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Patterns of co-authorship and research collaboration in Malaysia

Research
collaboration in
Malaysia

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Abstract

Purpose – By exploring the patterns of co-authorship, this paper aims to identify the degree and type of research collaboration in Malaysia.

Design/methodology/approach – A total of 22,244 publication records from five research universities in Malaysia were retrieved from Scopus database. Journal articles published for the period between 2008 and October 2011 were collected. Indicators such as number of authors, subject areas, number of local institutions and foreign countries, were analysed using simple statistical tools to identify the degree and type of collaboration.

Findings – The findings reveal that in Malaysia, researchers tend to work in teams but collaboration is more dominant in science-based research than social sciences. Academics published extensively with their colleagues from the same university or from other academic institutions, but there is little collaboration with researchers from public research institutes or industry. In terms of international collaboration, Iran, India, UK, Japan and the USA are the top five collaborating countries. Disciplines with significant international collaboration are physics and astronomy; chemistry; agricultural and biological sciences; engineering; health profession and computer sciences.

Originality/value – This paper is among the few that study the patterns of co-authorship in Malaysia and most probably the first to examine the patterns in the Malaysian research universities. The study highlights the skewed distribution of co-authorship patterns where there is limited evidence of cross sectors collaboration in journal publication. The findings call for policy makers as well as universities to look into the constraints as well as drivers that would enhance the linkage of different actors in the national research system.

Keywords Co-authorship, Malaysia, Academic research, Bibliometrics, Joint authorship, Scientific collaboration

Paper type Research paper

Introduction

Collaboration is a going concern in the knowledge-based economy. Through joint efforts, individuals are able to compete better in this increasingly dynamic, complex and interactive economy. In particular, collaboration in research is even more important, as knowledge is becoming more specialised as a result of the division of labour. The importance of research collaboration is clearly illustrated by Hausmann



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et al. (2011, p. 15), who maintain that “the amount of knowledge embedded in a society, however, does not depend mainly on how much knowledge each individual holds. It depends, instead, on the diversity of knowledge across individuals and on their ability to combine this knowledge, and make use of it, through complex webs of interaction”. Research collaboration bridges the different pieces of knowledge and integration allows for the creation of new knowledge. Thus, research collaboration is greatly emphasised and encouraged.

Many reasons for research collaboration have been cited in the literature. Amongst the popular motivations are greater output and higher quality research, the sharing of research facilities, and the acquisition of knowledge and expertise (Frame and Carpenter, 1979; Beaver, 2001; Glänzel and Schubert, 2001). Some view research collaboration as a process of diffusing scientific capacity and the formation of networks within the scientific community (Wagner and Leydesdorff, 2005; Bukvova, 2010). Not only is collaboration among researchers encouraged, but fostering collaboration across different sectors, particularly among universities, governments and industries, and international collaboration are increasingly becoming key agenda in many countries.

Research collaboration is a multi-faceted concept. Various definitions have been given and they range from the restrictive forms of intense collaboration, which involve close interaction and active participation, to loose forms such as contributing research ideas at the initial stage of the project or occasionally providing input throughout the duration of the project (Melin and Persson, 1996; Katz and Martin, 1997; Harirchi *et al.*, 2007; Bukvova, 2010). Taking into consideration both the weak and strong forms of collaboration, Katz and Martin (1997) describe research collaboration as a process of working together throughout a large part of the project, and collaborators are those who either initiate the project, or lead the project, or are responsible for the main part(s) of the project. Therefore, their names are included in the original research proposal, and they will very often appear as co-authors in publications.

Due to the vagueness of the definition of research collaboration, the subsequent question that arises is how to measure the degree of collaborative activity in research. As cited in Katz and Martin (1997), in the 1940s and 1950s, there were attempts to use co-authorship as a measure of the collaborative efforts among a group of researchers. At the same time, there are counter arguments to using co-authorship, because the level of contribution may well not be reflected by how co-authors are listed in the paper. As Harirchi *et al.* (2007) have pointed out in their study, not all co-authored publications have been the result of collaborative research. Although considered a limited or partial indicator by some researchers such as Katz and Martin (1997), co-authorship serves as a direct indication of the existence of collaboration among researchers, as publication is generally accepted as part of a research process (Bukvova, 2010; Savanur and Srikanth, 2010). Hence, co-authorship is often used in bibliometrics studies to measure research collaboration, particularly within academic communities.

Research collaboration in Malaysia

In an effort to realise the nation’s vision of becoming a fully developed nation by 2020 and of developing the nation as a regional and international hub of higher education, various measures have been taken to enhance the quality of higher education in Malaysia. In 2007, the Ministry of Higher Education, Malaysia introduced the National

Higher Education Strategic Plan (2007-2020) to spearhead the transformation and to develop a competitive higher education system in Malaysia. Seven main thrusts were formulated and various action plans have been and will be undertaken in four phases spanning the years 2007 to beyond 2020 (Malaysia, Ministry of Higher Education, 2007). Among the efforts taken has been the implementation of the Malaysian Research University programme.

