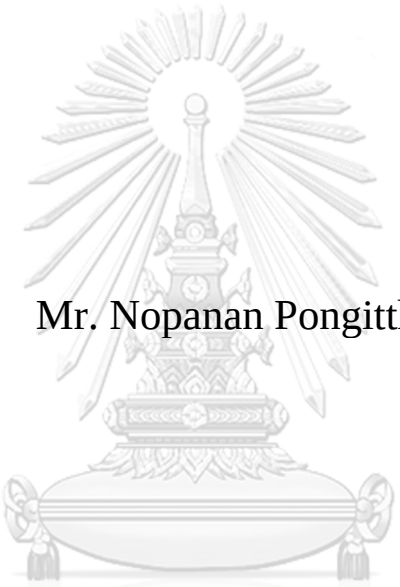
CITATION NETWORK ANALYSIS FOR JOURNAL SELECTION OF UNIVERSITY LIBRARY

Mr. Nopanan Pongitthidej



A Thesis Submitted in Partial Fulfillment of the Requirements
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การวิเคราะห์เครือข่ายการอ้างอิงเพื่อการเลือกวารสารของห้องสมุดมหาวิทยาลัย

นายนพอนันต์ พงศ์อิทธิเดช

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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By	Mr. Nopanan Pongitthidej
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นพอนันต์ พงศ์อิทธิเดช : การวิเคราะห์เครือข่ายการอ้างอิงเพื่อการเลือกวารสารของห้องสมุดมหาวิทยาลัย. (CITATION NETWORK ANALYSIS FOR JOURNAL SELECTION OF UNIVERSITY LIBRARY) อ.ที่ปรึกษาหลัก : ผศ. ดร.วีระ เหมืองสิน

ในทุกปีการศึกษาห้องสมุดมหาวิทยาลัยต้องทำการสมัครรับวารสารจำนวนมากเพื่อให้นักศึกษาและนักวิจัยได้รับวารสารที่ดีที่สุด ถึงกระนั้นวารสารเหล่านั้นก็ไม่ได้ถูกใช้อย่างเท่าเทียม อีกทั้งยังไม่ครอบคลุมถึงวารสารที่ใช้ในการอ้างอิงทั้งหมด ดังนั้นห้องสมุดจึงต้องการข้อมูลเพิ่มเติมเกี่ยวกับการใช้งานและความต้องการใช้วารสารเพื่อให้สามารถจัดการทรัพยากรห้องสมุดได้อย่างมีประสิทธิภาพ วิทยานิพนธ์ฉบับนี้ได้ใช้การวิเคราะห์เครือข่ายการอ้างอิงการวิเคราะห์บทความที่ถูกตีพิมพ์โดยนักวิจัยของมหาวิทยาลัยและวารสารอ้างอิงของบทความดังกล่าว ผลลัพธ์คือวารสารสองรายการที่อาจซ้อนเหลื่อมกันซึ่งแนะนำให้นำมาเป็นทรัพยากรของห้องสมุด ได้แก่ (ก)วารสารที่ตีพิมพ์งานของนักวิจัยในมหาวิทยาลัย และ(ข)วารสารที่ถูกอ้างอิงโดยนักวิจัยในมหาวิทยาลัย โดยค่าความสำคัญของวารสารจะให้คะแนนตามเมตริกศูนย์กลางของเครือข่ายหลายชนิด วิทยานิพนธ์ฉบับนี้ได้ใช้บทความที่ตีพิมพ์โดยนักวิจัยของจุฬาลงกรณ์มหาวิทยาลัย ระหว่าง ปี 2016 และ 2018 เพื่อวิเคราะห์และเปรียบเทียบกับผลการตีพิมพ์บทความในปี 2019 การทดลองในงานวิจัยฉบับนี้ถูกแบ่งออกเป็น 2 ระดับ โดยการทดลองแรกสนใจบทความที่ถูกตีพิมพ์ทั้งหมดของจุฬาลงกรณ์มหาวิทยาลัย และการทดลองที่สองสนใจบทความที่ถูกตีพิมพ์ในแต่ละคณะ โดยสนใจ 5 คณะที่ตีพิมพ์บทความมากที่สุด จากผลการวิเคราะห์แสดงให้เห็นว่าวารสารชั้นนำไม่ได้เปลี่ยนแปลงมากในช่วงหลายปี และผลการทดลองยังแสดงให้เห็นว่ารายชื่อของวารสารที่ถูกสร้างขึ้นจากบทความของปีก่อนหน้า ค่อนข้างใกล้เคียงกับรายชื่อของวารสารในปีถัดไป รูปแบบที่นำเสนอสามารถช่วยให้ห้องสมุดสามารถเข้าใจข้อมูลเกี่ยวกับการใช้งานและความต้องการใช้วารสาร และยังสามารถให้ข้อเสนอแนะเกี่ยวกับวารสารที่ควรจะถูกรวมอยู่ในคอลเลกชันของห้องสมุดมหาวิทยาลัยโดยดูจากบทความที่ถูกตีพิมพ์ในอดีต นอกจากนั้น ยังสามารถช่วยให้นักวิจัยเลือกวารสารที่เหมาะสมสำหรับการตีพิมพ์และการอ้างอิงได้อีกด้วย

สาขาวิชา	วิทยาศาสตร์คอมพิวเตอร์	ลายมือชื่อนิสิต .....
ปีการศึกษา	2562	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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KEYWORD: Citation Network Analysis, Centrality Metrics, Library Collection, Journal Selection

Nopanan Pongitthidej : CITATION NETWORK ANALYSIS FOR JOURNAL SELECTION OF UNIVERSITY LIBRARY. Advisor: Asst. Prof. VEERA MUANGSIN, Ph.D.

Every academic year, a university library must subscribe tons of journals to provide the best resource for the students and researchers. However, subscribed journals have been used unequally and some relevant journals are not subscribed. Therefore, the library needs supporting information about usedness and demand of journals for efficient collection management. In this paper, citation network analysis is applied to analyze the articles published by university researchers and their references. The result is two overlapping lists of journals that are recommended for the library collection i.e. (a) journals that the university researchers have published in and (b) journals that the university researchers have cited. The importance of the journals is scored based on multiple centrality metrics. We used articles published by Chulalongkorn University (CU) researchers between 2016 and 2018 to analyze and compared the results with articles publishing in 2019 to validate the proposed method. There are two levels of experiment in this research, the first experiment considers articles for the whole CU and second experiment considers top 5 faculties with the most publications. The results for both experiments show that top journals have not changed much over the years. The experimental results show that the ranked journal lists created from publication data of previous years closely matches the list produced from publication data in the subsequent year. The proposed model can help the university library to understand usedness and demand of journals and give suggestion of journals that should be included in the university library collection based on past publication data. The journal lists can also help researchers to choose journals for publication and reference.

Field of Study:	Computer Science	Student's Signature .....
Academic Year:	2019	Advisor's Signature .....

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Nopanan Pongitthidej

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CHAPTER 1 INTRODUCTION

1.1 Motivation

University library is the main organization that must provide the best source of knowledge, including books and journals, for the researchers and students. Even though the library wants to keep the most relevant and up-to-date journals in its collection, it is hard to know which journals are in current demand. For example, the Central Library of Chulalongkorn University (CU) needs to subscribe tons of journals. The subscription list is reviewed and revised every year. Nowadays, most journals in the library are subscribed via subscription packages. Due to very high subscription cost, it is a burden for the library to defend the budget without evidence of usedness of the journals. Usually, journals are added upon requests. Removing a journal subscription is a harder decision that requires information about its usedness.

Currently, usedness of journals can be measured by in-library use records, search statistics in the reference database, and annually report from subscription provider as shows in Figure 1. Surely, lots of subscribed journals have been frequently used, while some of them have never been touched. A more interesting question is what journals should be included in the collection based on their relevance in current research in the university.

Journal Citation Reports Custom Summary Report for Sep 2016-Dec 2016				
Date	Credentials	Subsessions	Queries	Records Viewed
16-Sep		444	808	1607
	103.10.229.206	1	3	5
	103.10.229.214	4	4	5
	103.10.229.222	1	0	0
	161.200.107.179	1	4	0

Figure 1 Journal report summary from subscription service

Figure 2 shows growth trend of article and conference papers published by CU researchers. The number of published documents is increasing every year. It is a responsibility for CU library to make sure that subscribed journals are up-to-date and available to serve current needs.

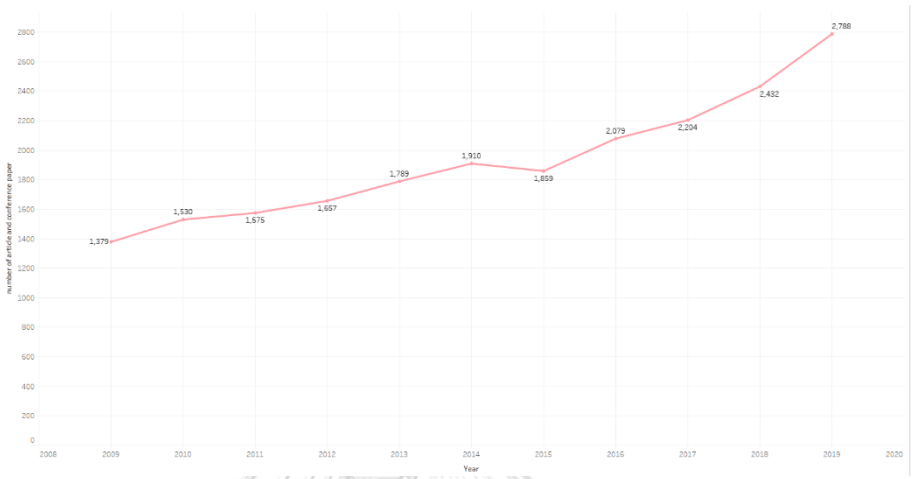

Figure 2 CU articles and conference papers published

In the field of Bibliometric, one way to measure usedness of journals is citation analysis. Citation analysis is a valuable means that support librarian to make decisions regarding collection development [1]. Therefore, by looking into research output of the University such as articles that have been published in journals and conference proceedings and their citations, the library can analyze the demands and impact of cited journals and conferences to the University research.

Citation network analysis is a relatively new citation analysis technique based on network graph analysis and measurements. A citation network that consists of articles published by researchers in an organization and their cited articles can capture the state and connections of active research in the organization.

There are several ways to rank journals based on impact in that fields [2] or impact of journals based on articles published in those journals [3]. Citation analysis has also been applied as a library collection development tool. K. Hoffmann and L. Doucette [4] used 34 articles that present a “user study” citation analysis between 2005 and 2010 with a goal of informing collection management. Results found that common themes among the methodologies can provide guidance for researchers who are planning to conduct citation analysis studies. S. Edwards [5] find solution that can

help them to better understand the demand on librarians by develop a sense from what materials are important to researchers and are being used the most. They used the data from University of Akron in area of polymer science and polymer engineering between 1990 and 1996 to investigate the pattern of citations and determine the characteristics of the materials being cited by graduate students. S. Wilson and C. Tenopir [6] study assessed the intermix of local citation analysis and survey of journal use and reading patterns for evaluating an academic library's research collection However, to the best of our knowledge, citation network analysis has not been used for library collection management yet.

1.2 Scope

We use data of articles published by CU collected from SCOPUS database between 2016 and 2018 as a train set and validate the result with articles published in 2019. The analysis result consists of two overlapping lists of journals that are recommended for the library collection i.e. (a) journals that the University researchers have published in and (b) journals that the University researchers have cited. I believe that both groups of journals should be included in the library collection to provide the best and suitable knowledge source for University researchers.

1.3 Contribution

- Present a citation network analysis method to analyze citation network that consist of published and cited journals and rank their importance based on multiple centrality metrics.
- Apply the method to publication data of Chulalongkorn University as a tool for library collection management and present the findings.

1.4 Thesis Publication

A part of this thesis is published as:

N. Pongitthidej and V. Muangsin, *"Citation Network Analysis for Journal Selection of University Library"*, The 13th International Conference on Advanced Computer Theory and Engineering (ICACTE), Hangzhou, China, September 18 - 20, 2020.

CHAPTER 2 BACKGROUND KNOWLEDGE AND RELATED WORK

2.1 Bibliometric

Bibliometric is the use of statistical methods to analyze articles and other publications. Bibliometric are frequently used in field of library and information science. One of popular methods in Bibliometric is citation analysis. Citation analysis has been used as a collection development tool in various disciplines. Literature reveals many citation studies conducted articles on a particular field with the purpose of developing a user-centric library collection. Citation graph is a technique in citation analysis based on a directed graph network in which a node in the network represent a document and an edge represent citation relation between each document [7]. Example in Figure 3, node A and E represent articles that are published by researchers and they cited articles C, B, D and C, B, respectively.

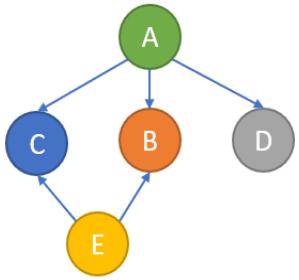

Figure 3 Article citation network

W. Glanzel and H.F. Moed [8] used the number of citations received in that year from articles published in those journals during the two preceding years, divided by the total number of "citable items" published in that journal during the two preceding years. Another indicator used to measure the impact on the Journal introduced by Scimago Journal & Country Rank is SCImago Journal Rank. It expresses the average number of weighted citations received in the selected year by the documents published in the journal in the three previous year [2].

