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Strength in small: the University of Malta's scientific output since accession

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Strength in small: the University of Malta's scientific output since accession

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Abstract

Purpose – The Triple Helix model of academia, government and industry posits that the university can play an important role, even an entrepreneurial one, in innovation in increasingly knowledge-based societies (Etzkowitz and Leydesdorff, 2000). No longer the “ivory tower” universities are now moving toward an entrepreneurial paradigm. The purpose of this research effort is to examine how such a migration has been accomplished in Malta with a particular focus on the changing activities of its University.

Design/methodology/approach – This paper uses advanced bibliometric techniques to examine the scientific output of the University of Malta. Data were downloaded from Thomson Reuters Web of Science. These data were then processed using the software packages Bibexcel and VOSviewer to produce detailed maps of the scientific activity.

Findings – The results were that the University has greatly expanded its scientific footprint since its 2004 accession to the European Union (EU). International collaborations and highly cited papers have gone up significantly.

Research limitations/implications – Only one country was examined in this effort, and further study should compare to Malta to other small EU countries. The findings suggest that while some might consider Malta's progress modest in absolute terms, it has made significant strides from its prior-to-accession base.

Practical implications – The findings have been presented to the Malta Council for Science and Technology as evidence of the outcomes of their efforts.

Originality/value – Because Malta is the smallest member-state in the EU, little research has been done on its science base. However, the authors believe their findings could inform research efforts on other EU, and even non-EU, countries.

Keywords Malta, Bibliometrics, Science, Triple helix

Paper type Research paper



1. Introduction

Malta is a Southern European island country consisting of an archipelago in the Mediterranean Sea. The country covers just over 316 km² (122 square miles), with a

population of just under 450,000 making it one of the world's smallest and most densely populated countries. Malta gained independence from the UK in 1964, joined the European Union (EU) in 2004 and adopted the euro as its currency in 2008. Its primary industries have historically been tourism and aquaculture, but, with accession into the EU, Malta has embarked on an effort to diversify its industrial base. Toward that end, Malta is attempting to adopt a Triple Helix approach to its research and innovation (R&I) efforts.

The Triple Helix model of academia, government and industry posits that the university can play an important role, even an entrepreneurial one, in innovation in increasingly knowledge-based societies (Etzkowitz and Leydesdorff, 2000). As knowledge becomes an increasingly important facet of innovation, universities as knowledge-producing and disseminating institutions play larger roles in industrial innovation. Historically, industrial innovation has fallen under the purview of corporations and the state, depending on the social system. However, given the increasing participation of academics in entrepreneurial activities, it can be assumed that the capitalization of knowledge is now part of the "university of the future". (Etzkowitz *et al.*, 2000).

No longer the "ivory tower" universities are now moving toward an entrepreneurial paradigm. However, universities still must be conducting cutting-edge research. For smaller countries that do not typically have a well-defined R&I infrastructure and tight university budgets, this top-tier research can be difficult to accomplish. Nevertheless, efforts have been made to quantify a Triple Helix approach in both larger and smaller countries.

Recent bibliometric research by Meyer *et al.* (2014) uncovered 277 papers about the Triple Helix subject. Of these, they further culled down the number of Triple Helix indicators papers to 109. While there were a number of indicators used including patents, grants and others, scientific publications from either the Thomson Reuters' Web of Science (WOS) or Elsevier's Scopus were very frequently used.

This purpose of this paper is to quantitatively examine the scientific research at the University of Malta by using the WOS and other bibliometric tools. Since its 2004 accession to the EU marked an important turning point for Malta, this research will use that as a demarcation point (ten years before and after) to study the knowledge base and research front for the university. By offering a measurement of its scientific results, it is hoped that this paper can assist the university in improving its research profile within the EU and beyond.

This paper begins with discussing the specific R&I challenges faced by smaller, sometimes less-developed, countries. Given these critical differences from larger nations, the literature on measuring innovation results in smaller countries is then specifically examined. The third part of this paper offers a brief overview of Malta and its particular R&I capabilities. After fully elucidating the context for this study, the methodology is explained with a description of the different bibliometric methods used. Following that are the results including many visual representations of this study's findings. The final part of the paper provides the conclusions, contributions and a number of opportunities for future research.

