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Evaluating the Performance of the Scientific Research in the Iraqi Universities

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Abstract: One of the most important factors that play a basic role in life development is scientific research. The main sources of scientific research are universities, laboratories, and research centers. In this regard, the importance comes in periodic evaluation of the performance of scientific research. This work deeply analyzes the performance of the Iraqi universities in terms of scientific research. It generates a Citation Network among the main Iraqi universities for this purpose. This type of network has the ability to reflect the actual status of scientific research in Iraqi universities. This study uses an approach based on the concepts of complex networks. The process of collecting data is done by designing a special-purpose program called a crawler. This crawler crawls the Google Scholar repository and retrieves all the data required. Based on the official educational domains of Iraqi universities, the crawler collects information from published research articles. The main facts on scientific research activities. The second contribution is to propose a local rank for the main Iraqi universities based on network measurements and other academic indicators.

Keywords: Citation Networks, Collaboration Networks, Iraqi Universities.

1. Introduction

Recently, scientific research in Iraq has witnessed a great revolution compared to the previous decade. This quantum leap came after moving the Iraqi Ministry of Higher Education and Scientific Research toward developing Iraqi universities. The most important step was to encourage Iraqi researchers to publish their work in high indexed venues. Another step was to provide scholarship opportunities for the scholars to carry out their research abroad and to bring some experiences with the aim of having a variety of experiences at Iraqi universities.

Furthermore, the collaboration opportunities with international institutions and universities have enriched Iraqi researchers with more experiences in terms of the quality of published research (Cress et al., 2016). According to (Yossra et al., 209), the quality and number of published articles have increased significantly in the last ten years. These facts lead to more thinking about the way of increasing the Iraqi universities' status and obtaining high international academic ranks. Therefore, observing the patterns of the research activities of Iraqi researchers is very important. Also, performing an evaluation process to have a deep view of the current scientific research status in Iraq. These processes help to develop and promote the current patterns in a way that leads to improve the whole scientific status of Iraqi universities. In this regard, the citation network of a university or a group of universities can be used to investigate the citation and publishing patterns followed by Iraqi researchers (Antonis et al., 2019). In a citation network, "two or more articles are considered to be connected if one of them is cited by the other article" (Son et al., 2018). In such networks, articles are represented as nodes and the links among them reflect citations among them. Citation networks are also used to measure the scientific status of a university or an individual researcher in a research community (Massucci & Docampo, 2019). They can also show all the past and the current collaboration activities performed by the authors.

This study aims in generating the Iraqi Citation Network for Iraqi researchers based on their disciplines and affiliations. This will reveal many facts about the actual scientific status of research communities of Iraqi universities. The main contributions of this work are:

- 1- Generate the citation network of the main Iraqi universities and extract the main facts on scientific research activities.
- 2- Propose a local rank for the main Iraqi universities based on network measurements and other academic indicators.
- 3- Investigate the scientific collaboration among the Iraqi universities and with the worldwide universities.

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Appendix I, Table 1 presents a summary of the Iraqi universities that have been considered in this work.

2. Related Work

The task of measuring the scientific impact of universities is not easy. There is a variety of indicators to evaluate a university. This kind of issue has been contained in some studies in the literature. Massucci & Docampo (2019) have used the PageRank algorithm to measure the universities' reputations. Their study has brought the necessary indicators from the Web of Science. Zhou et al. (2019), have extracted the impact of publishing venues depending on the number of citations and the impact of these venues. The basic problem of this study comes when the publishing venues do not have an impact factor. Lewis, Jonathan (2020), have measured the scientific collaboration in citation networks. Bu, 2020 has used data from the Web of Science and ECCN to explore citation networks. Three issues are investigated in this study, they are, the structure of the network, the function of the network, and the bibliometric indicators. The approach used these factors to evaluate the scientific status of authors and institutions. It was based on the frequency of citations among different disciplines.

3. Data Collection

For the purpose of collecting data, a crawler program has been designed by the R programming language. The crawler crawls the papers published by the Iraqi researchers using the Google Scholar service. The process of data collection has depended on a particular dictionary containing the main twenty-two Iraqi universities. The dictionary includes information about Iraqi universities such as university names and university domain names. In addition, the crawler retrieves all the published papers by the authors who are verified on Google Scholar using their official educational domain (e.g, *author@universitydomain.edu.iq*).