However, from the best of researcher knowledge, there are no measurement technique uses to calculate the core journals at University or community level.

2.2 Graph Theory

Graph is one of the best ways to display the relation between objects in the community, each object represents by a **node** in a graph while an **edge** represents the relation between 2 nodes. When two nodes are directly connected by an edge, they are adjacent. The number of other points to which a given point is adjacent is called the degree of that point.

In general, there are two types of edge, namely **undirected** edge and **directed** edge. An undirected edge indicates a two-way relationship between nodes. An undirected edge can be traversed in both directions. A directed edge indicates a one-way relationship. A directed edge can only be traversed in a single direction. In this research, directed graphs have been used because it is a structure for Citation graph.

2.3 Network Analysis Metrics

Network analysis is an analysis technique based on graph theory that studies the properties of complex networks such as social networks and citation networks. One of important properties of a network is Centrality that indicates the relative importance of each node in the network. There are many centrality metrics, each of which is based on different meanings of "center" or "importance" and thus different calculation.

2.3.1 Betweenness Centrality

Betweenness Centrality (BC) is the proportion of all the shortest paths passing through the node in the network (1)

$$b_i(g) = \sum_{(j,k),j\neq k\neq i} \frac{v_g(i:j,k)}{v_g(j,k)} \quad (1)$$

$v_g(j,k)$ represents the number of shortest paths between nodes j to nodes k, $v_g(i:j,k)$ represents the number of the shortest paths between nodes j and nodes k through node i .

2.3.2 Closeness Centrality

Closeness Centrality (CC) is based on the total distance between a node and every other node in the network (2)

$$c_i^{cls}(g) = \frac{n-1}{\sum_{j \neq i} \rho_g(i,j)} \quad (2)$$

$\sum_{i \neq j} \rho_g(i,j)$ represents the total sum of distances between nodes i and nodes j.

2.3.3 Eigenvector Centrality

Eigenvector Centrality (EC) is computed by assuming that the centrality of node i is proportional to the sum of centrality of node $i's$ neighbors: $\lambda c_i = \sum_j g_{ij} c_j$, where λ is a positive proportionality factor. In matrix term, $\lambda c = gc$. The vector $c_i^{eig}(g)$ is thus the right-hand-side eigenvector of g associated with the eigenvalue $\lambda^{max}(g)$.

This notion of centrality is closely related to ways in which scientific journals are ranked based on citations, and relates to influence in social learning [9]

2.3.4 PageRank

PageRank algorithm was first used for ranking web pages by Google search engine [10]. The underlying idea is that more important nodes are likely to have more links from other nodes. PageRank measures the importance of each node by counting the number and quality of links to the node. Let u be a node. Then let F_u be the set of pages u points to and B_u be the set of pages that point to u. Let $N_u = |F_u|$ be the number of the links from u and let c be a factor used to normalization. Then the PageRank value of node u is (3)

$$R(u) = c \sum_{v \in B_u} \frac{R(v)}{N_v} \quad (3)$$

2.3.5 HITS Algorithm

Hyperlink-Induced Topic Search (HITS) algorithm [11] was also developed for ranking web pages. The algorithm determines two values for each node, namely Hub and Authority, based on link analysis. Authority value is the sum of hub values of all nodes that point to it. Hub value is the sum of authority values of all nodes that it points to. To begin the ranking, first let $auth(p) = 1$ and $hub(p) = 1$ for each node then repeated iterations of the Authority Update Rule and the Hub Update Rule are applied.

- **Authority update rule**: For each p, we update $auth(p) = \sum_{q \in P_{to}} hub(q)$ where $P_{to}$is all nodes which link to node p. That is, a node's authority score is the sum of all the hub of nodes that point to it.
- **Hub update rule**: For each p, we update $hub(p) = \sum_{q \in P_{from}} auth(q)$ where $P_{from}$is all nodes which link to node p. That is, a node's hub score is the sum of all the authority of nodes that point to it.

Then the scores are normalized by dividing every Hub score by the sum of the squares of all Hub scores and dividing each Authority score by the sum of the squares of all Authority scores. After repetitions of the algorithm, the scores will eventually converge.

CHAPTER 3 METHODOLOGY

The proposed method is to use publication data of past years to recommend journals that should be in library collection for the next academic year. The result consists of two overlapping lists of journals i.e. (a) journals that the University researchers have published in and (b) journals that the University researchers have cited. List (a) can be produced by ranking the journals based on centrality metrics that favor journals with a lot of references to other journals, including out-degree, Closeness Centrality, and Hub. List (b) can be produced by ranking the journals based on centrality metrics that favor journals that are cited by a lot of other journals, including in-degree, Betweenness Centrality, PageRank, Eigenvector Centrality, and Authorities.

The method consists of the following steps:

1. Obtain a list of articles published by authors from the target university for each year using SCOPUS export function. Each record includes the journal name and references as shows in Figure 4.

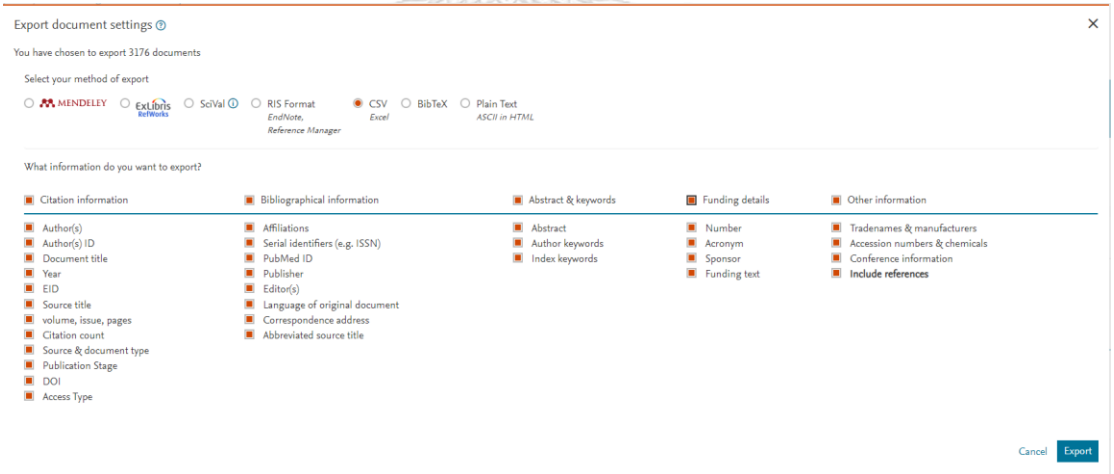

Figure 4 Scopus export function

2. Set up RPA script using UiPath application to load reference data for those documents downloaded form (1).

Figure 5 UiPath RPA

3. Use “Power Query” function in Excel to combine all the CSV file.

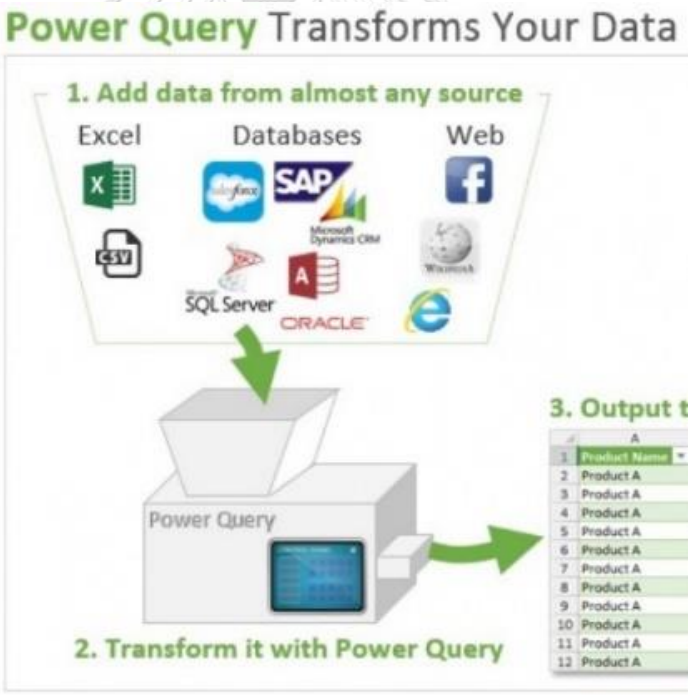

Figure 6 Excel Power Query function

4. Articles under the same journal are merged to create a citation network at journal level, as shown in Figure 7. The weight on an edge represents the number of articles in each relation.

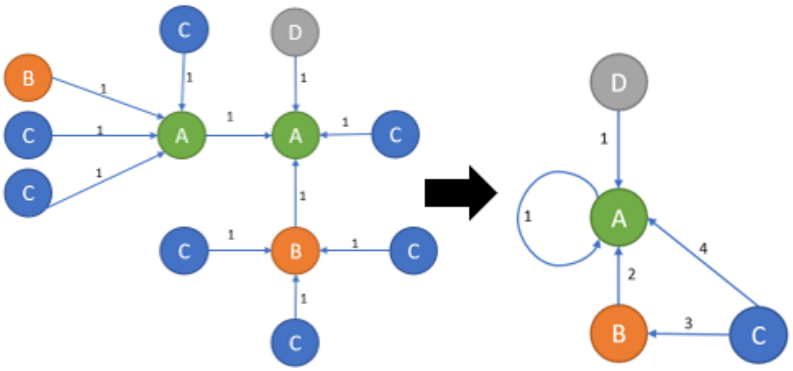

Figure 7 Merge articles under journal

5. Clean data by removing unnecessary and incomplete data. Then set up data into two Excel files, 1) Node table 2) Edge table to use in Gephi application.

   Note: Gephi application is an open source software for graph and network analysis. It uses a 3D render engine to display large networks in real-time and to speed up the exploration. A flexible and multi-task architecture brings new possibilities to work with complex data sets and produce valuable visual results. [12]

6. Import data into Gephi to create citation network.

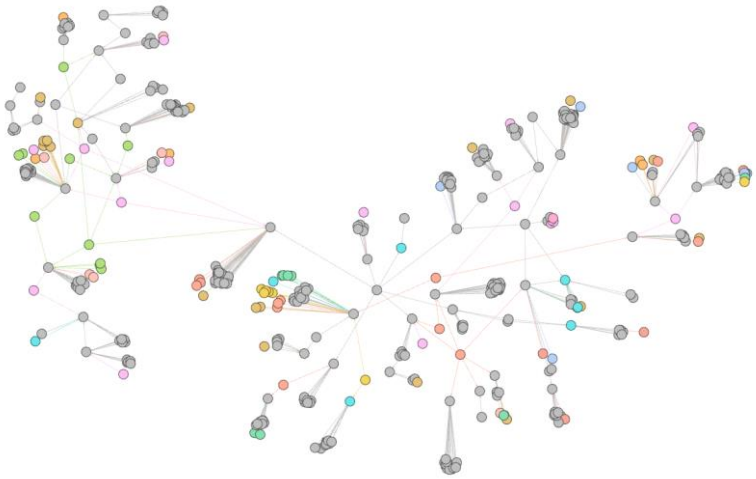

Figure 8 Citation Network in Gephi application

7. Centrality metrics are calculated. We use Gephi application to do the calculation in this step.

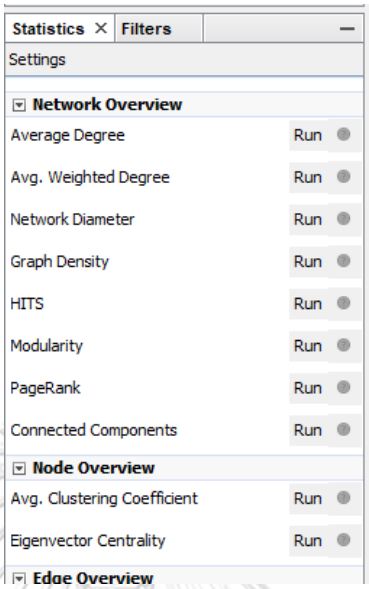

Figure 9 Gephi function

8. Min-Max normalization technique is applied to normalize the centrality metrics to be in the same range between 0-100 for journal scoring purpose.
9. Create two lists of journals.
   - The first one ranks journals based on the sum of Closeness centrality and Hub scores.
   - The second one ranks journals based on the sum of Betweenness Centrality, Eigenvector Centrality, PageRank, and Authority scores.
10. Percentile rank is applied in this step to calculate the total score so that the relative importance of journals can be compared across the years.
11. To evaluate the method, the median of percentile rank of a journal in the past 3 years is used as the predicted percentile rank in the subsequent year. The prediction is then compared to the actual value.
12. Summarize result and list core journals.

CHAPTER 4 EXPERIMENTS

The proposed method is applied to the case study based on published data of CU. This chapter presents four experiments. The first Experiment will consider the correlation between all the centrality purpose in this thesis. Second Experiment present finding from every centrality to analyze the journal that got the highest score in each centrality. Third experiment will apply the purpose method with number of articles in each journal to verify that is it possible to predict list of journals without using centrality in this thesis. experiment 5 and 6will be consisted with two parts that apply social network centrality with different set of data. The first part in each these 2 experiments considers data for the whole CU while the second part considers data based on researchers' faculty. Scope in experiment 3, 4, and 5 will be divided into two parts (a) focuses on the journals that CU/ Faculty researchers have published in. (b) deals with the journals that were cited.