In 2006, four public universities were given Research University (RU) status under the Ninth Malaysia Plan. These universities were Universiti Malaya (UM), Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM) and Universiti Putra Malaysia (UPM). Additional budgets were allocated to support these universities in achieving excellent performances, especially in R&D and commercialisation activities. The status is reviewed every three years using the Malaysia Research Assessment Instrument (MyRA). The evaluation focuses on the impacts created in the areas of human capital cultivation (researchers and postgraduate students), innovation and intellectual property (publications and patents), income generation activities (commercialisation), networking and links, and support services. In 2010, these four universities retained their research university status and Universiti Teknologi Malaysia (UTM) joined the group to become the fifth research university in Malaysia.

Research and development as well as commercialisation are clearly the key concerns in these research universities. In order to enhance research performance and achieve the goals set for these universities, particularly in increasing the number of journal publications, promoting collaborative research activity is critical. However, relatively little is known about the degree and type of collaboration among university researchers in Malaysia.

This paper aims to examine the patterns and characteristics of research collaboration in these universities. Some of the questions to be addressed in this paper are: to what extent are the researchers in these five RUs involved in research collaboration, who are their main collaborators, which disciplines tend to show a high level of collaboration and where are their collaborators located? Detailed structural analysis of the networks of collaboration among researchers in the five RUs in Malaysia allows for the mapping of research activity, the identifying of the strengths of research in each university and the tracking of the role of Malaysian researchers in collaborative research.

Co-authorship in journal articles is used as a proxy variable for collaboration among researchers in academic institutions. Papers published by researchers in the five research universities (RUs) in Malaysia from 2008 to October 2011, were retrieved from the Scopus database. Despite the fact that UTM acquired its research university status only in 2010, macro data (all five RUs combined) was used for general analysis, as the purpose of this paper is to identify the general pattern of research collaboration in these universities rather than to do a comparative study of universities with and without research university status.

A total of 22,244 records were analysed to examine the degree of collaboration and the type of collaboration. The degree of collaboration is measured by the number of co-authors that appear in a paper, while the type of collaboration explores the nature of the institutions and countries involved in joint publications. Three types of collaboration are investigated, namely, intra-organisation collaboration (with colleagues in one's own institution), local collaboration (with researchers from other local institutions) and international collaboration (with researchers from different countries).

Literature review

Collaboration in research is not a new phenomenon for scientists and academics. However, there is continued interest in exploring the topic, as different contexts produce different forms of research collaboration. In addition, there have been significant changes in terms of the quantity and structure of research collaboration during the past few years, due to changing communication patterns, the mobility of scientists and the emphasis on research funding (Glänzel and Schubert, 2004).

What are the degrees and types of collaboration? Which researchers are more inclined towards collaborative research? How do they engage in collaboration? The answers to these questions differ from country to country, and from discipline to discipline. In 1963, Zuckerman (1967) conducted a study to analyse the research patterns of 41 Nobel laureates in the US. His study revealed that laureates tended to collaborate more often and to produce more multi-author papers than a group of age-matched scientists. However, laureates are highly selective in choosing their collaborators and they only collaborate with renowned scientists who are productive. Most people tend to collaborate with leading researchers from leading scientific nations. However, in certain cases, researchers form specific types of research partnerships due to country-specific factors such as political reasons. For instance, in Iran, emigrants have become the main collaborators for most of the scientists in Iran. This is because Iran has a large diaspora outside the country due to the brain drain (Harirchi *et al.*, 2007).

In terms of the nature of collaboration, Wagner and Leydesdorff (2005) found that it was the researcher who decided on his or her research partners, rather than institutional or official arrangements being made in forming a research team. Using network analysis, preferential attachment explains how international networks of co-authors are formed. How researchers themselves independently select and organise research partnerships, coupled with the dynamic intertwining of co-operation and competition among researchers, are complicated processes to understand. Thus, studies in research collaboration are eliciting increasing interest, as they are studies of researcher behaviour, and the mechanism behind it has important social and economic implications.

While different disciplines may exhibit different trends in collaboration, a general review indicates that there is a growing popularity in collaborative research irrespective of disciplines. The number of co-authored papers has continued to increase, especially international co-authorship (Bukvova, 2010). There is a greater tendency for researchers in science-based disciplines (medicine, engineering, physics, chemistry and other pure science subjects) to collaborate rather than to do individual work (Frame and Carpenter, 1979; Sooryamoorthy, 2009). Many reasons are offered for this phenomenon. For instance, science-based projects are normally more costly and involve complicated laboratory experiments. It is rather impractical for a science-based project to be carried out by an individual researcher. Division of work increases productivity. Frame and Carpenter (1979) highlighted the fact that basic research tends to show a higher level of international collaboration than applied science, because basic research involves finding universal facts, while applied research is oriented towards discovering country-specific truths.