In this work, "information has been collected from the research of Iraqi researchers on the Google Scholar repository from 2000". The collected data included information such as 'author identifier', 'author's affiliation university', "author total citations', 'author discipline', 'author total articles', and "the affiliations of the author's co-authors". Then, the crawler processes and formalizes the collected data for the purpose of generating the dataset which contains publications as nodes and citations as edges between the nodes. The dataset also includes data have been collected from Scopus and ResearchGate repositories.

4. Methodology

After collecting data, the dataset is formalized by the crawler to be suitable for visualization. The dataset includes nodes and edges among them. This study follows a strategy for the creation of network objects (nodes and edges) depending on the following:

- a) "Each publication that was authored by an Iraqi author(s) is formed as a node".
- b) "If the publication in (a) was cited by a publication authored by another Iraqi author, then an un-directed edge is created between them".
- c) "Some of the publications might be authored by Iraqi and international authors, these cases are considered in this work since this kind of publication has Iraqi authors".

Many works in the literature have used the above strategy such as (Pramod & Menezes, 2013), (Mahmood et al., 2020), and (Basheer & Mahmood, 2020). The generated network has been called the 'Iraqi Citation Network (ICN)' which contained 25,834 nodes and 167,267 edges among the nodes. It should be mentioned that this study uses an undirected type of edges in spite of the citation being considered as one direction relation because the direction is not of interest in the concept of this study.

4.1 Network Measurements:

a) Average Path Length l: The Average Path Length defines the average number of all the shortest paths for all possible pairs of publications in ICN. It is calculated using the following equation (Sultan et al., 2020):

$$l = \frac{1}{n(n-1)} \sum_{i \neq j} d_{ij} \tag{1}$$

where d_{ij} is the length between the publication *i* and *j*.

- b) *Diameter O*: For all shortest paths in the network, it represents the longest path (Sultan et al., 2020). It shows the distance between the farthest two publications in ICN.
- c) *Density D*: It defines the ratio of the number of actual citations to the number of potential citations in a network (Sultan et al., 2020). In other words, it shows the density of relations

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among Iraqi authors in ICN. It can be calculated based on the following equation (Sultan et al., 2020):

$$D_{G} = \frac{2(E(G))}{N(N-1)}$$
(2)

- d) Average Clustering Coefficient A_{CO} : This measure is also named as global clustering coefficient. It defines the average of authors' tendance to cluster with each other. In another word, it reflects the average tendency of Iraqi authors to collaborate and work in research groups (Strogaz, 2001).
- e) *Communities cu:* It represents the density of connection of the Iraqi authors in ICN. Using the Girvan-Newman algorithm (Strogaz, 2001), this work extracts ICN clusters and reveals the collaborated research groups. By applying this algorithm, the relations among ICN communities are recognized and removed which makes the communities isolated. The Girvan-Newman algorithm discovers network communities depending on betweenness centrality.
- f) Degree Distribution: The degree distribution of a network is considered as an important indicator of the nature of that network. For instance, if the degree distribution of a network followed a power-law distribution, according to (Wu et al., 2007), this network is classified as a scale-free network. In this kind of network, the newly attached nodes tend to cluster and collaborate with the highly connected nodes in the network. This preferentialphenomenon is called attachment. In this context of the ICN network, the fresh researchers have a strong tendency to collaborate with the most influential researchers.
- g) Clustering Coefficient CO: As mentioned in (d), this measure shows the authors' tendency to collaborate and work in research groups. For each author, CO can be calculated as follows (Wu et al., 2007):

$$CO_{(i)} = \frac{2|\{l_{jk}: n_j, n_k \in Ni, l_{ik} \in E\}|}{ki(ki-1)}$$
(3)

Where l_{jk} is a research group between the publications n_j and n_k . While N_i is the total number of publications in ICN and ki are the closest cited publications in the network.

h) Betweenness Centrality C_b : It shows the number of citations for a publication in the ICN shortest path. So, a publication with high citations can be considered a bridge between the publications in ICN. Betweenness

Centrality can be also used to evaluate the level of scientific collaboration between the authors. The value of C_b for an individual *j* is calculated as follows (Mahmood et al., 2020):

$$C_b(j) = \sum_{i \neq j \neq k} \frac{\sigma_{ik}(j)}{\sigma_{ik}} \tag{4}$$

Where σ_{ik} is the shortest paths between publications i and k. $\sigma(j)$ is the number of paths passing through the publication *j*.