Before we process the mentioned experiment, we prepare the data of The CU articles. The list of journal articles with affiliation to Chulalongkorn University published between 2016 to 2019 was collected from SCOPUS database. Subsequently, the citation by each article was retrieved. The number of publish articles and their references are given in Table 1. After the data were converted to journal level, we created a citation network for each year by using Gephi application. The number of nodes and edges separated by year are given in Table 2.

Table 1 Number of CU articles collected from Scopus

Articles	Year			
	2019	2018	2017	2016
Published by CU	2,294	2,090	1,825	1,789
Referenced by CU articles	63,260	60,062	49,762	44,490

Table 2 Number of nodes and edges in CU citation networks

Graph Elements	2019	2018	2017	2016
Nodes	8,314	7,694	6,801	6,529
Edges	33,665	30,637	24,843	23,386

Figure 10, Figure 11, Figure 12, and Figure 13 show a visualization of the CU citation network in 2016, 2017, 2018, and 2019 respectively. They are generated by Gephi application. The graph was colored based on detected communities.

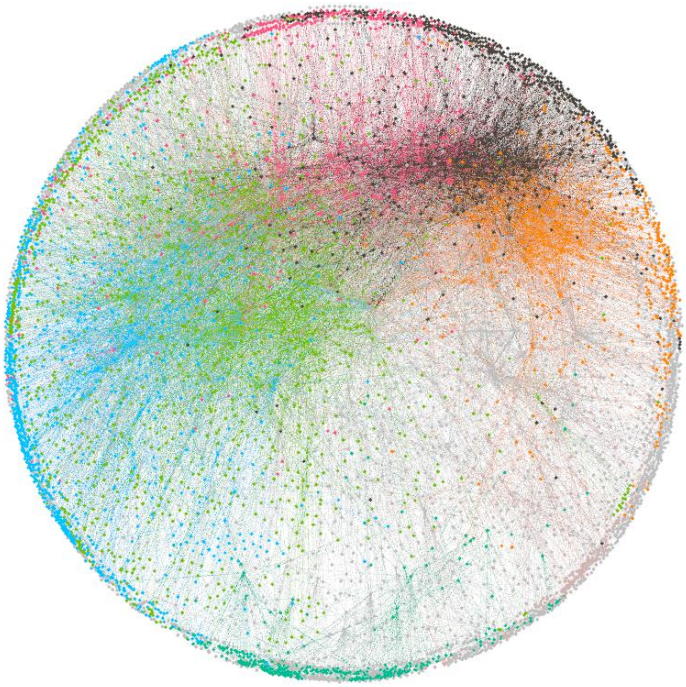

Figure 10 2016 CU Citation Network graph

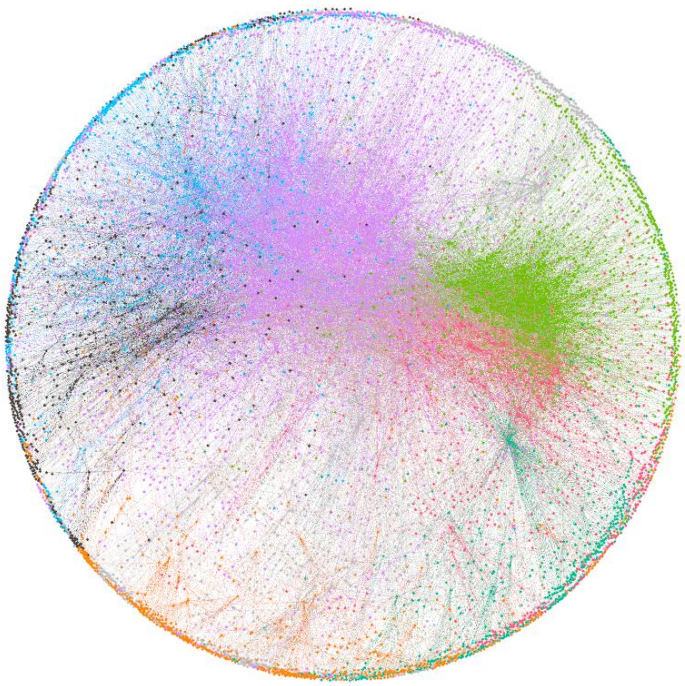

Figure 11 2017 CU Citation Network graph

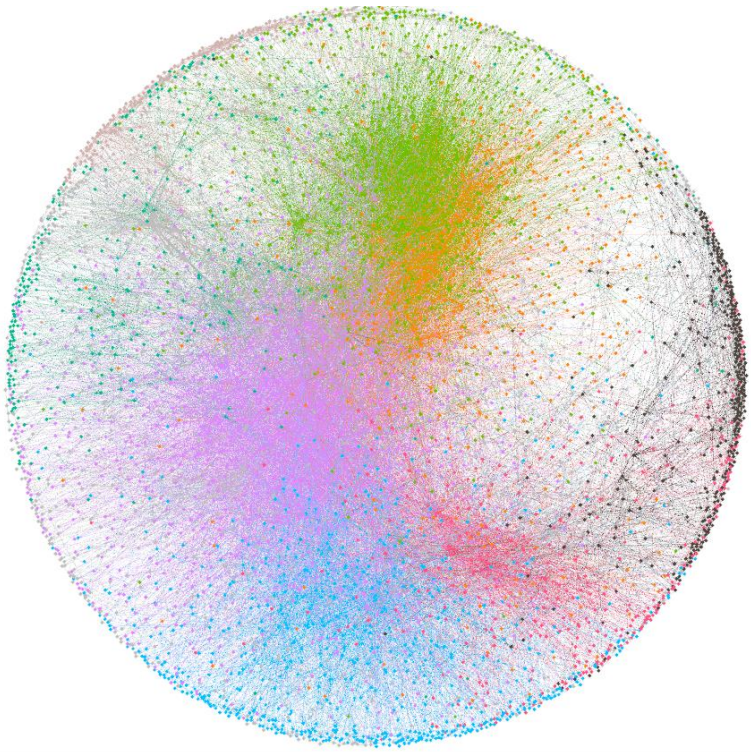

Figure 12 2018 CU Citation Network graph

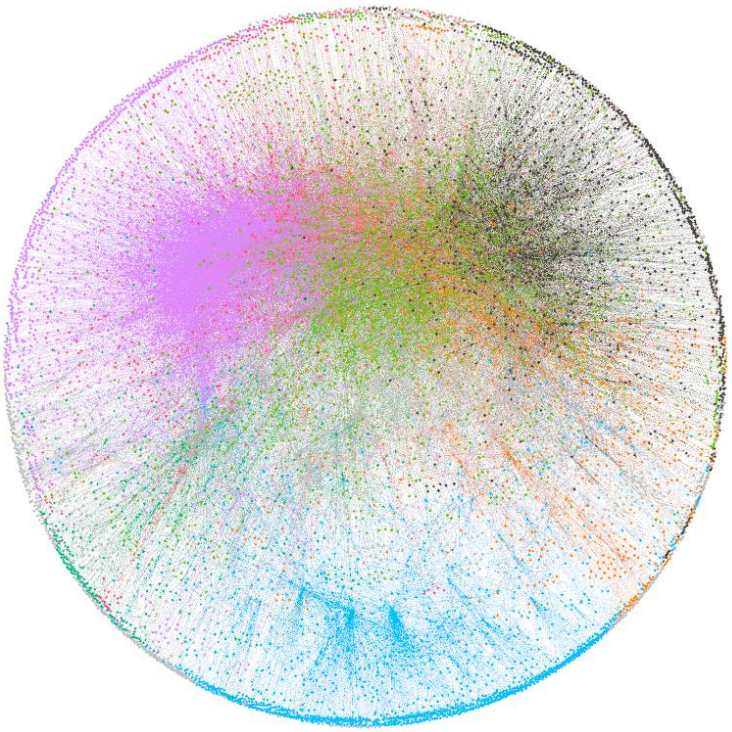

Figure 13 2019 CU Citation Network graph

The biggest community in each figure are presented in Pink color which cover around 20% of the total node. The majority of top journals that will be presenting in Experiment 4 are coming from this community.

4.1 Correlation between each Centrality

In this part of experiment, we use CU articles published in 2019 with its reference to calculate Betweenness Centrality, Closeness centrality, Eigenvector Centrality, PageRank, Authority, and Hub. Then we find the coloration between each centrality to understand that are there any centrality that will give the result in the same trend. Table 3 shows Pearson Correlation between each Centrality order by score and Figure 14 shows correlation graph between all centrality. Result shows that for first group Centrality that we purpose in this research with contain Closeness Centrality and Hub, the correlation between these two centralities are quite low compare to other. And for the second group which consider Betweenness centrality, Eigenvector centrality, PageRank, and Authority. We found that the correlation between Authority, Eigenvector centrality and PageRank are quite high. However, Correlation between Betweenness centrality and rest of the centrality in the same group are not high. So, we will still split Centrality in to two groups to balance the output in each list.

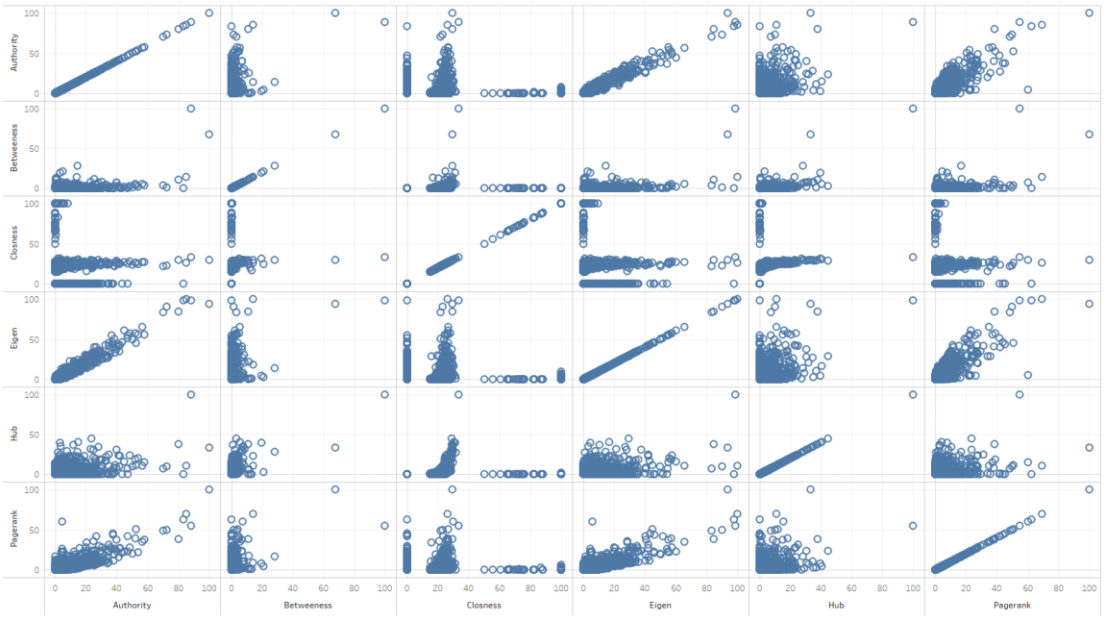

Figure 14 correlation graph between each centrality

Table 3Centrality Correlation

Rank	Centrality 1	Centrality 2	Pearson Correlation
1	Authority	EC	0.9714
2	EC	PageRank	0.8375
3	Authority	PageRank	0.8299
4	BC	Hub	0.5684
5	Authority	Hub	0.4925
6	EC	Hub	0.4707
7	BC	PageRank	0.4419
8	Hub	PageRank	0.419
9	Authority	BC	0.4004
10	BC	EC	0.3855
11	CC	Hub	0.3619
12	Authority	CC	0.164
13	CC	EC	0.1592

4.2 Core Journal in each Centrality

This experiment focus on the list of journals that got highest score of each centrality in 2019. Table 4 present top 5 journals with highest betweenness centrality. After analyzing the outcome, we found that list of journals in this centrality are journals that act like a bridge in the community, it needs to be journal that both Published by CU and Cited by CU researches. The journals that got the highest score is Scientific Report with 33 articles by CU and 329 articles cited by CU.

Table 4 Top 5 Journals from betweenness centrality

Rank	Journal	BC	Published by CU	Cited by CU
1	Scientific Reports	0.015086	33	329
2	PLoS ONE	0.010231	18	623
3	Journal of the Medical Association of Thailand	0.004255	45	81
4	Sustainability (Switzerland)	0.003173	5	36
5	Engineering Journal	0.00293	33	55

Journals that got highest Closeness Centrality are journals that connect and close to other node in the community. List of top 5 journals shows in Figure 5. After we are analyzing journals in this group, we found that journals that got highest score are coming from the urban community in the graph because in each urban community, the number of articles are not high comparing to main community. So, it is possible for the journal in this group to connect with every node in it owe community. Therefore, it also represents core journals in each urban citation network.