Street *et al.* (2010) have pointed out that although different disciplines share different norms and beliefs with regards to authorship attribution, there are more

concerns in health science journals. In health sciences, the names that appear on an article may not necessarily indicate the true contributors, as gift and ghost authorships are quite common in this discipline (Street *et al.*, 2010).

As internationally co-authored publications are becoming more prevalent, many studies have been devoted to analysing the features of such interactions, especially in terms of collaborating countries and disciplines. Unique data or R&D resources, strengths in specific disciplines, geographical distances, culture, language, political factors and education systems are some of the determinants shaping the international networks of research collaboration (Harirchi *et al.*, 2007; Anuradha and Urs, 2007). In a study conducted by Frame and Carpenter (1979), the authors concluded that both science (national R&D efforts and research enterprise) and non-science factors (geography, language, culture and politics) determined the degree and patterns of international collaborative behaviour.

Method

Publications by authors in the five RUs were retrieved from the Scopus database as raw data. There are many different document types available on the database, such as articles, reviews, conference papers, etc. In this study, the focus is on the "article". Search by institution was conducted from 2008 to October 2011. As the search was based on institutions rather than on authors, papers with at least one author from the RUs were retrieved. Thus, the researchers did not need to be Malaysian, but they had to be affiliated with one of the RUs in Malaysia. Publication records were manually classified based on authors, journals, institutions, countries, keywords, disciplines and times cited. Discipline was classified based on keywords provided by the authors in the article and followed the subject areas provided by Scopus. Categorized data were analysed to paint a picture of interactions for researchers in Malaysia. The main analysis includes the number of authors involved in the paper, who the leading researcher (first author) is and the disciplines of the article. The addresses of all the authors were examined to categorise the types of collaboration that prevailed in the research and the extent of research collaboration. Collaboration exists if the paper is produced by authors from different institutions. Sooryamoorthy (2009) defines the degree of collaboration in terms of the number of authors in a paper, while the type of collaboration is measured in terms of domestic (domestic intra-institution and domestic inter-institution) and international collaboration. In this study, we have adopted the definitions suggested by Sooryamoorthy.

There are some complications in categorising types of collaboration based on researchers' addresses. As pointed out by Katz and Martin (1997), if a researcher is associated with more than one institution (either as a research fellow, a consultant or an associate), it is normal practice for a researcher to list all the institutions rather than giving sole credit to the parental institution where he or she is a full-time employee. Double or multiple addresses are common in bibliometrics data. In this study, the number of multiple addresses was tracked and less than five per cent of authors showed multiple institutions. Since the number is insignificant and the impact is rather small with such a sizeable database, we did not take any remedial measures to rectify or remove the data.

In order to avoid multiple counting, fractional counting instead of the whole counting method is used in all calculations. For instance, if a paper is co-authored by

four researchers from four different institutions, each institution is given a count of 0.25 instead of 1.

Results and discussion

The number of publications in each RU increased significantly over time. From 2008 to 2010, total publications by these five RUs increased by more than 100 per cent (as the data for 2011 were only collected until October, they are not included in the calculations). Generally, engineering is the most productive discipline, having produced about 18 per cent of the total number of publications during the period January 2008 to October 2011. It is followed by computer science (about 11 per cent) and health professions (about 10 per cent).

Degree of collaboration

Out of the total of 22,244 papers published by researchers in the five RUs during the study period, less than four per cent were produced by a sole author. The degree of collaboration does not vary much among the five RUs and over time. Figure 1 shows the distribution of the number of authors in each institution. As shown in Figure 1, the majority of the papers involved more than one author. In total, according to the data from all five RUs, about 94 per cent of the papers were written by 2 to 8 authors (16.2 per cent by two authors, 24 per cent by three authors, 22.5 per cent by four authors, 17.3 per cent by five authors). The median is four authors per paper, while the mode is three authors per paper. The findings indicate that most of the papers were jointly produced by a group of researchers. This indicates the importance of collaboration in research in the RUs in Malaysia.

