting data, the word "earthquake" was researched in the search area of the Web of Science website with limiting factor of time period (1990-2011). The search resulted in 54,620 document hits. For more detailed and relevant analysis, the search was further refined and ultimately 21,357 documents were selected as the statistical data sample population. For the data analysis, statistical methods such as frequency and percentage distributions, central indices, and correlation coefficients of Pearson and Spearman were used using the SPSS software.

2. Results:

From 21,357 selected documents in the field of seismology in the science citation, the most documents in popularity that fit our research were narrowed down to 15,012 documents (70%) and 95% of documents were authored in the English language. Also, from the selected documents 6,683 documents (31%) concentrated on geophysics, 6,052 documents (28%) with concentration on geology, and 5,686 documents (25%) on earthquake engineering. Table 1 shows the detailed information.

Table 1: Format, subject, and language of scientific productions in the field of seismology from 1990 to 2011

Format					Subject			Language	
Short article	Review article	Editorial	Proceeding	Article	Geophysics	earthquake engineering	Geology	English	Others
238	270	544	5004	15012	6683	5686	6052	20012	1345
2%	2.23%	4%	23%	70%	31.16%	26.16%	28.33%	95%	5%

141 countries had cooperated in composing these documents in the field of seismology, with 28.41% of documents being produced by the United States alone, and other countries such as Japan, China, Italy, and France were ranked further down in the scale. 27,689 authors cooperated in composing 21,357 documents. The Japanese authors are the leading composers of the scientific productions in this field. Given the widespread cooperation of authors, it is difficult to centrally classify the authors. In another word, the Lotka principle cannot be applied in this field. The trend in the number of publications is shown in diagram 1. This diagram shows that in 1990 from 518 produced documents, after a period of 22 years the numbers have increased to 1,847 in 2011.

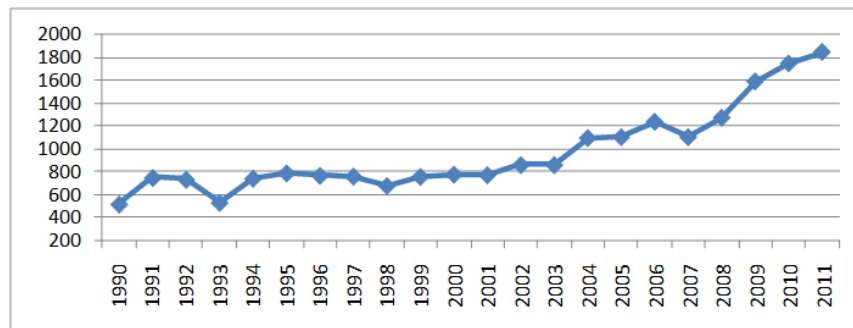
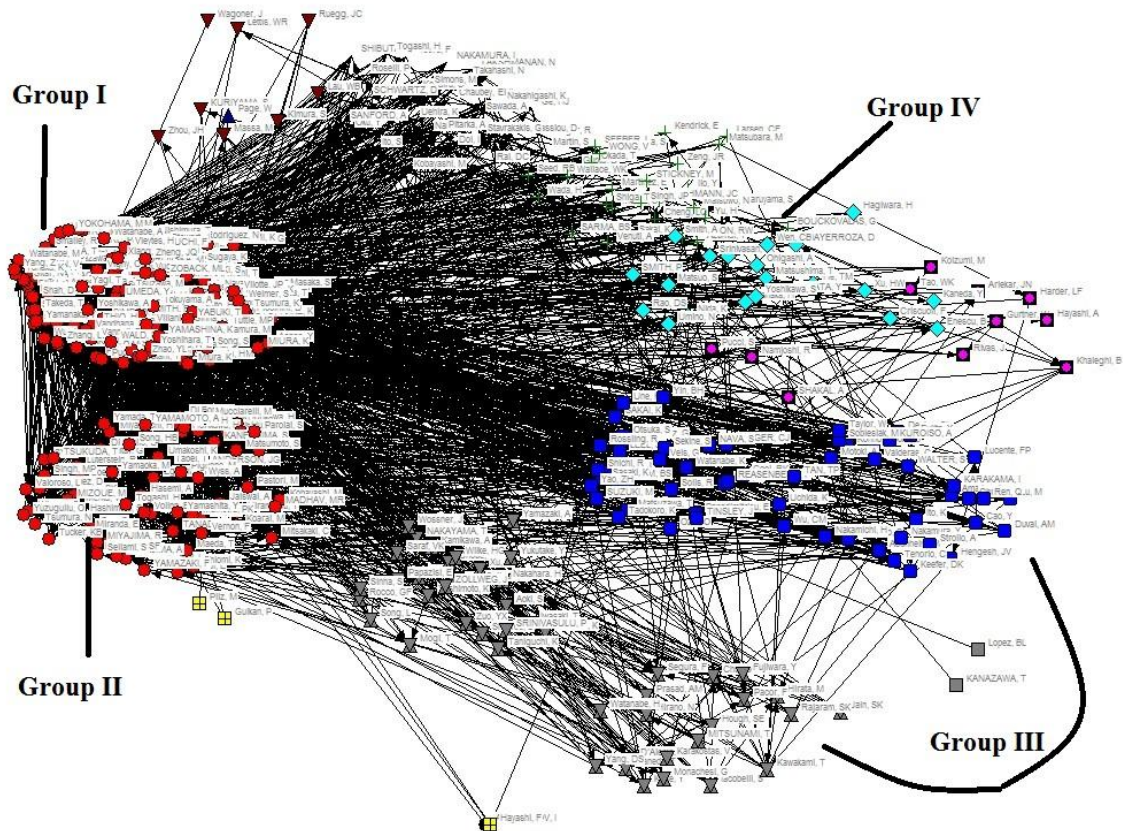