2. Research and innovation challenges in smaller countries

Historically, innovation theories and studies, including Triple Helix research, have focused on industrialized countries or larger developing ones. Thus, the role of research

and development (R&D) and the supply-side of innovation, the role of government in R&D and the means by which R&D results could be useful to the private sector were the primary emphases. With smaller and less-developed countries, technology and knowledge transfer from larger countries to the smaller ones being studied has historically been the important area of consideration. However, more recently, internal innovation has become much more important to smaller developing countries. Previous research (Hadjimanolis and Dickson, 2001) clearly and concisely enumerated many of the differences between larger and smaller countries. These differences include the following:

- *Restrains exist:* Small developing countries typically have limited markets, scarce physical resources, shortages of technical skills and a weak bargaining power for inter-state agreements.
- *Public sector dominates:* Government and the public sector play a dominant role in the economy, especially in scientific/technological affairs (Argenti *et al.*, 1990). For example, the bulk of R&D is carried out by the public sector.
- *Large firms do not dominate:* Small- and medium-sized firms are the predominant units of commercial activity in the economy. The predominance of small firms and their dependence on external resources for innovation affects the inter-firm linkages. For example, the complex subcontracting systems around large firms with first- and second-tier subcontractors as in Japan are largely absent in small developing economies, but there are, however, many formal and informal exchanges among more or less equal partners.
- *Innovation support systems are rare:* Institutions essential for the promotion of technological innovation such as technological intermediaries, research establishments and prototype testing facilities are weak or underdeveloped (Argenti *et al.*, 1990).
- *Emphasis on using versus inventing:* The most important activity in the national innovation system of small economies (even industrialized ones) is often technology diffusion in the form of absorption and adaptation of foreign technology (usually from industrialized countries) and not the indigenous development of new technology (Edquist and Lundvall, 1993). This phenomenon applies even more so to small developing countries.
- *High-tech sector modest:* The “high-tech” sector is invariably underdeveloped or non-existent, and the main issue is the application of high technology in existing sectors (Lall, 1992).

3. Previous innovation research regarding small (or smaller) countries

One of the first articles to examine the Triple Helix in a small country was done by Kaukonen and Nieminen (1999) focusing on Finland. They explored the steps Finland took to embrace the idea of university–industry–government. The Finnish effort included the development of the Technology Development Center (Tekes), the renaming of the Science Council into the Science and Technology Council and the Oulu Technology Center (a science park). In addition, while these entities support applied research, the Academy of Finland now provides funding for basic research. Also, the authors emphasize how smaller countries must try to strike a balance between national R&I interests and international cooperation. This balance is necessary because many

times the international cooperative research agreements may focus on issues having little or no importance to the smaller country.

Another early effort to examine innovation policy in a small country was conducted on Cyprus (Hadjimanolis and Dickson, 2001). They explored the national innovation policy (NIP) of Cyprus by surveying manufacturing managers in small to medium companies and cases studies of the same. They found that in general the managers were ambivalent toward an NIP, partially because of its lofty goals. Nevertheless, based on both their questionnaire and some case studies, they offered recommendations on how to improve the Cyprus NIP.

Saad *et al.* (2008) used a case methodology to examine the role of universities in developing countries, focusing specifically on Malaysia and Algeria. In both countries, their findings emphasized how the role of government needed to change. Both governments provided funding for universities but with very strict guidelines governing university priorities. Particularly in Algeria, the priority was to have many more Algerians attend college. While this goal is certainly laudable, Saad and colleagues argued that for the Triple Helix to truly take effect in smaller countries, the central governments must relinquish some control.

A more recent effort was conducted by Bouabid for the country of Morocco (Bouabid, 2014). He examined the science and technology metrics of the 15 national universities in that country. He concluded that while funding was generally abundant, the scientific and technical outputs from that funding were quite modest. However, he found there were significant improvements in international collaboration, one important measure of the success of science and technology policies. He attributed these improvements to the increased funding and international travel by researchers.

Each of the studies cited above explored different challenges that smaller countries face in improving their R&I capabilities and moving toward a Triple Helix type of function. The next step to understanding the salient context is to examine Malta particularly, including its R&I capabilities.