Single authorship is more commonly found in studies related to social sciences, where about one quarter of the papers published were written by a single author, followed by economics, econometrics and finance (19.8 per cent) and then arts and

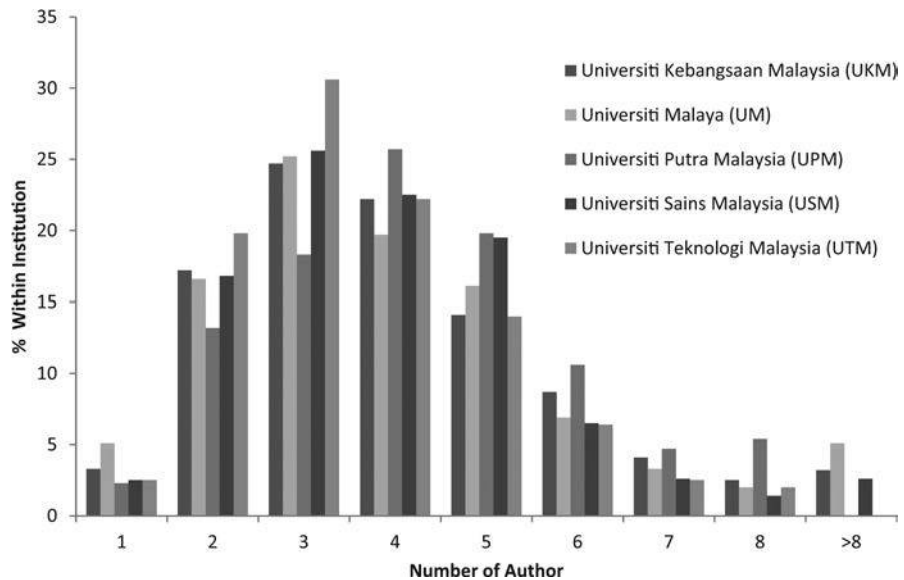


Figure 1.
Number of authors per paper

humanities (16.7 per cent). By contrast, most of the science-based publications, especially papers related to health, such as immunology and microbiology, material sciences and neuroscience, were jointly produced by a team of researchers. Table I shows the distribution of the number of authors according to disciplines. The numbers in the columns are the percentages of papers produced by different groups of authors in each discipline. The columns highlighted with an asterisk show the top three disciplines with different numbers of authors. As mentioned earlier, different disciplines exhibit different patterns of research collaboration. Health science research, particularly immunology and microbiology, and medicine, has shown a higher degree of research collaboration. In other words, co-authorship is a norm in science-related studies, but is less so in social science research.

On the assumption that the first author is the key or lead researcher in the collaboration, it was found that about 70 per cent of the joint papers were led by researchers from the university studied (herewith called the home institution), indicating the leadership role of the home institution in most of the papers published during the period 2008 to 2011. Figure 2 shows the percentage of papers in each institution where the first author comes from the home institution.

Types of collaboration

As most of the papers produced in these RUs are the result of collaborative efforts, analysis of collaborating institutions would be helpful for the RUs to draft co-publication maps, in order to identify the nodes and links of their research activities. As shown in Figure 3, about 3 per cent of the papers did not involve any collaboration as they were produced by a single author, while 65 per cent of the articles were domestically produced, which means that two-thirds of the papers were jointly produced by researchers in Malaysia without involving international collaborators.

Domestic collaboration. Of the 65 per cent domestically produced papers, 41 per cent were jointly produced by colleagues within the same institution (domestic intra-institution) and 24 per cent with local researchers from other institutions within Malaysia (domestic inter-institution). The local researchers came from different sectors in the country, particularly other universities, industry or public research institutes. Further analysis reveals that more than three-quarters of the publications were the result of collaboration with academics from different universities, while co-authorship with researchers from public research institutes and industry is insignificant. The findings indicate that journal publication is predominantly an academic activity and the links between industry, universities and research institutes are rather limited, signifying restricted cross-sector or university-industry research collaboration in the country.

International collaboration. There are many reasons for universities to put greater emphasis on international collaboration. Recently the focus has been on improving the university rankings through international collaboration. A distribution map indicates that Malaysian researchers are engaged in collaborative research with researchers from almost every corner of the globe. The top ten countries with which Malaysia is collaborating are Iran, India, the UK, Japan, the US, Australia, China, Indonesia, Thailand and Saudi Arabia. Geographical proximity does not seem to play a key role in this information age, as Singapore only ranks as the 11th collaborator for Malaysia.