Diagram 1: Scientific productions in the field of seismology from 1990 to 2011

In total, the rate of increase in scientific publications in this field is equal to 39%, as is shown in diagram 1. The scientific production in this field has enjoyed an annual increased growth with the peak reaching at 29% in 2009. In total, there are some 2,345 universities and research center cooperating in the field of seismology. The US Geological Survey Research Institute in the US and the Russian Academic Science in Russia as well as the Tokyo University in Japan hold the highest share of production of scientific documents in the field of seismology.

The rate of cooperation amongst the authors in this field was also the subject of this research and the produced documents were classified based on their authors. The coefficient of cooperation between the authors in the field was calculated to be at 85%. It seems that that the field of seismology is a unique field because the field has a number of sub-categories, thus in research projects many teams throughout the globe can cooperate with each other and their results are published in a group format in international journals. In the area of co-authoring, the Japanese authors in this scientific field have had more cooperation with the authors from other countries. Map 1 shows in details the levels of this cooperation.



Map 1: Grouping of authorship relationships

Map 1, based on the thematic homogeneity in related fields, constitutes communications circles. The concept of this map is that the cohesion amongst the authors is based on the theme of their field and scientific productions in respect to the field of seismology, in a way that the circles are colored; red indicating cohesion of authors' activities in the field of geology and fault lines. The color green showing the cohesion in the issues of planning, the color blue showing natural geography, and other colors scattered in the areas of earthquake engineering and dependent orientations.

2.1. The Relationship between Earthquakes and Scientific Productions in this field:

Between 1990 and 2011, 28 major earthquakes ranging from 6 or higher on the Richter scale have occurred in the earthquake-prone countries. Japan with 4 occurrences, Iran and Pakistan with 3 each, and Italy, California, and Turkey with 2 occurrences each are amongst the most important countries in this field. In 2003 and 2005, the world witnessed occurrences of 8 strong earthquakes in Iran, Algeria, Turkey, India, Indonesia, Japan, Pakistan, and China which caused enormous financial damage and great loss of life. In 2003 and 2005, the most number of earthquakes occurred, and at the same time during this period 2,013 scientific documents were produced in the field of seismology. These two years are ranked 15th and 16th, respectively. However, between 1999 and 2002, which 5 major earthquakes occurred, the trend in the publications growth remained nearly constant. Between 2004 and 2011, in total 12 major earthquakes occurred, the trend in the publication of scientific documents by authors enjoyed a 33% growth.

The United States of America holds 30% share of the productions in this field in this research. In total the earthquake-prone countries such as China with the least number of earthquakes have a positive number of scientific productions in this field, and also other countries such as Taiwan and Mexico despite not having experienced any major earthquakes during the span of 22 years of the study, have contributed to the production of the scientific products in this field. Also the city of San Francisco in the state of California in USA, Armenia, Morocco, Peru, Macedonia, and Nepal have similar situation. It seems being located on the earthquake zone plays an essential role in giving urgency in risks, thus the increase in the number of scientific products in this field, and this trend could be as result of previously recoded earthquakes prior to 1990 which are frequent in these cities and countries. The country of Japan with 5 major earthquakes is one of the most productive countries in this field. China and Italy hold the following rankings. Iran with 278 documents and 3 major

earthquakes holds the 10th position in this comparison. Pakistan with 3 major earthquakes alone has authored 57 scientific records in this field. Taiwan without any major earthquakes holds the 5th position.