- i) *Degree Centrality Cd*: For a particular publication in ICN, it shows the frequency of citations (Wu et al., 2007).
- j) Closeness Centrality C_c : It refers to the reciprocal of the sum of all shortest paths of a publication to other network publications. Also, Closeness Centrality shows the closeness of a publication/author to other network publications/authors and can be calculated as follows (Mahmood et al., 2020): $C_c(i) = \frac{N-1}{\Sigma d(ij)}$ (5)

Where d(ij) represents the distance between publications *i* and *j*.

4.2 The Proposed Approach for Ranking

This section describes the proposed approach for ranking Iraqi universities. The proposed approach is based on concepts inspired by sociology. These concepts can be as follows:

- Assortitivity or sometimes called Homophily: a) This concept refers to the tendency for people to have (non-negative) ties with people who are similar to themselves in socially significant ways. The term itself specifically refers to an internal preference (Rivera et al., 2010). In the context of this work, this concept means that authors tend to collaborate with others who have similar features such as affiliation and discipline. The value of assortitivity is calculated for each pair of authors in each university considered in this work separately aiming at having the average value of assortitivity for further use it in the proposed rank. The assortitivity is represented as a vector that includes the following information: Affiliation: aff(i,j) = 1; if the authors i and j
- work in the same university, and 0, otherwise.
- Discipline: disc(i,j) = 1; if the authors i and j have the same discipline, and 0 otherwise.
- Citations: cite(i,j) = 1 if the authors i and j have cited at least the same publication, and 0 otherwise.

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- Collaboration Frequency: *collaboration(i,j)* = the number of publications that the authors i and j worked together, and 0 otherwise.
- International Collaboration: *inter* collab(i,j)= 1 if both i and j co-authored a publication with international authors, and 0 otherwise

The formula assortitivity for each pair of authors in ICN for a university k can be as follows:

 $Ass. (i, j)_k = Aff(i, j) + disc(i, j) +$ cite(i, j) + collaboration(i, j) + $inter_colab(i, j)$ (6)

After calculating the assortitivity for all the pairs in ICN, the average assortitivity for each university (k) is extracted as follows:

Assortitivity $k = \sum_{i,j=1}^{N_k} Ass. (i, j)_k / N_k$ b) International Collaboration (*IC_k*): (7)

This indicator is very important since it shows a university's colourful experience with worldwide universities in terms of scientific collaboration. It can be calculated as follows:

$$IC_{k} = \sum_{i=1}^{N_{k}} inter_collab(i, j)_{k} / N_{k}$$
(8)

c) University Citations (C_k) : This indicator shows the impact of a university on research communities around the world and is calculated as follows:

 $C_k = \sum_{i=1,j=1}^{N_k} cite(i,j)_k / N_k$ (9) RG Score (*RG*_k): The academic social network d) ResearchGate assigns an indicator called RG Score for researchers around the world. The RG Score for a researcher depends on his scientific activities such as the number of published articles, the number of interactions, the number of projects, the number of answers to the questions of other researchers, and the number of uploaded scientific contributions on the platform. The RG Score for a university is the summation of RG Scores of that university's authors and is calculated by the following equation:

$$RG_k = \sum RG_{ik} \tag{10}$$

Where *i* is an author in a university *k*.