4. Malta and its innovation capacities

With a gross domestic product (GDP) of €6.5bn and a total population of just over 421,000 inhabitants in 2013, Malta is the smallest EU Member State accounting for under 0.1 per cent share of the EU28 total population. In 2012, the GDP per capita stood at €16,300, well below the EU28 average of €25,500. Real GDP growth was negative in 2009 but was positive in subsequent years, with a value of 2.4 per cent in 2013 compared to 0.1 per cent for the EU as a whole (Warrington, 2014).

Innovation expenditure for 2010 amounted to 1.5 per cent of GDP, with manufacturing activity accounting for 65 per cent of all innovation expenditure. R&D expenditure (GERD) in 2012 stood at 0.84 per cent of GDP compared to an EU27 average of 2.07 per cent. Spending on R&D remained almost flat in absolute terms over the period 2006-2009 while experiencing an annual decline when expressed as a percentage of GDP from 0.60 per cent in 2006 to 0.53 per cent in 2009. This negative trend was reversed in 2010, with significant increases year on year reaching 0.66 per cent in 2010, 0.72 per cent in 2011 and 0.84 per cent in 2012 (Warrington, 2014).

Despite this positive performance, Malta still ranks 21st in the EU in terms of R&D intensity. It has set itself a rather ambitious target of achieving an R&D expenditure of 2 per cent of GDP by 2020 (Warrington, 2014). To achieve such a goal, Malta has

restructured its R&I systems at a national level. The primary players in this process are illustrated in Figure 1.

The University of Malta is the main research performer in the higher education sector (there are a few, small research institutes), and, over the period 2009-2012, the university's research expenditure more than doubled, reaching €20.8m (36 per cent of GERD) in 2012. Most of the research is conducted in the field of Social Sciences followed by Medical Sciences, Engineering, Humanities and Natural Sciences, in that order. Personnel costs accounted for 70 per cent, whereas overhead accounted for 20 per cent of R&D expenditure in 2011 (Warrington, 2014).

Recent years also saw a significant increase in expenditure on buildings and instrumentation, where a number of infrastructure projects funded through the European Regional Development Fund (ERDF) for new laboratories at the University of Malta got underway. It is expected that the level of expenditure could taper off in 2016 and subsequent years following the completion of the current ERDF projects. While it is expected that there will be further investment in infrastructure funded through the next ERDF programming period, it is likely that there will be some delay until these get underway which could lead to a temporary dip in R&D expenditure in the higher educational area.

Similar to the Finnish efforts detailed above (Kaukonen and Nieminen, 1999), a major public initiative worthy of mention is the Life Sciences Centre (www.lifesciencepart.com), the development of a state-of-the-art industrial park dedicated to the life sciences sector estimated to cost around €30m (Warrington, 2014). This got underway in late 2011 and is scheduled for completion in late 2014. The initiative will promote the development of a knowledge cluster between the University of Malta, Mater Dei Hospital, the Malta Council for Science and Technology, the Malta College of Arts, Science and Technology and the Life Sciences industry. It is expected that this initiative will lead to a 0.33 per cent increase in R&D expenditure as a percentage of GDP with 100 direct jobs created by the end of 2020. The Life Sciences Park will have 50 labs/working units of various sizes. The importance of such joint efforts in fostering innovation in emerging countries has been demonstrated in Turkey, a close neighbor of Malta (Temel and Glassman, 2013).

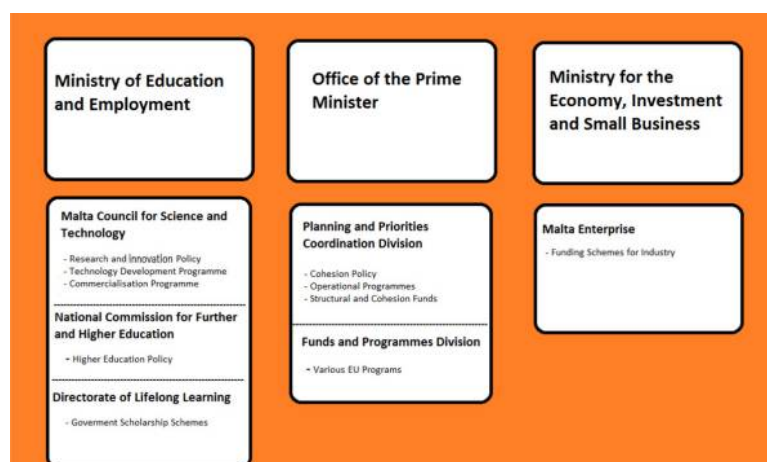
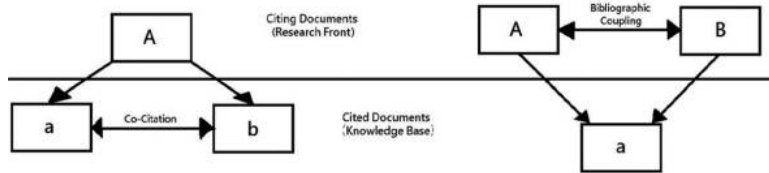