Table I.
Number of authors and
disciplines

Number of authors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total	
Agricultural and biological sciences	1.2	10.1	18.9	25.9	19.4	12.5	5.1	4.9	0.9	0.3	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1,770	
Architecture	8.6	30.1	20.4	22.6	15.1	3.2															93	
Biochemistry, genetics and molecular biology	0.4	5.5	7.4	18.5	31.7*	16.8*	6.7	7.1	2.3	1.1	1.1	0.4	0.5	0.4							567	
Chemical engineering	1.1	17.6	36.0*	23.9	11.2	5.8	2.5	1.1	0.2	0.1	0.2	0.1									828	
Chemistry	2.4	11.1	26.3	27.3*	22.4	5.8	2.7	1.0	0.4	0.2	0.1	0.1	0.1	0.1	0.1						1,651	
Computer science	2.2	21.9	27.4	24.3	13.9	5.6	1.9	1.9	0.5	0.2	0.2										2,498	
Decision sciences	1.0	14.8	28.6	16.3	11.3	6.9	4.9	1.0	0.5	0.5	0.5										203	
Dentistry	2.5	11.8	27.0	21.6	14.2	10.3	3.9	3.9	0.5	2.9*											204	
Earth and planetary sciences	12.7	15.5	31.0	19.2	13.1	3.3	1.9	1.9	0.5												213	
Energy		10.3	8.8	32.4*	23.5	16.2	5.9	2.9													68	
Engineering	2.1	16.6	27.9	24.9	17.0	6.8	2.4	1.6	0.4	0.2	0.1										4,048	
Environmental science	2.0	17.8	20.9	21.4	17.0	9.9	6.0	3.6	0.5	0.6	0.2										646	
Health professions	2.4	9.8	16.5	20.0	17.3	13.0*	6.6	7.1*	2.1*	1.3	1.3	0.5	0.3	0.4	0.2	0.1	0.2	0.0	0.2	0.1	2,384	
Immunology and microbiology	3.5	5.2	11.3	19.1	15.7	10.4	3.5	9.6*	3.5*	1.7*	5.2*	1.7*	2.6*	0.9		0.9	0.9	1.7	1.7		115	
Materials sciences	2.1	20.2	20.2	24.5	19.1	5.3	4.3		1.1	1.1		2.1*									94	
Medicine	1.1	12.3	15.9	22.0	18.6	11.1	8.6*	2.1	1.5	1.1	1.1	1.7*	0.2	0.4	0.6	0.4	0.2	0.2	0.2		522	
Neuroscience	6.5	6.5	10.9	17.4	15.2	13.0*	10.9*	15.2*			2.2*	2.2	2.2								46	
Nursing		9.1	45.5*	18.2	9.1		9.1		9.1*													11
Pharmacology, toxicology and pharmaceuticals	0.3	7.2	17.1	17.3	28.1	12.3	6.5	3.8	2.8	1.7*	1.3	0.7		0.2	0.3					0.2	601	
Science	3.0	15.9	24.5	21.7	18.4	8.6	3.7	2.6	0.7	0.2	0.1	0.1	0.1	0.1	0.1						1,676	
Veterinary	3.9	8.3	33.9*	26.1*	10.0	5.6	10.0	1.1					1.1							180		
Mathematics	6.2	34.9*	33.1	17.8	6.0	1.2	0.5	0.2			0.2										662	

(continued)

Number of authors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Physics and astronomy	1.4	12.9	22.5	23.7	29.2*	6.6	2.0	1.2	0.2	0.1	0.1				0.1						1,122
Multidisciplinary	10.3	31.1	25.3	18.7	9.2	4.4	1.1														273
Psychology	4.0	26.7	22.7	16.0	12.0	2.7	1.3	4.0	1.3	1.3	2.7*										75
Social sciences	23.3*	28.3	20.5	13.7	8.2	2.3	2.3	0.9		0.5											219
Arts and humanities	16.7*	31.2	22.8	15.9	8.3	2.2	0.5	1.1	0.5		0.5	0.3									372
Business, management and accounting	9.5	34.6*	39.4*	11.7	2.5	1.4	0.6														358
Economics, econometrics and finance	19.8*	35.0*	32.1	7.5	4.0	0.8	0.3	0.3							0.3						374
Undefined	7.0	17.3	22.6	24.0	12.4	8.6	4.0	1.1	1.3	0.3			0.8					0.3	0.3		371
Total papers	728	3,612	5,342	4,996	3,840	1,770	787	612	176	96	83	43	20	22	14	10	7	4	8	6	22,244