Scopus Indicator (SI_k) : The proposed rank e) included one of the most important indicators which is the Scopus indicator. For a particular university, it represents the ratio of the number of documents in Scopus to the number of registered authors in scopus. Scopus indicator shows the impact of a university in research

communities in worldwide and can be calculated as follows:

$$SI_k = \frac{\text{Number of publications of } k}{\text{Number of authors in } k}$$
(11)

Finally, the final formula of the proposed rank for ranking Iraqi universities will be as follows: (which is the summation of the collected values of the aforementioned indicators)

 $RANK_k = Assortitivity_k + IC_k + C_k + RG_k + SI_k$ (12)

Results and Discussion 5

This work has applied the visualization to the ICN network by using a visualization tool called Gephi (Bastian et al., 2009). The hardware requirements to perform the visualization process was; CPU Intel Core i7-9700TE, with a frequency of 3.8GHz, 8 cores, L2 Cache 8 × 256 KiB, and L3 Cache 12M, and RAM of 64 GB. The Windows 10 operating system has been used for the visualization. The visualization of the ICN network is shown in Figure 1.



Figure 1: The visualization of Iraqi Citation Network (ICN)

The above network shows the giant component of ICN. As described in the previous section, the publications are represented as nodes, and the citations among those publications are represented as edges between these nodes. In the figure above, it can be noted a lot of colored clusters. Each color represents a different discipline within Iraqi universities and each cluster represents a research group within an Iraqi university. The largest clusters belong to the largest Iraqi universities.

The main Characteristics of ICN are shown in Table 2. The average degree is 3.671, which means that the average number of Iraqi researchers'

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publications is low in comparison with researchers from worldwide universities (Pramod & Menezes, 2013). The diameter is 15, which is acceptable if it is compared with similar networks. In a citation network, the diameter is affected significantly by the scientific collaboration level among researchers. PL is the Average Path Length which shows the average shortest path for all pairs of nodes in ICN. The density reflects an accepted level of citations among Iraqi researchers. The modularity (GirvanNewman) level (Newman, 2006) reflects the strength level of the extracted communities. This level's value is 0.752; this means that the scientific collaboration among Iraqi authors is high, which is a positive indicator. The average clustering coefficient is 0.322, which means that the Iraqi authors' tendency to work in research groups is weak, and this negatively affects the expansion of the current groups. The average path length is 4.571, which is acceptable as compared to the diameter.

Table 2: The characteristics of the ICN network

No. of nodes	No. of Edges	DICN	0	D	Modularity (Girvan- Newman)	Aco	PL
25834	167267	3.671	15	0.01	0.752	0.322	4.571

The degree distribution of ICN follows a powerlaw distribution as shown in Figure 2. In citation networks, the power-law distribution is the most common feature. The networks that follow this distribution are called scale-free networks (Albert & Barabasi, 2002), and also, they have the preferential attachment characteristic (Albert & Barabasi, 2002). In other words, new authors prefer collaboration with those that have high connections (have many more published articles) in research communities.



Figure 2: Degree Distribution of ICN network.

Many main facts on scientific research in Iraq have been extracted based on the dataset. Table 3 in Appendix I presents the number of articles, RG score, number of authors verified in Google Scholar, the actual number of authors, and Google Scholar citations for each university has been considered in this work. It is clear that the university of Baghdad outperforms other universities in the number of articles, the number of citations, and the RG score. Table 4 in Appendix I presents the scientific situation in Iraq compared to neighboured countries. From the results, it can be observed that Iraq lags behind most of these countries because of the side-effect of the recent wars. Therefore, Iraq needs more work and effort to regain its leading role in scientific research in the region and worldwide.

Table 5 in Appendix I depicts the scientific research performance of each discipline in Iraqi universities within the Scopus repository. The table presents the h-index, the number of papers, the number of citations, and the average citation for each published paper. It can be observed that the Medicine field has the highest h-index of 85 and the highest average citation per article of 8.52, which means that the activist field of research in Iraq is Medicine and which is promising. The second activist field is Engineering with an h-index of 60, but the average citation per paper is 3.81, which is low compared to the h-index. The fields of business administration, economics, and humanities have low h-index values. So, these fields' research communities need to be more active in scientific publication.

The total citations of Iraqi universities have been presented in table 6. Unfortunately, some of the largest Iraqi universities such as the University of Al-Mustansiriah and the University of Basrah are not found in the table. However, that did not mean their performance is low compared to other universities.