Figure 1.
Malta's R&I system

Malta ranks last within the EU in terms of doctoral graduates per 100 population aged 25-34, although grants for doctoral students introduced in 2010 should address this dearth to a great extent. Nevertheless, the lack of funding for post-doctoral research in higher education leads to a lack of openings for researchers and presents a major obstacle to the development of a pool of experienced researchers. Recent research has emphasized the importance of internationalizing European higher education. Malta would likely benefit from some of the changes recommended here including developing an alternative visa requirement and internationalizing accreditation (Ritzen and Marconi, 2011).

This shortage of doctoral students has consequences beyond the narrow confines of research activity. The lack of a pool of experienced researchers creates a disincentive to foreign industry potentially interested in establishing R&D facilities in Malta. It also makes it very difficult for the university to participate in the FP7 Ideas Programme, thus losing out on a potential source of additional funding. Furthermore, it contributes to a brain drain and to the loss of important talent as researchers seek opportunities

Figure 2.
Comparison of
mapping procedures



Criterion	1995-2004	2005-2014
Total WOS publications	525	1,589
ARC	0.97	1.06
ARIF	0.82	0.97
Highly cited publications (%)	8.4	12.5
International co-publications	203	810
International collaboration rate (%)	38.7	51.0

Notes: *Total WOS publications*: the number of papers produced by the University of Malta in Web of Science; *Average of Relative Citations (ARC)*: measures the scientific impact of the University of Malta based on the amount of citations received by its scientific publications. A score above one indicates that the scientific “impact” of the university is above the world average. A score below one means the opposite; *Average of relative impact factors (ARIF)*: a measure of the expected scientific impact of publications produced by the University of Malta based on the impact factors of the journals in which they were published (measured by the journals’ citations). A score above one indicates that the research “quality” of the university is above the world average. A score below one means the opposite; *Highly cited publications*: represents the percentage of the University of Malta’s papers falling in the 10 per cent most cited papers in the reference database. A score above 10 per cent means that the university is contributing to highly cited papers beyond what would be expected, somehow reflecting research “excellence”; *International co-publications*: number of co-publications of the University of Malta; *International collaboration rate*: number of international co-publications of the University of Malta

Table I.
Summary of the
university of Malta’s
research efforts

Sources: Computed by Science-Metrix using WOS (Thomson Reuters); see Appendix 1 for breakdowns by discipline

overseas. The establishment of a post-doctoral grant scheme has been mentioned in a number of policy documents, but such a scheme has not yet been fully implemented (Warrington, 2014).

Having reviewed the larger contexts of the theory and research in general, and Malta's research capabilities specifically, the next section moves on to this study's research methodology.

5. Methodology

This study's methodology used a number of bibliometric techniques. These include not only standard counting of publications, number of citations and impact factors but also more advanced citation analysis including co-citation analysis and bibliographic coupling.