Note: *The top three disciplines with different numbers of authors

Figure 2.
The leading role in
research collaboration

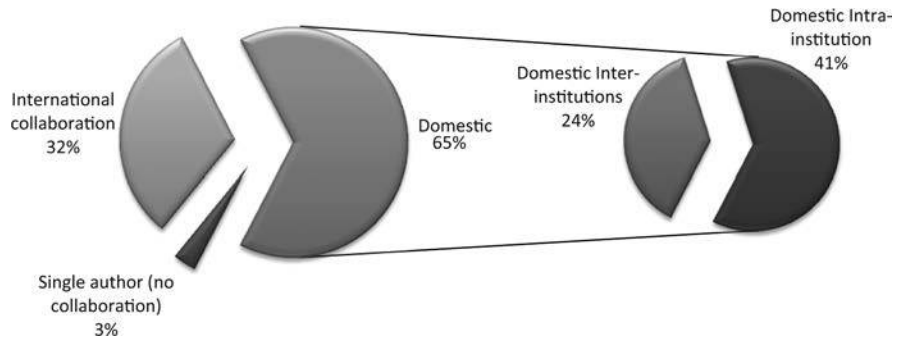
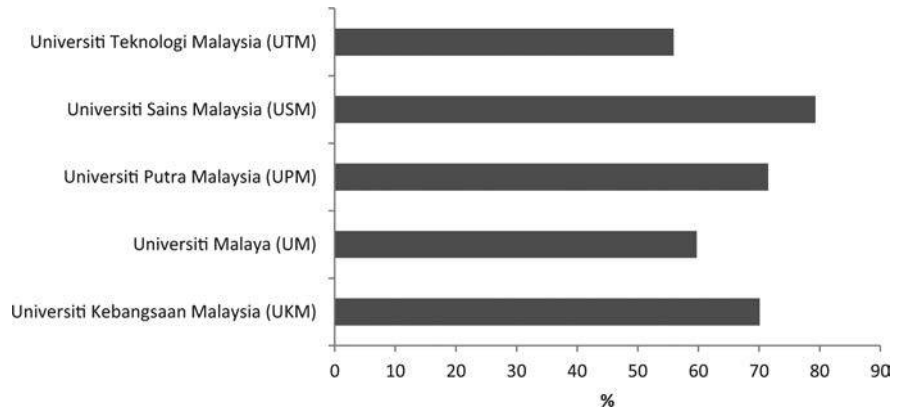


Figure 3.
Types of collaboration

Among the five RUs, UM tops the list in both the number of internationally co-authored papers and countries of co-authorship. UM collaborates extensively with researchers from various countries, such as Kazakhstan, Tanzania, Jamaica and Morocco, while other RUs show few links with these countries.

The bibliometrics analysis does not permit a more detailed analysis to investigate the identity of the main collaborators. However, from preliminary discussions with researchers in these five RUs, three factors can be used to discover who their collaborators are. International students' profiles, researchers' backgrounds and research agreements in each institution have shed some light on the distribution of collaborating countries. International students, particularly postgraduate students in Malaysia, come mainly from China, Iran, Indonesia, the Middle East and African countries. It is natural for researchers to collaborate with their postgraduate students, even after they have graduated and returned to their home countries. Another network that is maintained is the alumnus network. Many researchers in these five RUs were trained in countries such as the US, the UK and Australia; so the research links with these countries are significant. Alternative links are formed via research agreements, either at country-to-country level or at institutional level. A country like Japan is an active research partner for Malaysia.

Analysis of the association between discipline and collaborating country reveals patterns of collaboration and strengths of research in the five RUs of Malaysia. Which disciplines show the greatest tendency towards international collaboration and which countries are the main collaborators for these disciplines? By calculating the percentage of papers involved in international collaboration, on an aggregate basis, the top ten disciplines having significant international collaboration and the main associating countries are listed as follows: physics and astronomy (India), chemistry (Iran), biochemistry, genetics and molecular biology (Morocco), mathematics (Romania), agricultural and biological sciences (Iran), science (Saudi Arabia), chemical engineering (China), engineering (Iran), health professions (Australia), and computer science (UK).

Collaborative research reflects a certain level of dependency in the relationships among researchers, be it the sharing of resources or expertise. Thus, identifying disciplines that indicate a high level of international collaboration in each RU enables us to explore the research strengths of the institutions. The top five disciplines with extensive international collaboration are identified for each RU, as shown in Table II, while Figures 4 to 8 show the main collaborating countries for each of the five disciplines in each RU.

The research strengths identified are closely associated with the background of each university. For instance, when UM was formed, the focus was primarily on medicine and education to train civil servants for public administrative services. USM was established to provide science-based education and to train manpower specialized in science and industry skills, while UKM was created in 1970 to develop the national language as an active language of the nation. The fourth university, UPM (formerly known as Universiti Pertanian Malaysia) was built in 1971 to venture into areas related to agriculture and science. Another technical university, UTM, was established in 1975 to offer courses in science and technology.

The patterns of collaboration are partly similar between countries and partly different for each RU. Although associating with different disciplines in each RU, five countries which consistently appear in all five figures (Figures 4 to 8) are Australia, Iran, Japan, the UK and the US. The findings indicate the dominant links with these countries for research collaboration.