The collaboration network has been visualized in this work based on the data collected from the Scopus repository. Figure 3 visualizes the Iraqi

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Scientific Collaboration Network. Using the Geo layout visualization, each university is projected to its coordinates on an Iraq map by its latitude and longitude. Each node represents an Iraqi university and each edge represents a collaboration between two universities. Each university has a collaboration (relation) with all Iraqi universities. However, this work takes the strongest collaboration level between each pair of universities. In this regard, the work takes the highest two collaborators. For example, the University of Mosul's authors have collaborations with all Iraqi universities, but the most repeated collaborators are considered (the top two universities). In Figure 3, the University of Kirkuk has no edges meaning that its top collaborators are international. Anyway, the node that has one edge; one of its top two collaborators is international. The node that having three edges; two of its collaborators have the same level of collaboration.



Figure 3: Visualization of the Iraqi Scientific Collaboration Network for the Iraqi Universities.

The University of Baghdad has a degree of 15 because it has collaborations with almost all Iraqi universities and therefore can be considered the core centre of scientific research in Iraq. Although that, the degree of the network is not strong enough, which is 3.5. The diameter of the network is 4, which means that four edges are needed only to move between the farthest two nodes in the network. The density is 0.169, which is an accepted value because the strongest two collaborators are considered only. An interesting property is that after using the Girvan-Newman algorithm, five major communities have appeared with a weak modularity level of 0.376. This means the research communities in Iraq cluster into five interfered

communities. Based on the visualization, these communities are:

- North Community
- South Community
- Middle Community
- Middle South Community

Blended Community

Based on the communities extracted, it can be observed that the Middle community is the largest one and is the most productive in Iraq. The University of Kirkuk appears as an isolated node because it doesn't belong to any of the above communities based on the data collected from the Scopus repository. It should be mentioned that the University of Kirkuk has strong collaborations with Iraqi universities in publishing in the local Iraqi scientific journals. The average clustering coefficient is acceptable, which means that Iraqi universities tend to cluster in larger research communities. The average path length is 2.1 and is also acceptable in the need of getting from one university to another.

This work also visualizes the international collaboration of Iraqi universities based on the Scopus repository. It should be mentioned that Iraqi universities have collaborations with many more universities in the world. However, this study takes the strongest collaborations. Figure 4 shows the international collaboration network of Iraqi universities with worldwide universities. The international collaboration network is visualized by using the Geo layout visualization tool and the Map of Countries tool to project the countries' coordinates on the map of the world based on the latitudes and the longitudes of the countries (as had been applied in Figure 3). The nodes represent the countries and the center node represents Iraq because the collaboration is about Iraqi universities. Each edge represents a collaboration. The weight of each edge reflects the level of collaboration and depends on the frequency of collaboration.



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Figure 4: Visualization of the International Collaboration of the Iraqi Universities.

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Based on the results, the most robust collaboration was with Malaysia because most Iraqi researchers gained their degree from Malaysia and there was exist many post-doc positions available in recent years. The second strongest collaboration was with universities of UK, then with the US. That was due to the scholarships from 2009 to 2014 that led many Iraqi students to study there. Iraq has also strong collaboration withTurkey, Iran, China, Ukraine, and Jordan. However, the most powerful collaboration was with Malaysia, UK, US, Turkey, and Iran. These countries have excellent recods in scientific research. Therefore, it is very important to strengthen the collaboration level with these countries and thus strengthen the scientific research in Iraq and obtain better records in scientific research.



Figure 5: Distribution of Assortitivity of all the pairs of authors in ICN.

Now, the proposed approach presents the results of the rank. The approach takes five indicators to rank each university. These indicators are the assortitivity level of the university, the international collaboration, the university's total citations, the university's RG score, and the Scopus indicator (which is the ratio of the number of publications to the number of authors of the university). The assortitivity is calculated for each pair of authors in ICN. As mentioned, assortitivity means the tendency of authors with similar features to collaborate. It is very important to include assortitivity in the proposed rank because it digs deeply into the actual relations and the performance of each university in terms of scientific collaboration. The assortitivity of each university is calculated using Equation 7. Figure 5 shows the assortitivity distribution for all pairs of authors in Iraqi universities when using Equation 6. According to this figure, it can be noted that most pairs have low levels of assortitivity, while a few pairs have high levels.