2.2. Hypothesis testing:

In response to question number 9, for either existing or a lack of a relationship between scientific productivity and occurrence of earthquakes in the earthquake-prone country, a test was made. According to the test given the significance level of correlation coefficient of Pearson ($-1 \leq r \leq +1$), a significant relationship was observed between the occurrences of earthquakes and the production of scientific products in the earthquake-prone countries. It is translated that the occurrence of earthquakes directly correlates with increased scientific productions by authors. However, this relationship is not strong. Therefore, it is expected that the occurrence of this phenomenon results in more scientific productions throughout the globe.

3. Discussion and Conclusion:

The term "earthquake-prone country" in this research is referred to countries that within the past one hundred years have experienced at least one deadly earthquake with devastating damages. Based on this definition, 31 countries were identified in this research. Research investigation suggests that in the span of 22 years, between 1990 and 2011, 21,357 documents regarding seismological activities have been produced in these countries. The results of this research show that the growth of publications in this field has enjoyed rapid increases equaling to 39% growth rate. The results confirm Taskin's results [5]. In this field, the most productions are within the format of article, while 85% of all articles are written in 3 subcategories of geophysics, geology, and natural geographical and earthquake engineering. In the production of scientific documents in this field, 141 countries played a role of which 93.82% of the composed documents were accomplished by 16 countries. In composition of these documents, 27,879 authors had cooperated and there are no specific outstanding individual authors who could claim contributions of more than half of the productions to himself, meaning that Lotka principle cannot be applied here.

In this research, the relationship between the authors was also investigated. The results suggest that there is a widespread cooperation amongst the authors and in general an 85% coefficient of cooperation can be found in this area. In terms of social perspective, the earthquake phenomenon is considered an international occurrence, and whenever an earthquake happens all the people of the world express their sympathy, as well as nations coming together to provide care for each other. Based on the findings of this research, perhaps it can be concluded that just as nations come together to help one another in times of occurrences of earthquakes, authors are also influenced by this phenomena in sharing scientific productions specially using scientific methods in combating these phenomena. The graphical map showing the 85% coefficient of this cooperation confirms this fact. The results of this research show that the Japanese authors are more active in this field than any other authors. It can be considered that because Japan is the most earthquake-prone country in the world with the strongest earthquakes, this is impedance for high activities of Japanese authors. In general, it can be concluded that in the field of experimental sciences and technical and engineering science, co-authoring relationships are set at higher levels. These findings are compatible with the findings of Rahimi and Fatahi [7], Hasan-Zadeh and Baghaie [8], Osareh and Nourozi Chakoli, and Mariam Keshvari [9], Braun and others [10]. The result of this research also show that in the recent past one hundred years, 46 devastating earthquakes have occurred between 1906 and 2012, and the earthquake belt in the world is divided into three distinct zones. The results of the first research show the occurrence of earthquake influences the scientific production and has a significant meaning and its correlation coefficient was 539, meaning that in general and specific occurrences of earthquakes have a high value of influence on the produced scientific documents in this field, specifically in the three main categories that include earthquake engineering as a new academic discipline, geophysics, and geology.

In recent years, as a result of broad consequences, including heavy human and financial losses, the earthquake-prone countries in particular have become sensitive to this issue, and plan for reducing the devastating effects of earthquakes. In many of these countries, annual conferences and congresses are held at either national or international levels. New academic disciplines such as earthquake engineering and geology of earthquakes have started new trends in studies of fault lines, etc. Also, universities and earthquake engineering teaching groups have been established. Many authors have spent a lot of their times producing documents in this field. The discussion on education and prevention is focused on public education which is in the realm of government projects. Countries such as Iran, Turkey, Chile, and Japan have suffered greatly in the recent decades from these phenomena. Coastal communities are in great danger of earthquakes occurring at the ocean depths causing devastating tsunamis. The timing of these events are never apparent, but with scientific advances and global activities in this field, there will be a day that scientists could determine and predict the timing of occurrences, because scientific advances in the framework of produced scientific documents in this field all point to that premise.

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