UKM	Research University			
	UM	UPM	USM	UTM
<i>Disciplines</i>				
Engineering	Chemistry	Agricultural and biological sciences	Physics and astronomy	Engineering
Computer science	Health professions	Engineering	Chemistry	Computer science
Health professions	Science	Environmental science	Engineering	Science
Mathematics	Engineering	Health professions	Pharmacology, toxicology and pharmaceuticals	Chemical engineering
Agricultural and biological sciences	Computer science	Mathematics	Health professions	Physics and astronomy

Table II.
Disciplines with
extensive international
collaboration

AP
65,6

670

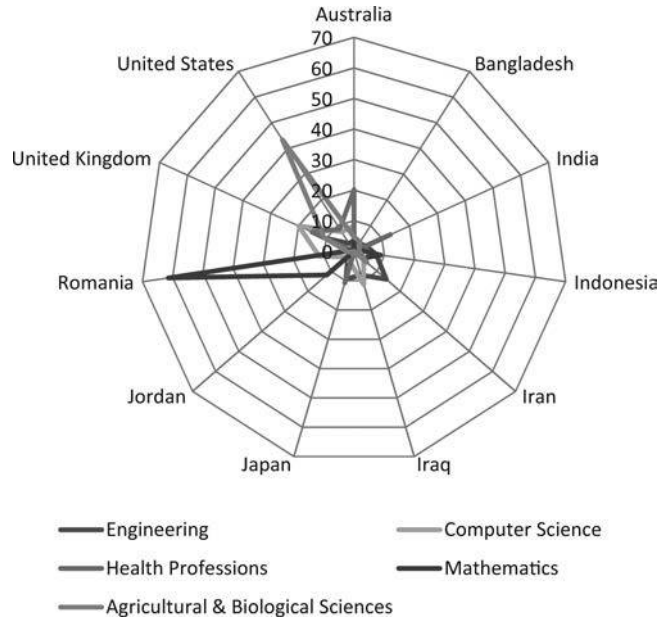


Figure 4.
Countries and disciplines
for international
collaboration (UKM)

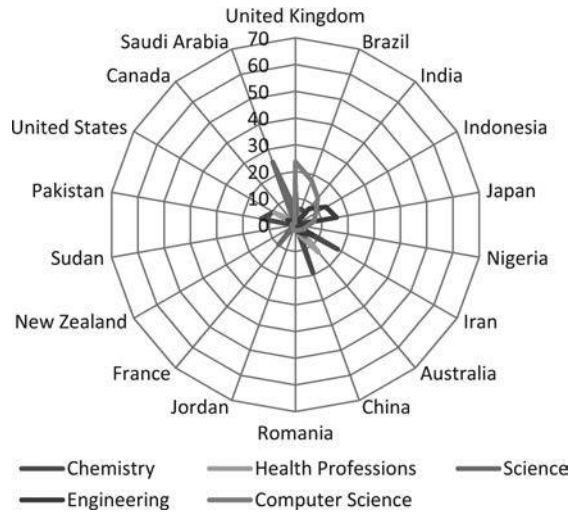
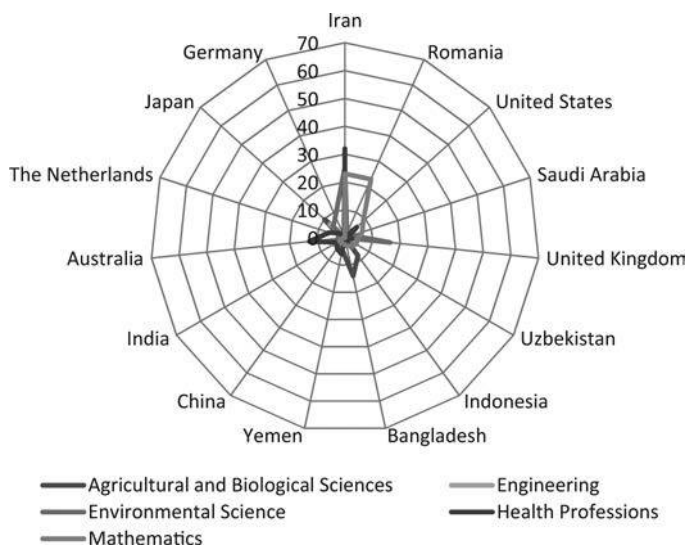


Figure 5.
Countries and disciplines
for international
collaboration (UM)

Conclusions

Structural analysis of scientific collaboration through co-authorship networks provides insights into the type and degree of collaboration among researchers, which contributes to a better understanding of the nature of research collaboration. As a country which is currently undergoing a series of pre-emptive transformations and is armed with the ambition to develop the nation as a regional education hub, achieving



Research collaboration in Malaysia

671

Figure 6. Countries and disciplines for international collaboration (UPM)