Table 5 Top 5 Journals from Closeness centrality

Rank	Journal	CC	Published by CU	Cited by CU
1	LEARN Journal: Language Education and Acquisition Research Network	1	5	0
2	International Journal of Machine Learning and Computing	1	3	1
3	Asian Review of Accounting	1	2	5
4	Thai Journal of Mathematics	1	2	0
5	LEARN Journal: Language Education and Acquisition Research Network	1	5	0

Note that there are 107 journals that got Closeness centrality equal to 1

Table 6 shows top 10 articles ordered by Eigenvector centrality. All the articles shown it this table are considered as an influencer journals in the network. If we analyze number of articles cited by CU in this group is quite high. Another thing that interesting in this centrality are Nature journal, this journal got a very high number of Eigenvector centrality and cited a lot by CU researchers. However, we did not have any articles published in this journal. I investigate data from 2016-2019 that we loaded from Scopus and found that number of citation articles from this journal are very high in every year and we never publish any articles in it.

Table 6 Top 5 Journals from Eigenvector centrality

Rank	Journal	EC	Published by CU	Cited by CU
1	Proceedings of the National Academy of Sciences of the United States of America	1	2	358
2	Scientific Reports	0.985024	33	329
3	Nature	0.976792	0	300
4	PLoS ONE	0.938667	18	623
5	Journal of the American Chemical Society	0.899193	2	264

Top 5 journals with highest PageRank value are shows in Table 7, we found that list of top journals in this centrality are quit the same with list from Eigenvector centrality. However, the rank there are still some different in rank of those journal.

Table 7 Top 5 Journals from PageRank

Rank	Journal	PageRank	Published by CU	Cited by CU
1	PLoS ONE	0.00107	18	623
2	Proceedings of the National Academy of Sciences of the United States of America	0.000761	2	358
3	Nature	0.000695	0	300
4	Journal of High Energy Physics	0.00067	45	1994
5	Scientific Reports	0.000617	33	329

Table 8 shows top 5 journal that got highest Hub score. Hub scorer are the score that consider out degree from it. Result in this list shows top journals that got highest journals that citation to other journals in the community.

Table 8 Top 5 Journals from Hub

Rank	Journal	Hub	Published by CU	Cited by CU
1	Scientific Reports	0.367535	33	329
2	International Journal of Hydrogen Energy	0.163173	14	277
3	Journal of Molecular Liquids	0.148259	6	33
4	Engineering Journal	0.145562	33	55
5	RSC Advances	0.138216	7	232

Table 9 shows top journals with highest Authority, which is the journals that got citation relation from a lot of journals.

Table 9 Top 5 Journals from Authority

Rank	Journal	Authority	Published by CU	Cited by CU
1	PLoS ONE	0.208717	18	623
2	Scientific Reports	0.184403	33	329
3	Proceedings of the National Academy of Sciences of the United States of America	0.177879	2	358
4	Nature	0.173433	0	300
5	RSC Advances	0.167535	7	232

Result from this Experiment shows that list of the journal in each centrality are different because each centrality represents different purpose in the network. Even for centrality that got highest correlation are also give the different journal on each rank.

4.3 Prediction using number of articles.

In this experiment, we want to analyze the result by using the purpose method with number of articles that published by CU and cited by CU to know that is it possible to predict the result using only number of articles in each years.

4.3.1 Journals that CU researchers have published in

Table 10 show top 10 journals in 2019 ordered by the number of articles published in those journals and number of articles in year 2016-2018.

Table 10 top 10 articles published by CU order by number of articles in 2019

journal	Number of articles published by CU			
	2019	2018	2017	2016
Journal of High Energy Physics	45	68	47	34
Journal of the Medical Association of Thailand	45	36	25	27
Engineering Journal	33	36	52	31
European Physical Journal C	33	24	23	18
Scientific Reports	33	26	21	14
Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics	27	26	29	30
International Journal of Innovation, Creativity and Change	26	0	0	0
International Journal of Supply Chain Management	24	0	0	1
Asian Biomedicine	23	1	12	26
Physical Review D	20	20	16	26

Then percentile rank was applied to the score in each year to normalize the score into a value between 0 and 1, then we calculated the median of percentile ranks between year 2016-2018 and 2019 separately, then calculated the difference between median percentile rank of 2016-2018 and 2019 (shown in Table 11).

To evaluate the prediction result, the journals are divided into two groups, the first group has the difference value <= 0.1, and the other has the difference value > 0.1. Table 12 shows that the first group, indicating accurate prediction, contains about 30% of journals CU articles published in and covers only 22% of all articles by CU researchers.

Table 11 compare CU percentile rank for top 10 journals by number of articles

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
Journal of High Energy Physics	1	0.999	0.998	0.999	0.999	0
Journal of the Medical Association of Thailand	0.998	0.997	0.994	0.997	0.999	0.002
Engineering Journal	0.998	1	0.996	0.998	0.996	0.002
European Physical Journal C	0.994	0.996	0.989	0.994	0.996	0.002
Scientific Reports	0.995	0.995	0.987	0.995	0.996	0.001
Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics	0.995	0.998	0.995	0.995	0.995	0
International Journal of Innovation, Creativity and Change	0	0	0	0.000	0.995	0.995
International Journal of Supply Chain Management	0	0	0	0.000	0.994	0.994
Asian Biomedicine	0	0.99	0.992	0.990	0.993	0.003
Physical Review D	0.992	0.991	0.992	0.992	0.992	0

Table 12 Difference between CU percentile rank and article cover group a

Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
<= 0.1	87	521	5.988506
> 0.1	212	1773	8.363208

4.3.2 Journals that CU articles have cited

Table 13 show top 10 journals in 2019 ordered by the number of articles citation form those journals and number of articles in year 2016-2018.

Table 13 top 10 articles citation by CU order by number of articles in 2019

journal	Number of articles published by CU			
	2019	2018	2017	2016
Journal of High Energy Physics	1994	2056	1558	1169
European Physical Journal C	819	996	658	378
Physical Review Letters	658	776	524	498
Journal of Instrumentation	635	717	395	296
PLoS ONE	623	639	466	405
Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics	552	771	561	371
Physical Review D - Particles, Fields, Gravitation and Cosmology	546	691	632	657
Physical Review D	385	403	262	155
Proceedings of the National Academy of Sciences of the United States of America	358	394	268	233
Bioresource Technology	342	292	292	306

Then the percentile rank was applied to the score in each year. The median of percentile ranks between year 2016 and 2018 was calculated and compared to that of 2019 to calculate difference between median percentile rank of 2016-2018 and 2019 as shown in Table 14.

The journals are divided into two groups according to the different as shown in Table 15. The result shows that the first group, with more accurate prediction, contains 22% of journals cited by CU articles and covers over 70% of all articles that CU researchers cited.

Table 14 compare CU percentile rank for top 10 journals in 2019 group b

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
Journal of High Energy Physics	1	1	1	1	1	0
European Physical Journal C	0.999	0.999	0.999	0.999	0.999	0
Physical Review Letters	0.999	0.999	0.999	0.999	0.999	0
Journal of Instrumentation	0.999	0.999	0.998	0.999	0.999	0
PLoS ONE	0.999	0.999	0.999	0.999	0.999	0
Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics	0.999	0.999	0.999	0.999	0.999	0
Physical Review D - Particles, Fields, Gravitation and Cosmology	0.999	0.999	0.999	0.999	0.999	0
Physical Review D	0.999	0.998	0.997	0.998	0.999	0.001
Proceedings of the National Academy of Sciences of the United States of America	0.998	0.998	0.998	0.998	0.999	0.001
Bioresource Technology	0.998	0.998	0.999	0.998	0.999	0

Table 15 Difference between CU percentile rank and article cover group b

Percentile rank Difference	Number of Journals	Number of articles	AVG articles/journals
<= 0.1	1881	45201	24.0303
> 0.1	6433	18059	2.807244

4.4 Chulalongkorn University

Min-Max normalization technique was applied to all measurements to normalize values in the same range between 0 and 100.

4.4.1 Journals that CU researchers have published in

To measure and rank the usedness of journals that CU researchers have published in, we use Closeness centrality and Hub as the scoring metrics. Table 16, Table 17, Table 18, and Table 19 show top 10 journals from 2016 to 2019 ordered by the score. Top 10 journals list published by CU researchers of each year shows that all of it are related to the scope of Science knowledge such as Science, Engineering, Medicine, etc. However, a list of journals in each year are quite different. Only Scientific Reports that show up in the results as a top 10 in the 4 - year period.

Then percentile rank was applied to the score in each year to normalize the score into a value between 0 and 1, then we calculated the median of percentile ranks between year 2016-2018 and 2019 separately, then calculated the difference between median percentile rank of 2016-2018 and 2019 (shown in Table 20).

In order to evaluate the prediction result, the journals are divided into two groups, the first group has the difference value <= 0.1, and the other has the difference value > 0.1. Table 21 shows that the first group, indicating accurate prediction, contains about 30% of journals CU articles published in but covers 49% of all articles by CU researchers. The outcome shows that by using 3 year back data, we are able predict list of journals that half of the research from CU will be publishing into in the following year.

Table 16 top 10 journals published by CU researchers in 2016

Journal	CC	Hub	Total Score
Scientific Reports	32.77	100.00	132.77
Carbohydrate Polymers	31.46	83.72	115.18
Thai Journal of Veterinary Medicine	32.40	78.71	111.11
PLoS ONE	31.10	71.74	102.83
International Journal of Endocrinology	100.00	2.61	102.61
Neurocase	100	2.59	102.59
Nephrology	100	1.50	101.50
Journal of Clinical Oncology	100	1.06	101.06
Journal of Obstetrics and Gynaecology Research	100	0.94	100.94
Nursing Research	100	0.80	100.80

Table 17 top 10 journals published by CU researchers in 2017

Journal	CC	Hub	Total Score
Engineering Journal	33.75	100.00	133.75
Scientific Reports	33.22	70.02	103.24
Acta Mechanica	100.00	3.15	103.15
Annals of Tropical Medicine and Public Health	100.00	1.81	101.81
Angiology	100.00	1.16	101.16
European Archives of Oto-Rhino-Laryngology	100.00	0.95	100.95
Journal of Public Health Research	100.00	0.92	100.92
Applied Neuropsychology: Child	100.00	0.85	100.85
Pain Research and Management	100.00	0.82	100.82
International Journal of Communication Systems	100.00	0.74	100.74

Table 18 top 10 journals published by CU researchers in 2018

Journal	CC	Hub	Total Score
Scientific Reports	32.39	100.00	132.39
PLoS ONE	31.85	75.09	106.94
Journal of Thoracic Oncology	100.00	3.67	103.67
BMC Medical Genetics	100.00	1.97	101.97
Plant Cell, Tissue and Organ Culture	100.00	1.96	101.96
Economic Journal	100.00	1.82	101.82
Microbiology Resource Announcements	100.00	1.34	101.34
Obesity Medicine	100.00	1.06	101.06
JGH Open	100.00	0.80	100.80
Epilepsy and Behavior	100.00	0.68	100.68

Table 19 top 10 journals published by CU researchers in 2019

Journal	CC	Hub	Total Score
Scientific Reports	33.40	100.00	133.40
Indian Journal of Critical Care Medicine	100.00	1.81	101.81
International Journal of Diabetes in Developing Countries	100.00	1.24	101.24
Climacteric	100.00	1.13	101.13
Journal of Endourology	100.00	0.93	100.93
Substance Abuse: Treatment, Prevention, and Policy	100.00	0.76	100.76
Histopathology	100.00	0.75	100.75
Nutrition and Dietetics	100.00	0.73	100.73
Journal of Diabetes Research	100.00	0.65	100.65
Health Research Policy and Systems	100.00	0.58	100.58

Table 20 compare CU percentile rank for top 10 journals in 2019 group a

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
Scientific Reports	1	0.999	1	1.000	1	0
Indian Journal of Critical Care Medicine	0.925	0	0.944	0.925	0.999	0.074
International Journal of Diabetes in Developing Countries	0	0	0	0.000	0.999	0.999
Climacteric	0.963	0.94	0	0.940	0.999	0.059
Journal of Endourology	0.915	0.956	0.943	0.943	0.999	0.056
Substance Abuse: Treatment, Prevention, and Policy	0	0	0	0.000	0.999	0.999
Histopathology	0	0	0	0.000	0.999	0.999
Nutrition and Dietetics	0	0	0	0.000	0.999	0.999
Journal of Diabetes Research	0.96	0	0	0.000	0.999	0.999
Health Research Policy and Systems	0	0	0	0.000	0.999	0.999

Table 21 Difference between CU percentile rank and article cover group a

Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
<= 0.1	356	1,130	3.17
> 0.1	851	1,164	1.37

4.4.2 Journals that CU articles have cited

In this part of the experiment, Betweenness centrality, Eigenvector centrality, PageRank, and Authority were used to measure and rank the importance of journals that CU articles have cited to. Table 22, Table 23, Table 24, and Table 25 shows top 10 journals from 2016 to 2019 ordered by the score. List of top 10 journals in each year are quite similar, 6 out of 10 journals are shows up along 4 years of experiment and all the journal's list are also related to knowledge of Science.

Then the percentile rank was applied to the score in each year. The median of percentile ranks between year 2016 and 2018 was calculated and compared to that of 2019 to calculate difference between median percentile rank of 2016-2018 and 2019 as shown in Table 26. Result show that 9 out of 10 journals got the same percentile rank number between median percentile rank of 2016-2018 and 2019 and another journal got a very small number of different.