Funding agency	No. of grants
University of Malta	63
ERDF Malta	29
European commission	23
European union	19
Malta council for science and technology	14
Malta government	12

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Table II.
Funding agencies
2005-2014

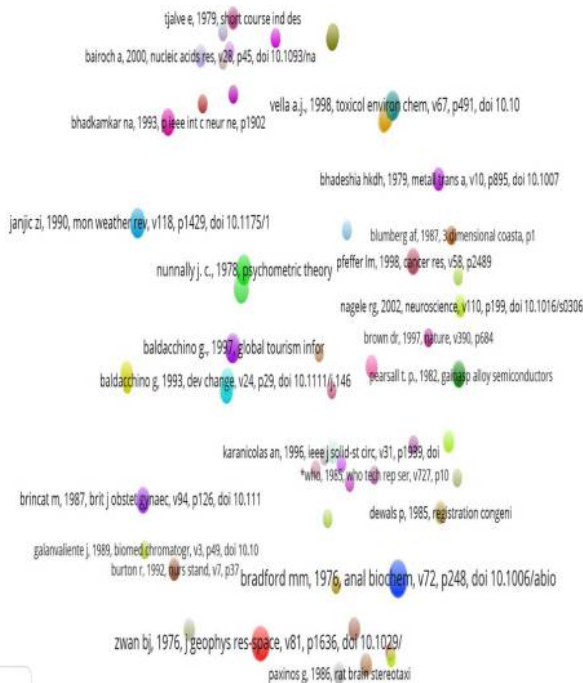


Figure 3.
Co-citation map of
cited references
(1995-2004)

Briefly, citation analysis assumes that the mere existence of a citation (whether used in a positive or negative sense) is taken as a measure for the significance allocated to the reference or its author in the relevant article. A citation is taken to be a valid and reliable indicator of scientific communication (Garfield, 1979; Small, 1978) and a basis for the identification of “invisible colleges”, i.e. research networks that refer to each other in their research papers without being linked by formal organizational ties (Crane, 1972; de Solla Price, 1965). Co-citation analysis enables the identification of groups of scientists and their publications and for conclusions to be drawn about the inner structure of research disciplines, schools or paradigms (Small, 1980). A co-citation is taken to exist if two references or authors appear in the same bibliography. It is interpreted as a measure for similarity of content of the two references or authors. The number of co-citations determines the proximity of any two publications in terms of content and is generally used to uncover invisible colleges.

In addition to citation analysis, the methodology of this paper included bibliographic coupling to reveal a more comprehensive picture of the corpus of Malta’s research. Bibliographic coupling is accomplished by examining which articles a group of papers cite. The more formal definition is: *a single item of reference shared by two papers is defined as of unit of coupling between them* (Jarneving, 2005). It differs substantially from co-citation analysis in that it is fixed at the time an article is published. Whereas

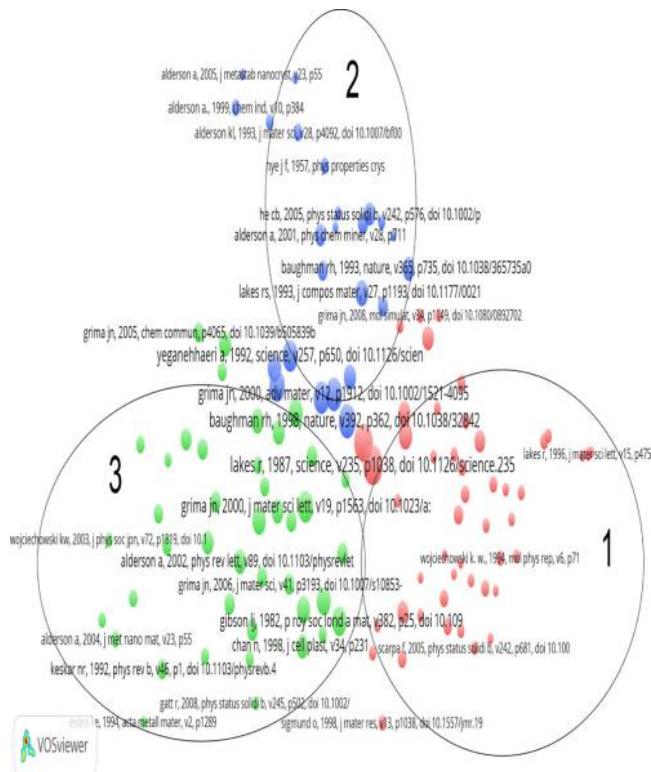


Figure 4.
Co-citation map of
cited references
(2005-2014)

co-citation analysis may, and most times does, change over time, a paper's references do not change over time (Figure 2).

Science-Metrix, a Canadian bibliometric consultancy, provided the raw data from Thomson Reuters' WOS and the preliminary citation analysis. While there has been criticism of the WOS and its coverage internationally, recent research has found that the current coverage adequately reflects global trends (Leydesdorff *et al.*, 2013).