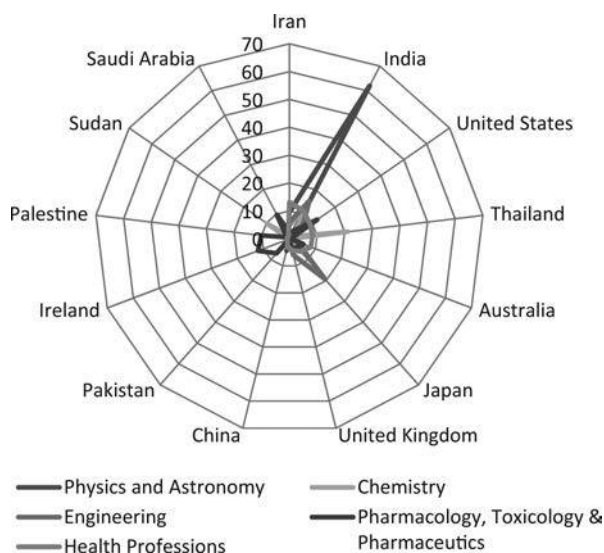


Figure 7. Countries and disciplines for international collaboration (USM)

research excellence is essential for Malaysia. The implementation of the Research University Programme and the identification of five research universities in Malaysia mark the determination of the government to develop a competitive higher education system in Malaysia, which puts greater emphasis on research performance. Collaborative efforts in R&D, which are typically translated into joint publications, are generally accepted as a way to enhance the effectiveness and efficiency of the production, distribution and application of knowledge and innovation, and are, therefore, greatly emphasised.

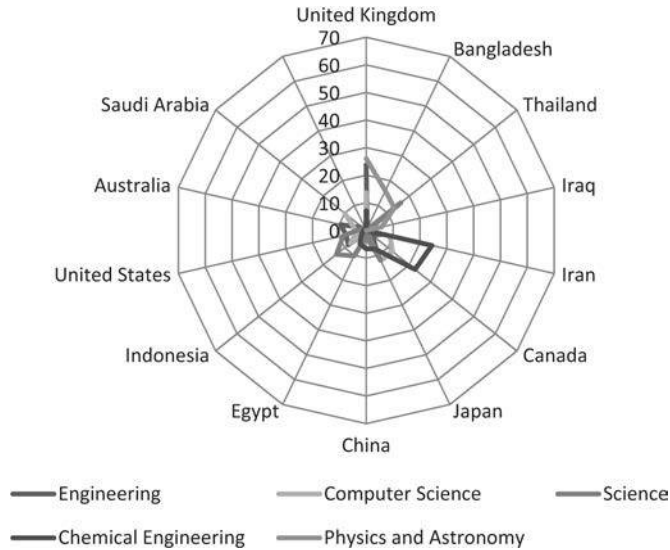


Figure 8. Countries and disciplines for international collaboration (UTM)

To summarise: in this study, bibliometrics analysis is conducted on 22,244 records to examine the patterns of research collaboration and the different networks that exist among researchers in Malaysia. Publication records from five research universities (RUs) for the period 2008 to October 2011 are examined. The results reveal some important trends of research collaboration in Malaysia. Research collaboration in terms of co-authorship is prevalent in Malaysia, as the majority of the papers are the result of collaborative efforts where the median number of authors per paper is four. It is not surprising to find that the degree of collaboration is the greatest in science-based research. This finding is consistent with the literature in research collaboration.

Publication seems to be a predominant activity for academics in universities, as most of the papers are published or jointly published by academics. There is limited evidence of joint publications between universities and both industry and public research institutes, as only 5 per cent of the publications were jointly produced by academics with industry partners and 15 per cent with researchers from public research institutes. More than two-thirds of the records showed that a researcher from the home institution was the first author. If the first author is assumed to be the lead researcher, it implies that the researchers from the home institutions are playing a leading role in most of the multi-authored papers.

In terms of international collaboration, about one-third of the publications involved international collaborators. Generally, Iran, India, the UK, Japan and the US are the top five collaborating countries. A detailed analysis by RUs reveals a slightly different distribution, as different RUs have different research strengths, hence different associating countries. Basically RUs in Malaysia show extensive international collaboration in the areas of physics and astronomy, chemistry, agricultural and biological sciences, engineering, health professions and computer science.

The findings of this study highlight the patterns, nodes and links established among researchers in the five research universities in Malaysia. The distribution of the

collaborative networks reveals the research strengths as well as the limitations of these universities in research collaboration. The study provides useful information for policy makers seeking to intensify scientific collaboration, particularly international collaboration and collaboration with industry partners. Establishing international collaboration as well as university-industry collaboration is becoming more important for academic research. The structural analysis method applied in this study provides guidance to countries, particularly emerging economies in the Asia-Pacific region, Eastern Europe and Sub-Saharan Africa as well as some countries in the Middle East (Ocholla *et al.*, 2012; Davarpana and Behrouzfar, 2009; Mahmood *et al.*, 2009). These countries are also in the process of developing competitive scientific research systems. It is essential for these emerging countries to identify their research strengths and networks of collaboration in order to improve research visibility and productivity.

However, more detailed analysis is needed to examine the nature of collaboration and to understand how research collaboration is formed among researchers in Malaysia. That information is not available from bibliometrics studies. It is recommended that future studies take different approaches, such as using qualitative analysis and in-depth personal interviews, to examine the research collaboration process, particularly the motivation and the collaboration strategies of researchers.

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