The journals are divided into two groups according to the different as shown in Table 27. The result shows that the first group, with more accurate prediction, contains 36.5% of journals cited by CU articles and covers over 80% of all articles that CU researchers cited. It means that by using centrality measurement with 3-year citation data, it can predict majority journals that will be cited by CU articles in the following year.

Table 22 top 10 journals cited by CU articles in 2016

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	100.00	100.00	100.00	100.00	400.00
Proceedings of the National Academy of Sciences of the United States of America	26.91	63.71	95.25	92.45	278.32
Nature	13.89	60.17	85.41	83.80	243.28
Journal of Biological Chemistry	3.02	71.93	76.98	78.80	230.74
Journal of the American Chemical Society	0.00	73.35	82.16	63.35	218.86
Science	0.00	51.38	82.51	84.40	218.30
Bioresource Technology	9.99	78.53	61.64	50.93	201.09
Chemical Engineering Journal	8.99	42.59	55.48	47.40	154.45
Langmuir	2.51	36.71	61.60	50.09	150.91
Journal of Physical Chemistry B	1.65	38.41	56.94	48.68	145.68

Table 23 top 10 journals cited by CU articles in 2017

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	100.00	100.00	100.00	100.00	400.00
Proceedings of the National Academy of Sciences of the United States of America	14.91	65.05	89.17	90.78	259.91
Science	0.00	47.76	93.35	96.12	237.23
Nature	0.00	53.20	89.49	90.16	232.86
Journal of the American Chemical Society	0.00	53.81	87.42	84.01	225.23
Scientific Reports	77.80	21.16	58.05	53.49	210.50
Journal of Biological Chemistry	17.94	47.52	59.14	60.57	185.17
RSC Advances	20.94	31.08	70.61	60.65	183.28
Langmuir	2.13	26.84	70.13	63.55	162.66
Bioresource Technology	12.87	51.27	45.35	50.99	160.48

Table 24 top 10 journals cited by CU articles in 2018

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	100.00	100.00	96.47	100.00	396.47
Scientific Reports	62.44	38.05	90.93	92.25	283.67
Proceedings of the National Academy of Sciences of the United States of America	3.39	74.70	100.00	95.31	273.40
Journal of the American Chemical Society	0.00	46.60	85.03	81.92	213.55
Science	0.00	40.37	85.71	86.59	212.67
Nature	0.00	48.56	75.04	81.62	205.22
RSC Advances	17.02	22.79	88.06	76.35	204.23
Journal of Biological Chemistry	10.28	47.35	71.09	60.47	189.19
Chemical Engineering Journal	0.77	28.00	64.02	63.47	156.26
Chemical Communications	1.48	19.53	70.73	55.22	146.97

Table 25 top 10 journals cited by CU articles in 2019

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	67.82	100.00	93.87	100.00	361.68
Scientific Reports	100.00	54.70	98.50	88.35	341.55
Proceedings of the National Academy of Sciences of the United States of America	13.96	69.10	100.00	85.22	268.28
Nature	0.00	62.50	97.68	83.09	243.27
RSC Advances	10.84	38.40	84.53	80.27	214.04
Journal of the American Chemical Society	1.22	49.70	89.92	72.59	213.42
Science	3.33	48.60	83.12	70.09	205.14
Journal of Biological Chemistry	5.64	35.00	65.45	56.38	162.48
Chemical Engineering Journal	3.62	37.10	55.41	57.75	153.88
Industrial and Engineering Chemistry Research	5.06	38.80	57.04	51.84	152.74

Table 26 compare CU percentile rank for top 10 journals in 2019 group b

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
PLoS ONE	1	1	1	1	1	0
Scientific Reports	0.999	0.999	0.997	0.999	0.999	0
Proceedings of the National Academy of Sciences of the United States of America	0.999	0.999	0.999	0.999	0.999	0
Nature	0.999	0.999	0.999	0.999	0.999	0
RSC Advances	0.999	0.999	0.998	0.999	0.999	0
Journal of the American Chemical Society	0.999	0.999	0.999	0.999	0.999	0
Science	0.999	0.999	0.999	0.999	0.999	0
Journal of Biological Chemistry	0.999	0.999	0.999	0.999	0.999	0
Chemical Engineering Journal	0.999	0.999	0.999	0.999	0.999	0
Industrial and Engineering Chemistry Research	0.998	0.998	0.998	0.998	0.999	0.001

Table 27 Difference between CU percentile rank and article cover group b

Percentile rank Difference	Number of Journals	Number of articles	AVG articles/journals
<= 0.1	2,967	50,481	17.01
> 0.1	5,142	12,779	2.49

Note that both lists contain the same journals but ranked with different metrics. Therefore, some journals can be on the top in both lists.

4.5 Faculty in Chulalongkorn University

In this experiment section, we analyze journals by Faculty in CU. The list of faculties and institutes in CU is taken from the University website. The data collected from SCOPUS is then divided by Faculty/Institute information in affiliation. Table 28 shows faculties and institutes in CU with articles published between 2016 and 2019 with rank and number of articles in each year. In this thesis, I will focus only top 5 faculties with the most publications which are Faculty of Science, Faculty of Medicine, Faculty of Engineering, Faculty of Veterinary Science, and Faculty of Pharmaceutical Sciences.

Table 28 CU faculties with number of published articles from 2016 to 2019

Rank	Faculties and Schools	Number of documents				Total
		2019	2018	2017	2016	
1	Faculty of Science	717	797	664	648	2826
2	Faculty of Medicine	607	526	442	434	2009
3	Faculty of Engineering	307	302	286	269	1164
4	Faculty of Veterinary Science	118	118	117	149	502
5	Faculty of Pharmaceutical Sciences	121	115	111	140	487
6	Faculty of Dentistry	96	96	93	74	359
7	Graduate School	76	79	67	56	278
8	The Petroleum and Petrochemical College	73	71	54	75	273
9	No Faculty in articles	50	45	42	44	181
10	Faculty of Allied Health Sciences	50	51	38	33	172
11	College of Public Health Sciences	47	61	40	22	170
12	Faculty of Commerce and Accountancy	48	29	25	20	122
13	Metallurgy and Materials Science Research Institute	27	29	23	18	97
14	Environmental Research Institute	20	23	19	17	79
15	Social Research Institute	67	3	2	3	75
16	Faculty of Economics	25	18	15	11	69
17	Faculty of Education	18	17	16	16	67

Rank	Faculties and Schools	Number of documents				Total
		2019	2018	2017	2016	
18	Faculty of Nursing	16	13	16	11	56
19	The Institute of Biotechnology and Genetic Engineering	21	6	2	6	35
20	Faculty of Psychology	13	9	8	4	34
21	College of Population Studies	9	7	9	8	33
22	Faculty of Arts	10	7	8	6	31
23	Faculty of Sports Science	9	7	6	7	29
24	Faculty of Political Science	5	3	10	10	28
25	Sasin Graduate Institute of Business Administration of CU	7	4	8	5	24
26	Energy Research Institute	5	4	7	3	19
27	Faculty of Architecture	4	6	5	4	19
28	Institute of Asian Studies	10	2	0	0	12
29	Aquatic Resources Research Institute	4	2	4	2	12
30	Faculty of Law	5	4	0	1	10
31	Faculty of Communication Arts	5	2	2	0	9
32	Language Institute	3	2	3	1	9
33	School of Agricultural Resources	3	3	1	2	9
34	Transportation Institute	3	3	1	2	9
35	Faculty of Fine and Applied Arts	3	2	1	0	6
36	Chulalongkorn University Intellectual Property Institute	0	0	0	0	0
37	Confucius Institute	0	0	0	0	0
38	Institute of Thai Studies	0	0	0	0	0
39	School of Integrated Innovation (SCII)	0	0	0	0	0
40	The Sirindhorn Thai Language Institute	0	0	0	0	0

The experiment step in this experiment is also divided into two parts as same as experiment 4.1. The first part in each faculty focuses on the journals that each faculty researchers have published in. The second part deals with the journals that were cited.

4.5.1 Faculty of Science

Faculty of Science (SC) is the number 1 faculty that got the highest number of articles which cover more than one third of the total articles in each year. Table 29 shows the number of articles published by SC researches from 2016 to 2018 and total number of references those articles cited.

Table 29 Number of SC articles collected from Scopus

Articles	Year			
	2019	2018	2017	2016
Published by SC	717	797	664	648
Referenced by SC articles	24525	28408	21124	19169

Then the data were converted to journal level, citation network has been created separately for each year using Gephi application. The number of nodes and edges separated by year are given in Table 30

Table 30 Number of SC Network components

Graph Elements	2019	2018	2017	2016
Nodes	3211	3496	2915	3033
Edges	10619	11723	9085	8938

Figure 15, Figure 16, Figure 17, and Figure 18 shows visualization of the citation network in 2016, 2017, 2018, 2019 of SC journals, respectively. It is generated using Gephi application. The graph was colored based on detected communities.

Then Betweenness centrality, Closeness centrality, Eigenvector centrality, PageRank, Authority, and Hub were calculated using Gephi application function. Min-Max normalization technique was applied at this step to all measurements to normalize values to the same range between 0 and 100.