Figure 6 shows the rank of each university based on the proposed approach.



Figure 6: The ranks of the Iraqi universities based on the proposed approach.



Figure 7: Visualization of world contributions in all the disciplines.

Moreover, this work presents some international indicators on the Iraqi universities compared to world performance in scientific research. It describes the position of scientific research in Iraq compared to the word for all the known-disciplines. Figure 7 shows the worlds' publications in all the disciplines.



Figure 8: Visualization of the collaborations of the Iraqi authors with international authors in all the disciplines.

Figure 8 depicts the collaboration of the Iraqi authors with international authors in a particular discipline. Each node represents a contribution in a discipline, the colors refer to the discipline of collaboration. Also, node size reflects the strength of collaboration (big nodes reflect strong collaboration).

Figure 9 shows the performance of the Iraqi authors in terms of their h-index values. It can be seen that the disciplines of Biochemistry, Genetics, Molecular Biology, Immunology, and Microbiology have the highest h-index values (big nodes) compared to all the disciplines in Iraq.



Figure 9: Visualization of the h-index of the Iraqi authors in all the disciplines.

Figure 10 depicts some disciplines in the network show an extreme level of self-citation such as Biochemistry, Genetics, Molecular Biology, Immunology and Microbiology, Agricultural and Biological Science, Business Management, and Accounting. The Iraqi authors should be aware of this specific issue that can lead their h-index value to be decreased.



Figure 10: Visualization of the self-citation of the Iraqi authors in all the disciplines.

6 Conclusion

This paper has presented a deep analysis of scientific research in the main Iraqi universities. The data have been collected mainly from Google Scholar, ResearchGate, and Scopus repositories. The data was collected based on the scientific contributions that are published from 2000 to February 2020 (the date of collecting data). Moreover, twenty-two main Iraqi universities have been considered as a case study. The approach is based on the concepts of Complex Networks.

Therefore, the analysis approach is performed using network measurements at both node level and network level. The data collection process is performed using a crawler program that was designed for this work. The output of the crawler represents the dataset. Based on the collected dataset, a network is generated in which the contributions (e.g., articles, papers, books, reviews) are represented as nodes and if there is a citation between two contributions, an edge is created between them and so on. The generated network represents the Giant Component of what has been called the Iraqi Citation Network (ICN). After applying network measurements, a comprehensive evaluation of the ICN network is performed. The evaluation is organized according to different aspects aiming at having a microscopic view of the current status of the Iraqi universities in terms of scientific research. These aspects can be summarized as follows:

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Appendix I

No	University	City	Governorate	Year founded	No. of Faculty members	No. of Students
1	University of Baghdad	Baghdad	Baghdad	1957	6321	70615
2	University of Mosul	Mosul	Ninawah	1967	4281	47000
3	University of Basrah	Basra	Basrah	1964	2886	45000
4	University of Diyala	Baquba	Diyala	1999	1376	22450
5	University of Kufa	Kufa	Najaf	1987	2144	27006
6	Al-Nahrain University	Baghdad	Baghdad	1987	1061	11531
7	Tikrit University	Tikrit	Salah Al-Din	1987	1978	54869
8	University of Technology	Baghdad	Baghdad	1975	1573	10111
9	Mustansiriyah University	Baghdad	Baghdad	1963	3300	37757
10	University of Kerbala	Karbala	Karbala	2002	1337	20072
11	University of Wasit	Kut	Wasit	2003	400	24000
12	University of Babylon	Hillah	Babylon	1991	1998	25462
13	University of Thi-Qar	Nasiriya	Thi-Qar	2000	1179	20634
14	Al-Muthanna University	Samawa	Muthanna	2007	535	13266
15	University of Anbar	Ramadi	Anbar	1987	1674	22719
16	University of Kirkuk	Kirkuk	Kirkuk	2003	813	27500
17	University of Al-Qadisiyah	Qadisiya	Diwaniya	1987	1432	21303
18	University of Samarra	Samarra	Salah Al-Din	2012	338	8205
19	Southern Technical University	Basra	Basrah	2014	535	17370
20	Northern Technical University	Mosul	Ninawah	2014	836	17555
21	Middle Technical University	Baghdad	Baghdad	2014	1515	40758
22	Al-Furat Al-Awsat Technical University	Kufa	Najaf	2014	989	22702