6. Results

This effort begins, as does all citation analysis, with basic counting of publications. Researchers at the University of Malta have been actively publishing their findings to the greater scientific community in the periods both before and after EU accession. There are, however, some interesting and important differences between the two periods. The initial findings are provided in Table I.

The number of SCI publications with a University of Malta address more than tripled between the two periods. In addition, measures of citation impact (ARC and ARIC) indicate improvements in those areas, too. These normalized impact factors indicate that the university's publications are being much more highly cited in the more recent period.

An important measure that the EU uses to assess scientific progress is the number of international collaborators. In this aspect, as indicated in Table I, the university more than doubled in terms of number of papers.



Figure 5.
Co-Authorship map
of author addresses
(1995-2004)

In addition, while the university had no highly cited papers in the WOS in the first period, there were five Maltese highly cited articles in WOS SCI in the most recent time frame (2005-2014), which are as follows (all citation counts through end of year 2014):

- (1) Asher *et al.* (2006);
- (2) Bolla *et al.* (2010);
- (3) Beasley *et al.* (2008);
- (4) Monecke *et al.* (2011); and
- (5) Dick *et al.* (2007).

Highly cited papers must receive enough citations to be placed in the top 1 per cent of the academic field based on a highly cited threshold for the field and the publication year.

Perhaps the most important component in R&I activities by universities is receiving funding, either internal or external. In this area, the university received substantially more during the most recent period, even though its participation in a number of EU initiatives was still modest. And it is important to note that the university provided much of the funding indicating its willingness to support high-quality academic research (Table II).

The evaluation of the university's scholarship results next moves to exploring which "invisible colleges" it participated in within each period. To do so, this study analyzed citation patterns during the two periods.

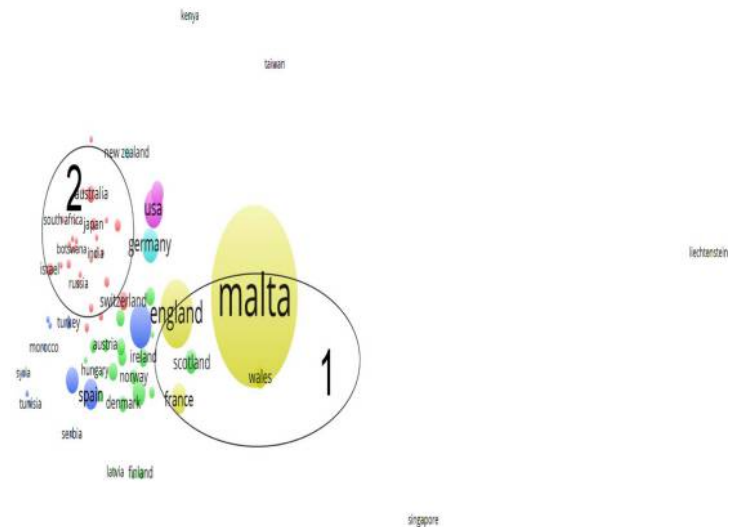


Figure 6.
Co-Authorship map
of author addresses
(2005-2014)



After data regarding the cited references, author addresses and keywords were downloaded from the WOS, the bibliometric software VOSviewer was utilized to process and map the data. Salton's cosine was used for normalization purposes (Leydesdorff, 2008).

Analysis of the cited references reveals the “invisible colleges” in which Malta researchers participated. As shown in Figure 3, the primary focus of university research during 1995-2004 was in biochemistry and medicine. This indicates that the Mater Dei Hospital was the primary contributor to the scientific literature during this period. During the 2005-2014 period, the university concentrated its efforts with the primary focus being in physics. This shows that the scientific efforts of the university extended beyond the hospital. Also, if one examines Appendix 1, they would see that the percentage of health sciences articles dropped from 43 per cent in the first period of the total to 34 per cent in the second period. Additionally, Figure 4 illustrates there are more defined clusters emerge suggesting that the university has better concentrated its research efforts.