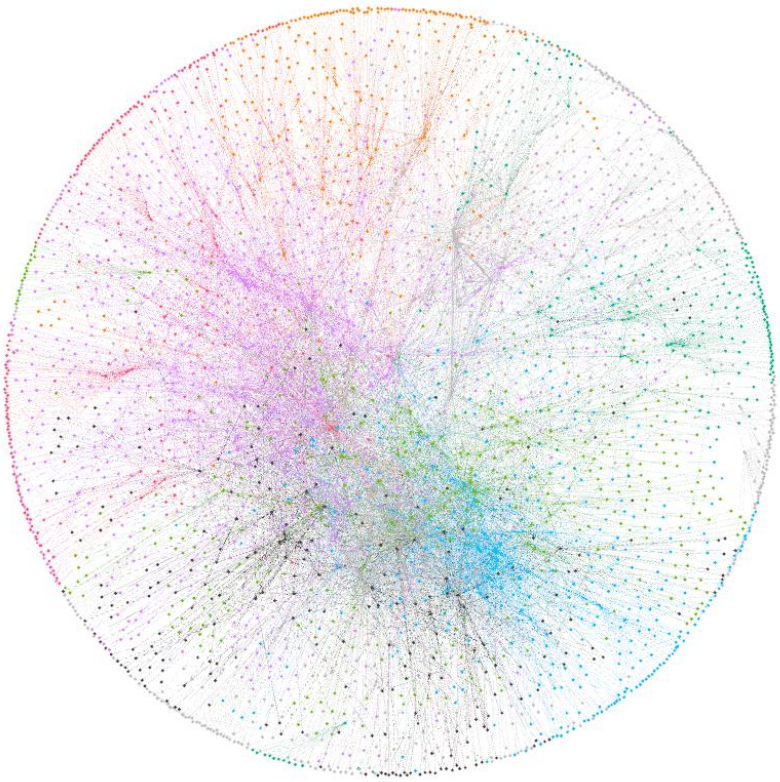

Figure 15 2016 SC Citation Network graph

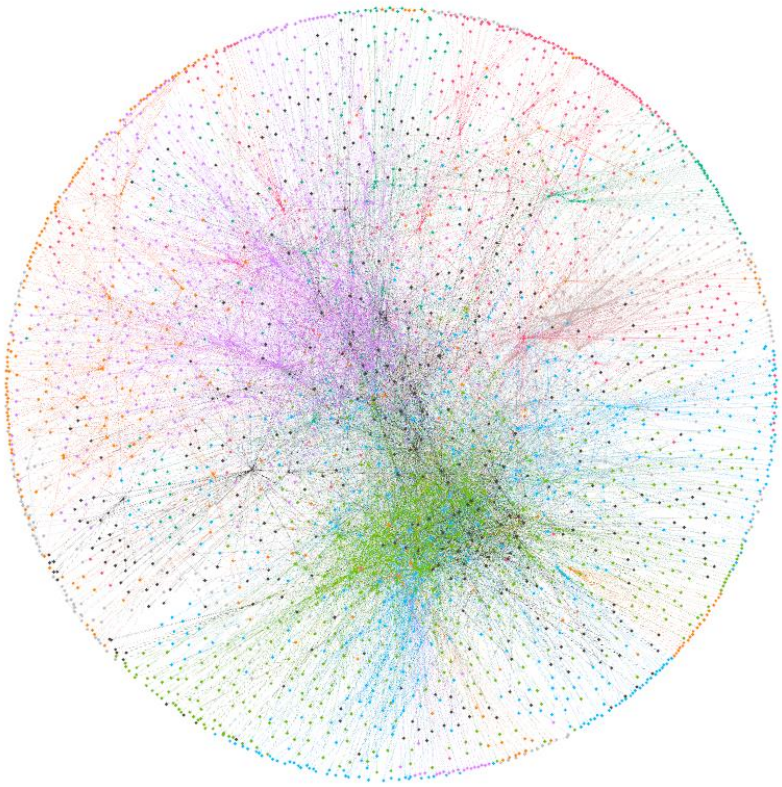

Figure 16 2017 SC Citation Network graph

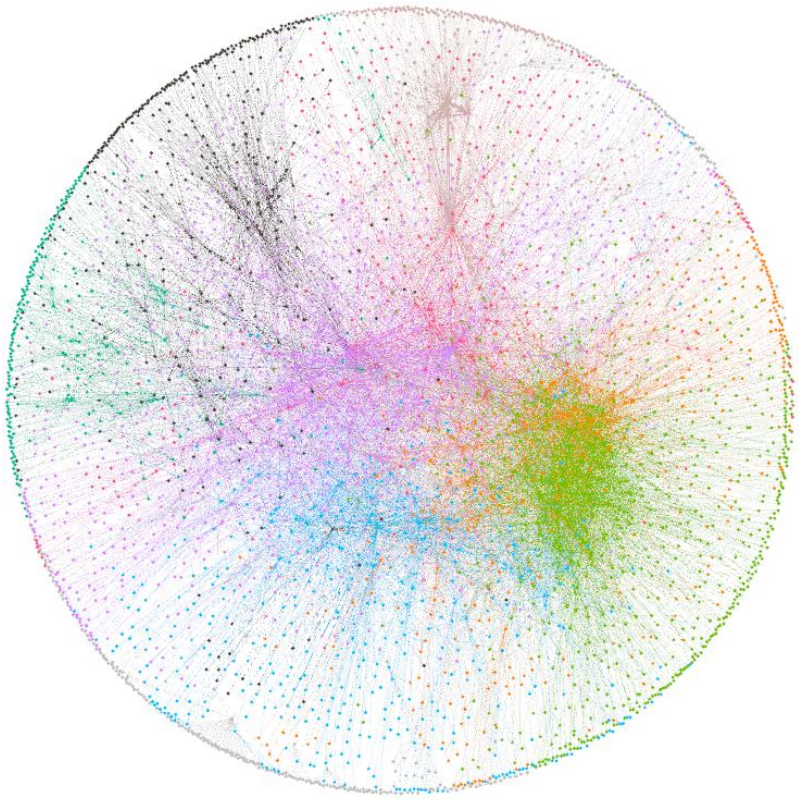

Figure 17 2018 SC Citation Network graph

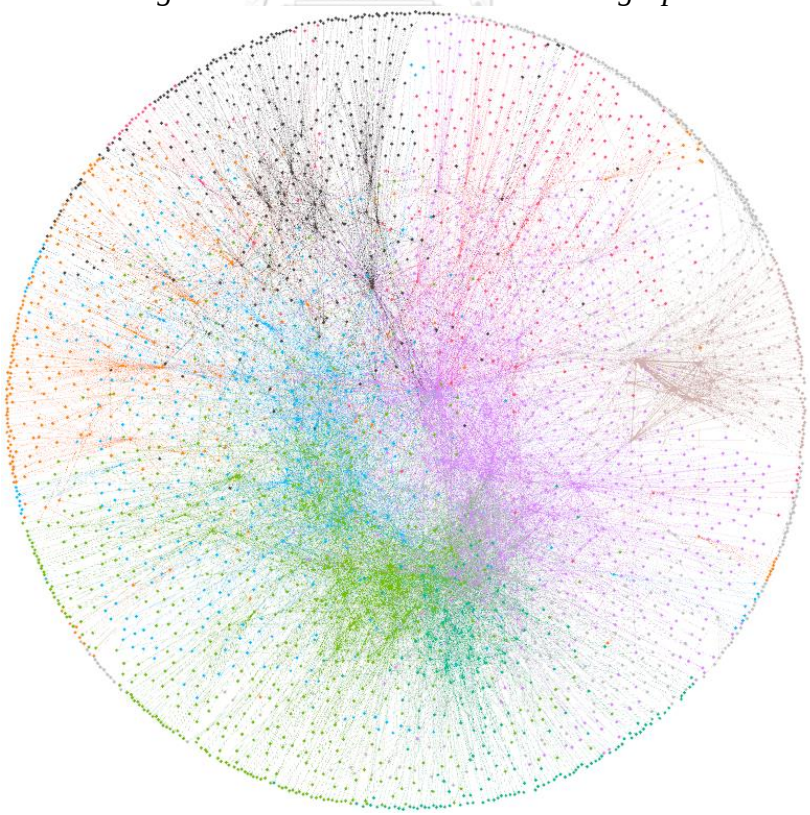

Figure 18 2019 SC Citation Network graph

a. Journals that SC researchers have published in

To rank the importance of journals that SC researchers have published in, Closeness centrality and Hub was selected and use to scoring metrics. Table 31, Table 32, Table 33, and Table 34 show top 10 journals from 2016 to 2019 ordered by the score. Result shows that list of journals that got highest score in each year are quite different comparing to another year in the scope.

Then percentile rank was applied to the score in each year to normalize the score into a value between 0 and 1, then we calculated the median of percentile ranks between year 2016-2018 and 2019 separately, then calculated the difference between median percentile rank of 2016-2018 and 2019 (shown in Table 35). The output form this step show that for Top 10 journals that SC researcher published in, 6 out of 10 journals got percent rank for year 2016, 2017, and 2018 equals to 0, which mean SC researches never publish articles into those journal in the mentioning year.

To evaluate the prediction result, the journals are divided into two groups by using the different between percent rank from the earlier step, the first group has the difference value <= 0.1, and the other has the difference value > 0.1. Table 36 shows that the first group, indicating accurate prediction, contains about 30% of journals SC articles published in but covers 54% of all articles by SC researchers.

Table 31 top 10 journals published by SC researchers in 2016

Journal	CC	Hub	Total Score
RSC Advances	30.31	100.00	130.31
Talanta	30.21	95.32	125.53
Carbohydrate Polymers	31.39	93.89	125.28
Water Science and Technology: Water Supply	100.00	5.44	105.44
Iranian Polymer Journal (English Edition)	100.00	5.21	105.21
South African Journal of Botany	100.00	1.82	101.82
Sustainable Environment Research	100.00	1.55	101.55
Tropical Life Sciences Research	100.00	0.74	100.74
Sleep and Breathing	100.00	0.68	100.68
Bulletin of Geosciences	100.00	0.39	100.39

Table 32 top 10 journals published by SC researchers in 2017

Journal	CC	Hub	Total Score
Journal of Molecular Liquids	34.51	100.00	134.51
Dyes and Pigments	30.62	82.25	112.87
RSC Advances	30.30	78.23	108.53
Carbohydrate Polymers	32.12	74.01	106.12
Journal of Physical Chemistry C	29.53	76.29	105.82
Materials and Design	31.91	73.74	105.65
Current Bioinformatics	100.00	5.11	105.11
Natural Product Communications	100.00	4.56	104.56
Ecosystem Services	100.00	3.67	103.67
Journal of Alloys and Compounds	32.04	71.09	103.13

Table 33 top 10 journals published by SC researchers in 2018

Journal	CC	Hub	Total Score
Scientific Reports	31.57	100.00	131.57
RSC Advances	30.36	74.72	105.09
Journal of Oral Science	100.00	4.89	104.89
Sensors and Actuators, B: Chemical	32.23	72.63	104.86
IET Nanobiotechnology	100.00	4.34	104.34
Pediatric Nephrology	100.00	3.39	103.39
Chiang Mai University Journal of Natural Sciences	100.00	3.28	103.28
Zoology in the Middle East	100.00	2.98	102.98
Journal of Medical and Biological Engineering	100.00	2.52	102.52
Bioinformatics	100.00	2.31	102.31

Table 34 top 10 journals published by SC researchers in 2019

Journal	CC	Hub	Total Score
Scientific Reports	37.2546	100	137.2546
Agriculture and Natural Resources	100	2.399449	102.3994
International Journal of Systematic and Evolutionary Microbiology	100	2.245114	102.2451
Brain	100	1.397305	101.3973
Suranaree Journal of Science and Technology	100	1.14146	101.1415
Clinical Nephrology	100	0.682597	100.6826
Modelling and Simulation in Engineering	100	0.601028	100.601
Vacuum	100	0.564774	100.5648
Journal of General Virology	100	0.459122	100.4591
Atmospheric Measurement Techniques	100	0.334048	100.334

Table 35 compare SC percentile rank for top 10 journals in 2019 group a

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
Scientific Reports	1.000	0.996	0.997	0.997	1.000	0.003
Agriculture and Natural Resources	0.971	0.985	0.980	0.980	0.999	0.019
International Journal of Systematic and Evolutionary Microbiology	0.979	0.989	0.000	0.979	0.999	0.02
Brain	0.000	0.000	0.000	0.000	0.999	0.999
Suranaree Journal of Science and Technology	0.000	0.000	0.000	0.000	0.999	0.999
Clinical Nephrology	0.000	0.000	0.000	0.000	0.999	0.999
Modelling and Simulation in Engineering	0.000	0.000	0.000	0.000	0.999	0.999
Vacuum	0.000	0.000	0.000	0.000	0.999	0.999
Journal of General Virology	0.000	0.985	0.995	0.985	0.999	0.014
Atmospheric Measurement Techniques	0.000	0.000	0.000	0.000	0.999	0.999

Table 36 Difference between SC percentile rank and article cover group a

Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
<= 0.1	118	393	3.331
> 0.1	268	324	1.209

b. Journals that SC articles have cited

In this part of experiment, Betweenness centrality, Eigenvector centrality, PageRank, and Authority were used to measure and rank the importance of journals that SC articles have cited to. Table 37, Table 38, Table 39, and Table 40 shows top 10 journals from 2016 to 2019 ordered by the score. The top citation journals list for SC are quite similar to the top journals list for whole University.

Then the percentile rank was applied to the score in each year. The median of percentile ranks between year 2016 and 2018 was calculated and compared to that of 2019 to calculated difference between median percentile rank of 2016-2018 and 2019 as shown in Table 41. The different value for each journal is very small or equal to zero, which mean that there is almost no change in ranking for each journal along 4-year period.

The journals are divided into two groups according to the difference as shown in Table 42. The result shows that the first group, with more accurate prediction, contains 51% of journals cited by SC articles and covers over 90% of all articles that SC researchers cited. Which mean we can predict most of the journals that will be cited by SC articles in the following year.

Table 37 top 10 journals cited by SC articles in 2016

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	100.00	71.98	58.97	67.32	298.26
Journal of the American Chemical Society	0.00	81.86	100.00	100.00	281.86
Nature	57.32	56.05	74.46	92.92	280.75
Proceedings of the National Academy of Sciences of the United States of America	35.09	59.27	83.18	97.43	274.97
Bioresource Technology	28.23	81.69	62.00	65.65	237.58
Science	0.00	54.97	83.96	98.64	237.57
Physical Review Letters	56.16	72.71	64.33	29.40	222.60
Analytical Chemistry	11.56	62.32	69.95	66.53	210.36
Journal of Physical Chemistry B	8.47	50.56	67.86	74.69	201.58
Journal of Agricultural and Food Chemistry	27.41	68.59	53.51	49.38	198.89

Table 38 top 10 journals cited by SC articles in 2017

Journal	BC	PageRank	EC	Authority	Total Score
Journal of the American Chemical Society	0.00	95.93	100.00	100.00	295.93
RSC Advances	64.08	57.28	87.12	73.99	282.48
Proceedings of the National Academy of Sciences of the United States of America	52.59	66.23	71.69	63.65	254.15
Scientific Reports	100.00	35.38	39.96	40.68	216.02
Science	0.00	62.16	76.50	77.16	215.82
Analytical Chemistry	25.22	63.13	66.71	53.55	208.62
PLoS ONE	23.56	68.18	61.51	55.36	208.61
Bioresource Technology	34.91	86.87	42.85	42.38	207.01
Journal of Physical Chemistry C	26.42	57.40	52.98	63.52	200.32
Nature	0.00	63.59	68.90	63.79	196.28

Table 39 top 10 journals cited by SC articles in 2018

Journal	BC	PageRank	EC	Authority	Total Score
Label	85.84	100.00	73.62	64.82	324.27
PLoS ONE	100.00	55.70	81.47	78.58	315.75
Scientific Reports	0.00	91.90	100.00	100.00	291.90
Journal of the American Chemical Society	37.97	57.32	98.10	92.21	285.60
RSC Advances	0.00	83.23	82.75	72.85	238.82
Proceedings of the National Academy of Sciences of the United States of America	4.12	85.88	82.04	61.06	233.10
Analytical Chemistry	0.00	51.94	86.49	92.84	231.27
Science	43.25	61.27	58.78	56.76	220.05
Carbohydrate Polymers	28.07	60.82	67.25	56.49	212.62
Sensors and Actuators, B: Chemical	26.44	56.02	72.04	56.51	211.01

Table 40 top 10 journals cited by SC articles in 2019

Journal	BC	PageRank	EC	Authority	Total Score
Scientific Reports	100.00	58.42	84.75	77.06	320.23
RSC Advances	38.75	61.51	84.32	100.00	284.58
Journal of the American Chemical Society	6.02	68.03	100.00	97.44	271.49
Proceedings of the National Academy of Sciences of the United States of America	26.80	61.31	86.83	75.64	250.57
Nature	0.00	66.41	94.15	77.29	237.85
PLoS ONE	32.10	57.76	62.07	63.44	215.37
Bioresource Technology	14.26	85.18	44.27	60.60	204.31
Science	0.00	58.47	76.97	68.56	204.00
Analytical Chemistry	0.00	74.91	58.04	58.04	190.99
Physical Review Letters	20.66	72.23	54.38	31.81	179.07

Table 41 compare SC percentile rank for top 10 journals in 2019 group b

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
Scientific Reports	0.999	0.999	0.995	0.999	1.000	0.001
RSC Advances	0.999	0.999	0.999	0.999	0.999	0
Journal of the American Chemical Society	0.999	1.000	0.999	0.999	0.999	0
Proceedings of the National Academy of Sciences of the United States of America	0.999	0.999	0.999	0.999	0.999	0
Nature	0.999	0.999	0.999	0.999	0.999	0
PLoS ONE	1.000	0.999	1.000	1.000	0.999	0.001
Bioresource Technology	0.998	0.999	0.999	0.999	0.999	0
Science	0.999	0.999	0.999	0.999	0.999	0
Analytical Chemistry	0.999	0.999	0.999	0.999	0.999	0
Physical Review Letters	0.998	0.999	0.999	0.999	0.999	0

Table 42 Difference between SC percentile rank and article cover group b

Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
<= 0.1	1645	22029	13.391
> 0.1	1566	2496	1.593

Note that both lists contain the same journals but ranked with different metrics. Therefore, some journals can be on the top in both lists.