Table 1: A summary of the main Iraqi Universities

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University	Articles	RG score	No. of	Actual Number of	Google Scholar
			authors	authors	Citations
University of Baghdad	8355	11,298.12	5070	6321	67883
University of Mosul	2805	4,593,54	3030	4180	40105
University of Basrah	2193	6,065.99	2861	2886	43971
University of Diyala	519	1,900.97	1244	1376	13741
University of Kufa	1062	3,540.40	2086	2144	26702
University of Al-Nahrain	1131	1,845.50	739	1061	4108
Tikrit University	692	1,699.24	1559	1978	17396
University of Technology	1211	4.118.39	1657	1573	45753
University of Al-Mustansiriyah	544	3,320.64	1977	3300	7233
University of Karbala	346	1,805.78	1097	1337	19222
University of Wasit	168	894.73	593	400	2669
University of Babylon	1359	3,986.94	2306	1998	49631
University of Thi-Qar	349	975.51	762	971	19326
University of Al-Muthana	165	925.56	615	535	237
University of Al-Anbar	755	2,308.17	1377	1674	4629
University of Kirkuk	428	738.51	399	813	19592
University of Al-Qadisiyah	393	2,965.07	1307	1432	21270
University of Samarra	172	137.42	92	338	675
Southern Technical University	51	245.93	218	535	719
Northern Technical University	98	780.88	675	836	3558
Middle technical University	261	1,235.71	792	1515	3186
Al-Furat Al-Awsat Technical University	201	1,347.53	571	989	1106
Total	23258		31027	38192	412712

Table 3: Numbers and Facts on Scientific Research in the Iraqi Universities.

Table 4: The scientific research in Iraq compared to the neighbored countries.

Country	H-Index	Total Number of Papers	Total Citations	Average Citation per cited paper
Turkey	443	1,279,318	14,039,162	10.97
Iran	329	581,253	5,509,736	9.48
KSA	361	422,538	5,169,638	12.23
Jordan	176	91,768	932,958	10.17
Iraq	109	82,978	385,306	4.571
Kuwait	162	54,494	635,924	11.67
Syria	113	16,020	217,694	13.59

Table 5. The performance of scientific for each discipline in fragi universities.	Table 5: The performance of scientific	for each discip	oline in Irac	ji universities.
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scipline	H-Index	Papers	Citations	Average Citation per paper
Medicine and Health Science	85	15598	132934	8.52
Engineering	60	24098	91900	3.81
Chemistry	55	8462	47742	5.64
Physics	52	11590	50950	4.40
Pharmacy	48	8072	22852	2.83
Computer Science	40	14324	34944	2.44
Agriculture	38	8592	23896	2.49
Veterinary	21	1600	5772	3.61
Humanities	16	1196	2984	2.49
Economics and Business administrations	12	406	1614	3.98

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Rank	University	Discipline	Citations
1 st	University of Baghdad	Medicine	15566
2 nd	University of Kirkuk	Petroleum Engineering	11676
3 rd	University of Thi-Qar	Pharmacy	7549
4 th	University of Mosul	Chemistry	7002
5 th	University of Al-Qadisiyah	Medicine	5914
6 th	University of Technology	Renewable Energy	5606
7 th	University of Babylon	Biotechnology	4678
3 th	University of Kufa	Medicine	3590
) th	University of Al-Qadisiyah	Pharmacy	3143
10 th	University of Baghdad	Medicine	3000

Table 6: Top 10 highest citations authors by the Iraqi Universities

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No. of nodes	No. of Edges	Average Degree	Diameter	Density	Modularity (Girvan- Newman)	Average Clustering coefficient	Average Path Length
22	39	3.5	4	0.169	5/0.376	0.543	2.133

Table 7: The characteristics of the Iraqi Scientific Collaboration Network

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