4.5.2 Faculty of Medicine

Faculty of Medicine (MD) is the second faculty in CU that got the highest number of articles in this experiment. Table 43 shows number of articles published by MD researches between 2016 and 2018 and total number of references those articles cited.

Table 43 Number of MD articles collected from Scopus

Articles	Year			
	2019	2018	2017	2016
Published by MD	607	526	442	434
Referenced by MD articles	14899	13279	10926	9947

Then the data were converted to journal level, citation network have been created separately for each year using Gephi application. The number of nodes and edges separated by year are given in Table 44.

Table 44 Number of MD Network component

Graph Elements	2019	2018	2017	2016
Nodes	3243	2987	2627	2428
Edges	9318	8281	6712	6273

Figure 19, Figure 20, Figure 21, and Figure 22 shows visualization of the citation network in 2016, 2017, 2018, 2019 of MD journals, respectively. It is generated using Gephi application. The graph was colored based on detected communities.

Then Betweenness centrality, Closeness centrality, Eigenvector centrality, PageRank, Authority, and Hub were calculated using Gephi application function. Min-Max normalization technique was applied at this step to all measurements to normalize values to the same range between 0 and 100.

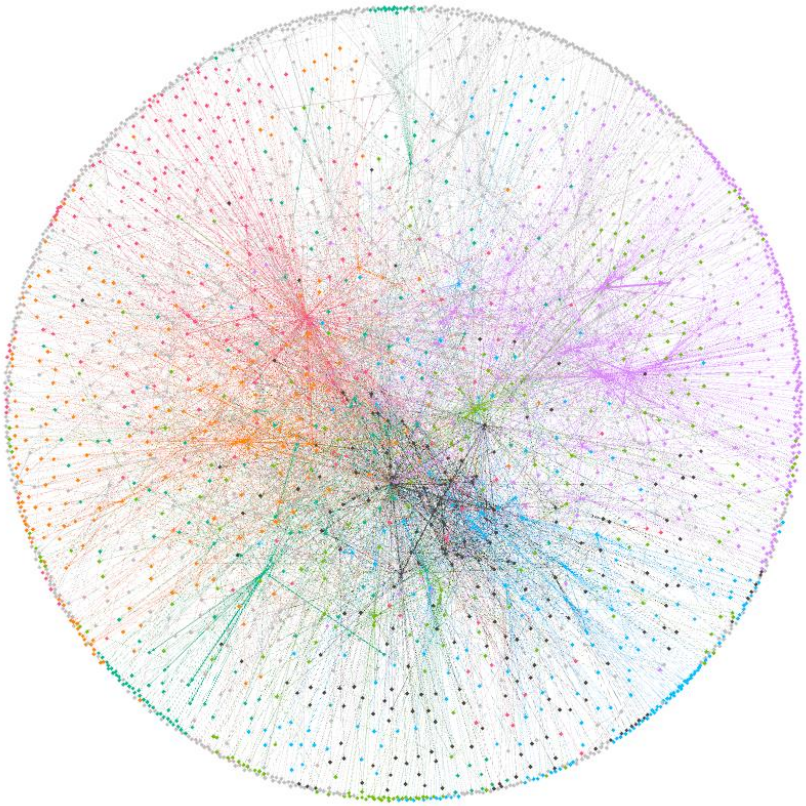

Figure 19 2016 MD Citation Network graph

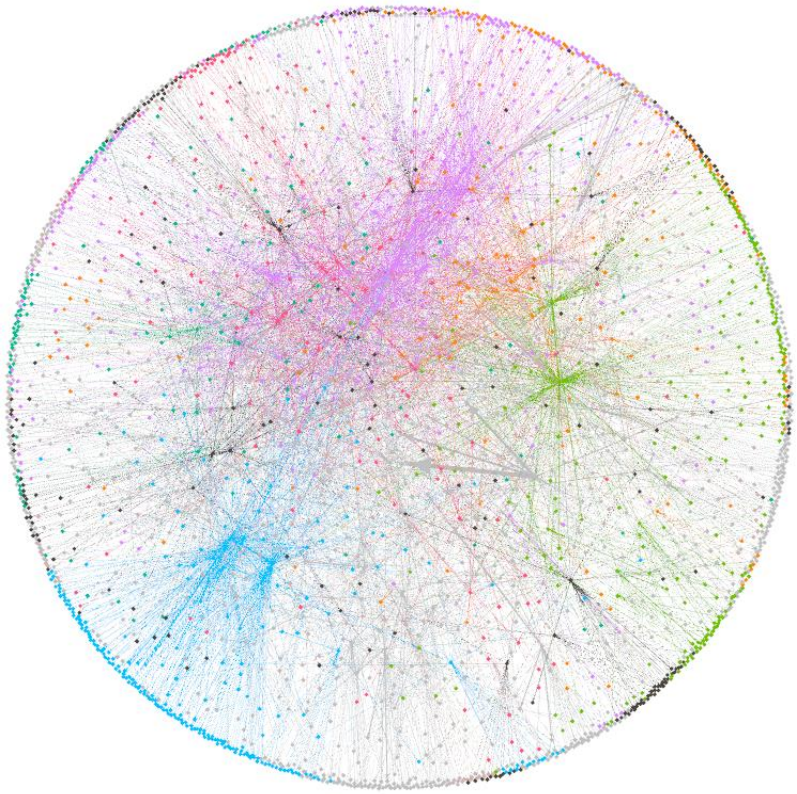

Figure 20 2017 MD Citation Network graph

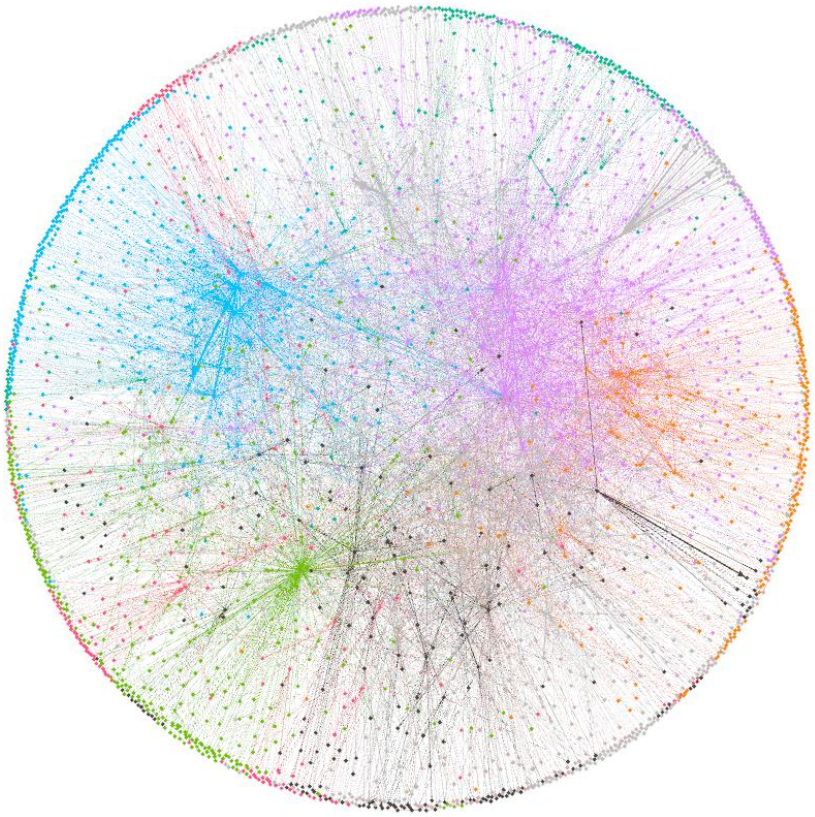

Figure 21 2018 MD Citation Network graph

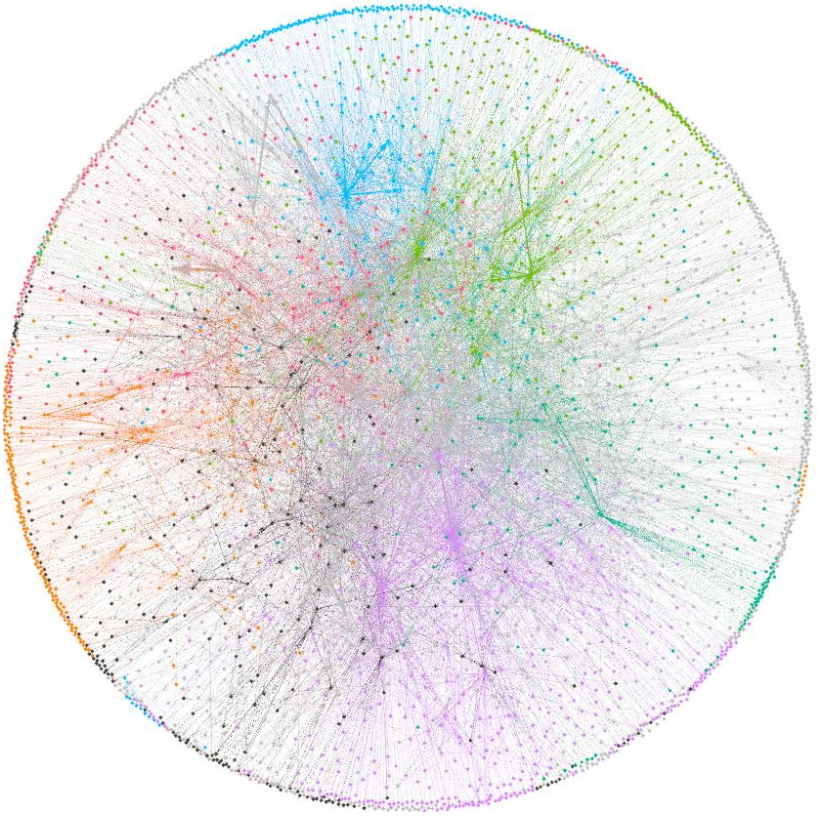

Figure 22 2019 MD Citation Network graph

a. Journals that MD researchers have published in

To find the best journal that MD Researchers have published the articles in, we still consider Closeness centrality and Hub. Top 10 journals from 2016 to 2019 ordered by the score shows in Table 45, Table 46, Table 47, and Table 48, respectively. Result shows that most of the top journal are journal in medicine field However, there are also some journal in the list that about base on Science such as PLoS ONE and Scientific Reports. After compare the list, we found that list of journals that got highest score in each year are quite different comparing to another year in the scope. It might be that for Medicine knowledge, there are various journal base on topic of study, if the researcher's study about specific Disorders, it most likely that the research will be publish in journal related to that disorders instead of the general journal about Medicine, so the research scope in each year might be one of the factor that affect the journals researchers choose to publish their work.

Then percentile rank was applied to the score in each year to normalize the score into a value between 0 and 1, then we calculated the median of percentile ranks between year 2016-2018 and 2019 separately, then calculated the difference between median percentile rank of 2016-2018 and 2019 (shown in Table 49).

The result is divided into two group by using percentile rank different to evaluate the prediction, first group has the difference value <= 0.1, and the other has the difference value > 0.1. Table 50 shows that the first group, indicating accurate prediction, contains about 22.8% of journals MD articles published in and covers 36% of all articles by MD researchers.

Table 45 top 10 journals published by MD researchers in 2016

Journal	CC	Hub	Total Score
Asian Biomedicine	38.58	100.00	138.58
PLoS ONE	33.32	76.46	109.78
JAMA Oncology	100.00	8.90	108.90
Molecular and Cellular Proteomics	100.00	8.90	108.90
BMC Endocrine Disorders	100.00	7.55	107.55
International Journal of Endocrinology	100.00	4.86	104.86
Odontology	100.00	4.10	104.10
Nephrology	100.00	3.55	103.55
EJNMMI Research	100.00	2.76	102.76
Endocrine	100.00	2.56	102.56

Table 46 top 10 journals published by MD researchers in 2017

Journal	CC	Hub	Total Score
PLoS ONE	38.1429	100	138.1429
Scientific Reports	32.1742	74.79185	106.966
New England Journal of Medicine	100	6.538829	106.5388
Journal of the Medical Association of Thailand	36.3602	68.86372	105.2239
Angiology	100	4.600521	104.6005
Journal of Ultrasound in Medicine	100	3.94179	103.9418
Genetic Testing and Molecular Biomarkers	100	3.321396	103.3214
Annals of Microbiology	100	2.62568	102.6257
BMC Health Services Research	100	2.517207	102.5172
Pain Research and Management	100	2.434668	102.4347

Table 47 top 10 journals published by MD researchers in 2018

Journal	CC	Hub	Total Score
PLoS ONE	36.77	100.00	136.77
Journal of the Medical Association of Thailand	32.93	86.66	119.59
Gene Therapy	100.00	12.08	112.08
Journal of Thoracic Oncology	100.00	7.83	107.83
Neurology Asia	100.00	5.78	105.78
Journal of Medical and Biological Engineering	100.00	5.12	105.12
BMC Medical Genetics	100.00	4.24	104.24
Microbiology Resource Announcements	100.00	4.12	104.12
Epilepsy and Behavior	100.00	3.65	103.65
Journal of Pain and Symptom Management	100.00	3.50	103.50

Table 48 top 10 journals published by MD researchers in 2019

Journal	CC	Hub	Total Score
Journal of the Medical Association of Thailand	36.66	100.00	136.66
BMC Cardiovascular Disorders	100.00	8.37	108.37
Scientific Reports	34.09	73.45	107.54
Indian Journal of Critical Care Medicine	100.00	6.80	106.80
Blood	100.00	5.41	105.41
International Journal of Diabetes in Developing Countries	100.00	5.02	105.02
Asian Biomedicine	32.27	72.58	104.85
Climacteric	100.00	4.69	104.69
Biomedical Reports	100.00	3.65	103.65
Journal of Endourology	100.00	3.59	103.59

Table 49 compare MD percentile rank for top 10 journals in 2019 group a

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
Journal of the Medical Association of Thailand	0.999	0.999	0.996	0.999	1.000	0.001
BMC Cardiovascular Disorders	0.988	0.000	0.985	0.985	0.999	0.014
Scientific Reports	0.996	0.999	0.996	0.996	0.999	0.003
Indian Journal of Critical Care Medicine	0.983	0.000	0.981	0.981	0.999	0.018
Blood	0.979	0.000	0.989	0.979	0.999	0.02
International Journal of Diabetes in Developing Countries	0.000	0.000	0.000	0.000	0.999	0.999
Asian Biomedicine	0.997	0.996	1.000	0.997	0.999	0.002
Climacteric	0.990	0.984	0.000	0.984	0.999	0.015
Biomedical Reports	0.995	0.000	0.000	0.000	0.999	0.999
Journal of Endourology	0.974	0.992	0.980	0.980	0.999	0.019

Table 50 Difference between MD percentile rank and article cover group a

Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
<= 0.1	83	219	2.639
> 0.1	307	388	1.264

b. Journals that MD articles have cited

In this part of experiment, Betweenness centrality, Eigenvector centrality, PageRank, and Authority were used to measure and rank the importance of journals that SC articles have cited to. Table 51, Table 52, Table 53, and Table 54. shows top 10 journals from 2016 to 2019 ordered by the score. List of the top journals are the combining of Medicine knowledge journal and Science knowledge journals. After comparing list for each year, we found that the top journals are quite the same along 4-year period which mean that it is the core journal that using by MD researchers and cited in their work.

Then the percentile rank was applied to the score in each year. The median of percentile ranks between year 2016 and 2018 was calculated and compared to that of 2019 to calculated difference between median percentile rank of 2016-2018 and 2019 as shown in Table 55.

The journals are divided into two groups according to the difference as shown in Table 56. The result shows that the first group, with more accurate prediction, contains 46.7% of journals cited by SC articles and covers over 80% of all articles that SC researchers cited.

Table 51 top 10 journals cited by MD articles in 2016

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	100.00	100.00	100.00	100.00	400.00
New England Journal of Medicine	0.00	83.72	71.39	71.21	226.32
Proceedings of the National Academy of Sciences of the United States of America	0.00	59.04	58.38	71.42	188.83
Journal of Biological Chemistry	0.00	58.05	48.10	66.12	172.28
Clinical Infectious Diseases	0.00	55.96	67.38	47.12	170.46
Nature	0.00	47.17	52.06	64.28	163.51
Journal of Infectious Diseases	0.71	53.30	64.20	39.85	158.05
Journal of Clinical Microbiology	28.87	39.85	38.61	37.85	145.17
The Lancet	0.00	40.40	55.42	46.09	141.91
Hepatology	10.29	43.96	45.06	41.15	140.46

Table 52 top 10 journals cited by MD articles in 2017

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	100.00	100.00	100.00	100.00	400.00
New England Journal of Medicine	0.86	64.98	80.76	72.66	219.25
Proceedings of the National Academy of Sciences of the United States of America	0.00	48.84	52.77	58.56	160.16
Journal of Biological Chemistry	0.00	46.96	51.95	54.98	153.90
Journal of the Medical Association of Thailand	45.77	34.19	36.43	29.26	145.66
The Lancet	0.00	45.13	51.10	47.23	143.45
Nature	0.00	43.68	46.48	50.62	140.77
Clinical Infectious Diseases	0.00	47.21	44.64	29.97	121.83
Journal of Clinical Investigation	4.66	29.83	41.10	46.14	121.73
AIDS	5.82	46.92	41.30	26.06	120.11

Table 53 top 10 journals cited by MD articles in 2018

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	100.00	100.00	100.00	100.00	400.00
Proceedings of the National Academy of Sciences of the United States of America	0.00	63.11	62.28	61.45	186.84
New England Journal of Medicine	0.00	60.95	64.47	54.43	179.84
Scientific Reports	19.18	35.15	52.15	56.19	162.67
Journal of Biological Chemistry	11.35	39.26	40.43	35.14	126.19
Nature	0.00	36.10	44.82	45.21	126.13
Clinical Infectious Diseases	6.16	51.14	46.56	17.89	121.75
Journal of Clinical Microbiology	2.14	51.64	36.81	21.75	112.34
The Lancet	0.00	36.56	41.64	33.69	111.89
Science	0.00	33.28	40.61	35.04	108.93

Table 54 top 10 journals cited by MD articles in 2019

Journal	BC	PageRank	EC	Authority	Total Score
PLoS ONE	79.33	100.00	100.00	100.00	379.33
Scientific Reports	100.00	38.36	52.76	43.99	235.11
New England Journal of Medicine	0.00	76.55	83.85	68.45	228.85
Journal of the Medical Association of Thailand	82.70	29.19	20.71	24.37	156.97
Gastroenterology	28.66	41.57	54.56	32.14	156.92
Proceedings of the National Academy of Sciences of the United States of America	17.28	44.15	46.86	46.62	154.91
Journal of Clinical Microbiology	0.60	53.67	47.86	34.14	136.26
Hepatology	0.00	55.67	45.46	28.94	130.07
Clinical Infectious Diseases	4.71	43.57	41.65	33.89	123.82
Nature	0.00	36.23	42.85	44.72	123.80

Table 55 compare MD percentile rank for top 10 journals in 2019 group b

Journal	Percentile rank			Median percentile rank 2016 - 2018	Percentile rank 2019	Difference
	2018	2017	2016			
PLoS ONE	1.000	1.000	1.000	1.000	1.000	0
Scientific Reports	0.999	0.997	0.992	0.997	0.999	0.002
New England Journal of Medicine	0.999	0.999	0.999	0.999	0.999	0
Journal of the Medical Association of Thailand	0.998	0.999	0.999	0.999	0.999	0
Gastroenterology	0.998	0.998	0.998	0.998	0.999	0.001
Proceedings of the National Academy of Sciences of the United States of America	0.999	0.999	0.999	0.999	0.999	0
Journal of Clinical Microbiology	0.999	0.997	0.999	0.999	0.999	0
Hepatology	0.999	0.999	0.999	0.999	0.999	0
Clinical Infectious Diseases	0.999	0.999	0.999	0.999	0.999	0
Nature	0.999	0.999	0.999	0.999	0.999	0

Table 56 Difference between MD percentile rank and article cover group b

Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
<= 0.1	1515	11978	7.906
> 0.1	1728	2921	1.690

Note that both lists contain the same journals but ranked with different metrics. Therefore, some journals can be on the top in both lists.

Researchers also did the experiment for another top 3 faculties which are Faculty of Engineering (ENG), Faculty of Veterinary Science (VET), Faculty of Pharmaceutical Sciences (PHARM). The difference between 2016-2018 median percent rank and 2019 percent rank of group (a) the journals that each Faculty researchers have published in shows in table 57 and for group (b) the journals that were cited shows in table 58. Detailed for each faculty are presented in the appendix section

Table 57 Difference between ENG, VET, PHARM percentile rank and article cover group a

Faculty	Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
ENG	<= 0.1	45	114	2.533
ENG	> 0.1	159	193	1.214
VET	<= 0.1	19	48	2.526
VET	> 0.1	53	70	1.321
PHARM	<= 0.1	20	41	2.05
PHARM	> 0.1	68	80	1.176

Table 58 Difference between ENG, VET, PHARM percentile rank and article cover group b

Faculty	Percentile rank Difference	Number of Journals	Number of articles	AVG articles / journals
ENG	<= 0.1	818	6523	7.974
ENG	> 0.1	981	1529	1.559
VET	<= 0.1	435	2483	5.708
VET	> 0.1	498	696	1.397
PHARM	<= 0.1	495	2495	5.040
PHARM	> 0.1	644	895	1.389

CHAPTER 5 CONCLUSION AND FUTURE WORK

5.1 Conclusion

In this thesis, we show that citation network analysis is an effective tool to analyze usedness and demand of journals from publications by researchers in a university. By focusing on two groups of journals, the ones that researchers have published and the one that their articles have cited, we employ different sets of centrality metrics that are suitable for ranking the journals in each group. We apply the method to the different set of CU articles loaded from SCOPUS database and created an experiment focus on different size of data.

The first experiment consider data at the University level while the second experiment focus on faculty in CU. From publication data in previous years at each level, the proposed method can produce two lists of recommended journals for the coming year. The experimental results based on publication by CU researchers show that the ranked journal lists created from 2016-2018 publication data closely matches the list produced from 2019 publication data. For the first list that consider journals CU researchers published in, the prediction rates are around 33-55%. and for second group the cited by articles publish by CU, we got the prediction rates from 73 to 90 percent. By using social network analyst, the result is better than using only number of citation which help increase prediction percent.

Therefore, we can conclude that our method can support the University library in journal selection process by giving suggestion on journals that should be included in the University library collection based on past publication data. The journal lists can also help the University researchers to choose journals for publication and reference.

5.2 Limitation

The result of this work may have some bias regarding fields of knowledge, more than 90% of articles collected from SCOPUS database are articles related to Science knowledge such as Science, Medicine, Engineering, etc. I recommend that articles in the other fields such as Arts, Language should take into consideration to include the University library collection also.

5.3 Future work

An immediate future work is to take the results from this research into the collection management process of the library by comparing the recommended journal lists with the current subscription list and taking into account the in-library use and search statistics in reference databases.

Another future work is to consider articles that publish by researches from multiple fields to understand the usedness of journal that focus on more than one research area.

REFERENCES

1 S. Weerasinghe, “Citation Analysis of Library and Information Science research output for collection development,” Journal of the University Librarians Association of Sri Lanka, 20(1), 2017, pp.1–18. doi: http://doi.org/10.4038/jula.v20i1.7893

2 SCImago, (n.d.). SJR — SCImago Journal & Country Rank [Portal]

3 K.G. Sudhier, “Application of Bradford’s law of scattering to the physics literature: A study of doctoral theses citations at the Indian Institute of Science,” DESIDOC Journal of Library & Information Technology, 30(2), 2010, pp.3-14, doi : 10.14429/djlit.30.3 .

4 K. Hoffmann and L. Doucette, “A Review of Ciatation Analysis Methodologies for Collection Management,” College and Research Libraries, 73(4), 2012, pp. 321-335

5 S. Edwards, “Citation analysis as a collection development tool: A bibliometric study of polymer science theses and dissertations?,” Serials Review, 25(1), 1999, pp. 11-20

6 S.C. Wilson, and T. Carol, “Local Citation Analysis, Publishing and Reading Patterns: Using Multiple Methods to Evaluate Faculty Use of an Academic Library’s Research Collection,” Journal of the American Society for Information Science and Technology, 59 (9),2008, pp.1393–408. doi: 10.1002/asi.20812.

7 J. Derek, et al. (1965) “Networks of Scientific Papers,” Science, 149(3683),1965, pp.510-515

8 W. Glanzel, H.F. Moed, “Journal Impact Measures in Bibliometric Research,” Scientometrics, 53, 2002,pp.171–93.

9 B. Francis, J. Matthew, T. Oietro, “Centrality measures in networks,” 2016, Available at SSRN 2749124.

10 L. Page, S. Brin, R. Motwani, and T. Winograd, “The PageRank Citation Ranking: Bringing Order to the Web,” Technical Report: Stanford University, Stanford, CA, 1998.

11 J. M. Kleinberg, “Authoritative sources in a hyperlinked environment,” Proceedings of the ACM-SIAM symposium on discrete algorithms, 46,1999, pp. 604–632, doi: https://doi.org/10.11 45/32413 3.324140

12 Bastian M., Heymann S., Jacomy M. (2009). Gephi: an open source software for exploring and manipulating networks. International AAAI Conference on Weblogs and Social Media.

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