Again, international collaborations are a measure that the EU considers quite important in evaluating member states' R&I outcomes. For Malta, the National R&I Strategy (February 2014) likewise acknowledges the importance of international scientific

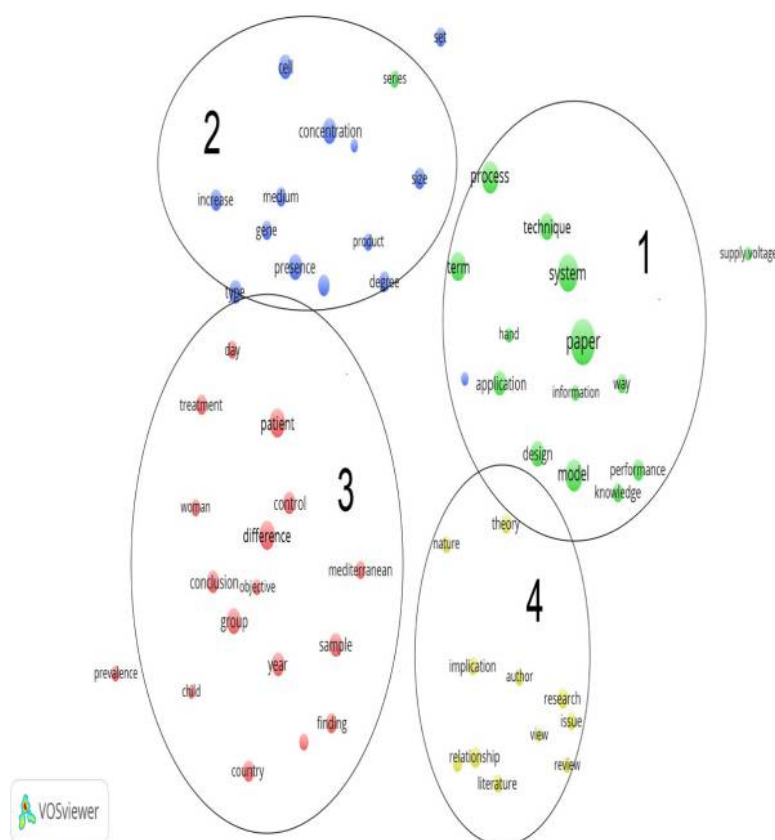


Figure 7.
Co-citation map of
key words
(1995-2004)

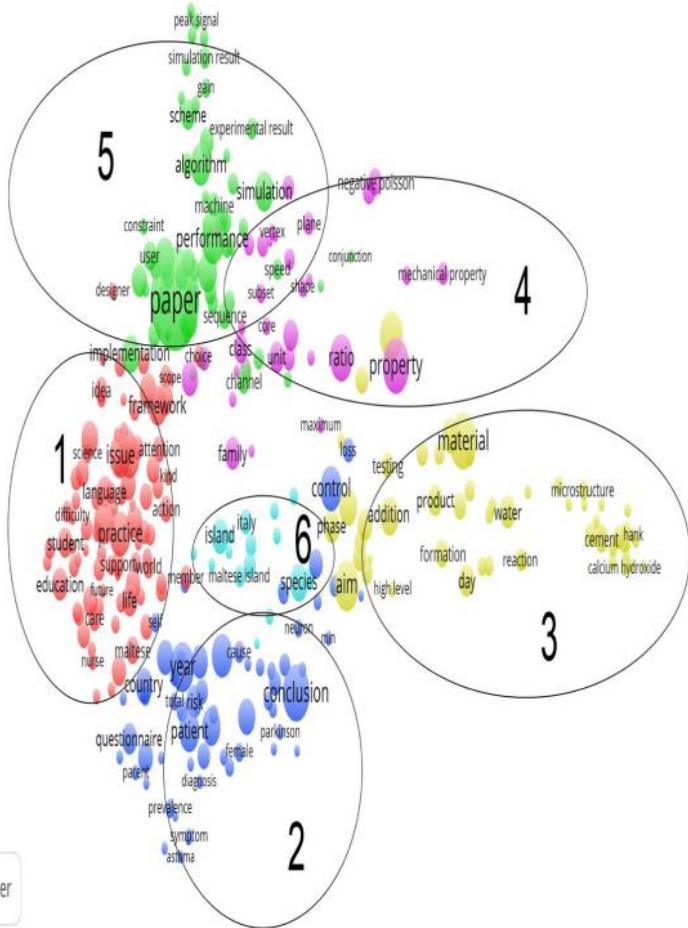


Figure 8.
Co-citation map of
keywords
(2005-2014)

cooperation but rightly points out that the differences in size, economic structure and maturity of the R&D system restrict the direct applicability and transferability of R&I policy approaches from one country to the other. In consequence, each country has to find its own way to contextualize the EU-level policy 28 dimension into national policy and strategy and tailor its responses and activities accordingly. It goes on to say that:

As a country which is still developing its R&D activity, Malta’s collaborations are largely “under construction” and the collaboration profile is evolving over time.

Based on its importance both nationally and with the EU, an examination of the Malta’s international collaborations were warranted. To do so, author addresses were analyzed for co-author relationships. During the first observation period, Figure 5 illustrates that while there was some co-authoring, it appears relatively modest, with few clusters appearing. In 2005-2014, many more clusters are evident, suggesting there was a more concentrated effort in the area of co-authoring. In addition, the clustering of the

relationships is much closer than in the previous period indicating that these are stronger connections. Finally, as one might hope, there is more collaboration with fellow EU countries than in the prior period (Figure 6).

This study next examines the analysis of co-words in the scientific publications emanating from Malta. During the 1995-2004 period, the primary focus was on biochemistry and medical issues. In the most recent period, mirroring the cited references results, there was more of a concentration of effort into physics and physical chemistry. Also, as with the collaboration results, the clusters are much tighter signifying a more extensive relationship (Figures 7 and 8).

Finally, this study attempted to identify and explore the current research front for Malta. In the bibliometric literature, there has been considerable debate on how to do so, but recent research (Boyack and Klavans, 2010) suggests that bibliographic coupling best illustrates the research front.

Again, because international collaborations are so important for a small nation such as Malta, the research front for the two ten-year periods was examined with an eye to both countries and organizations.

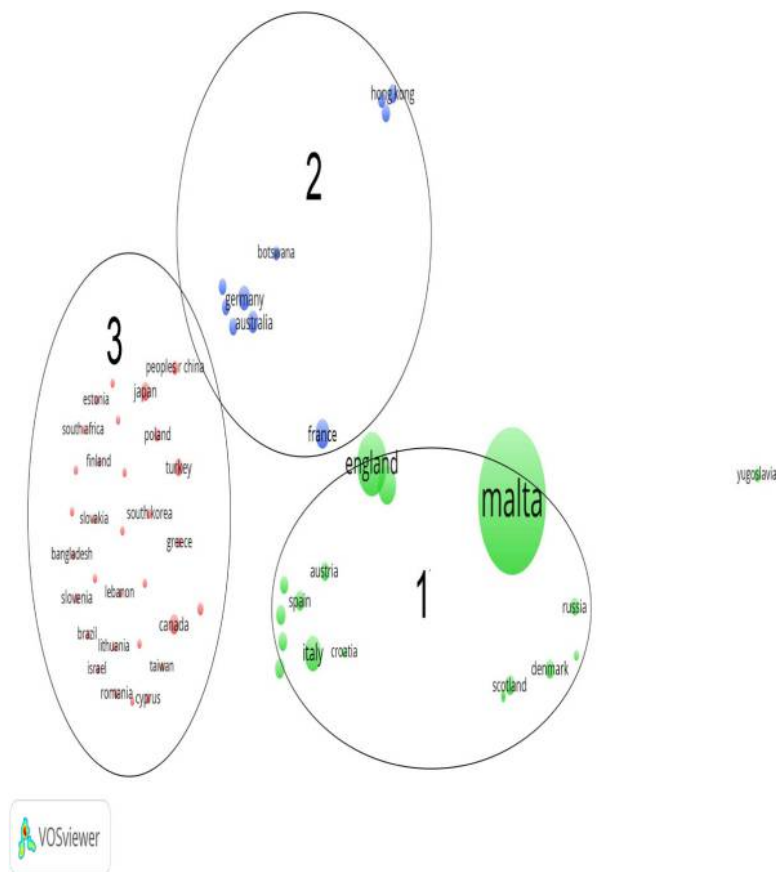


Figure 9.
Bibliographic
coupling of countries
1995-2004

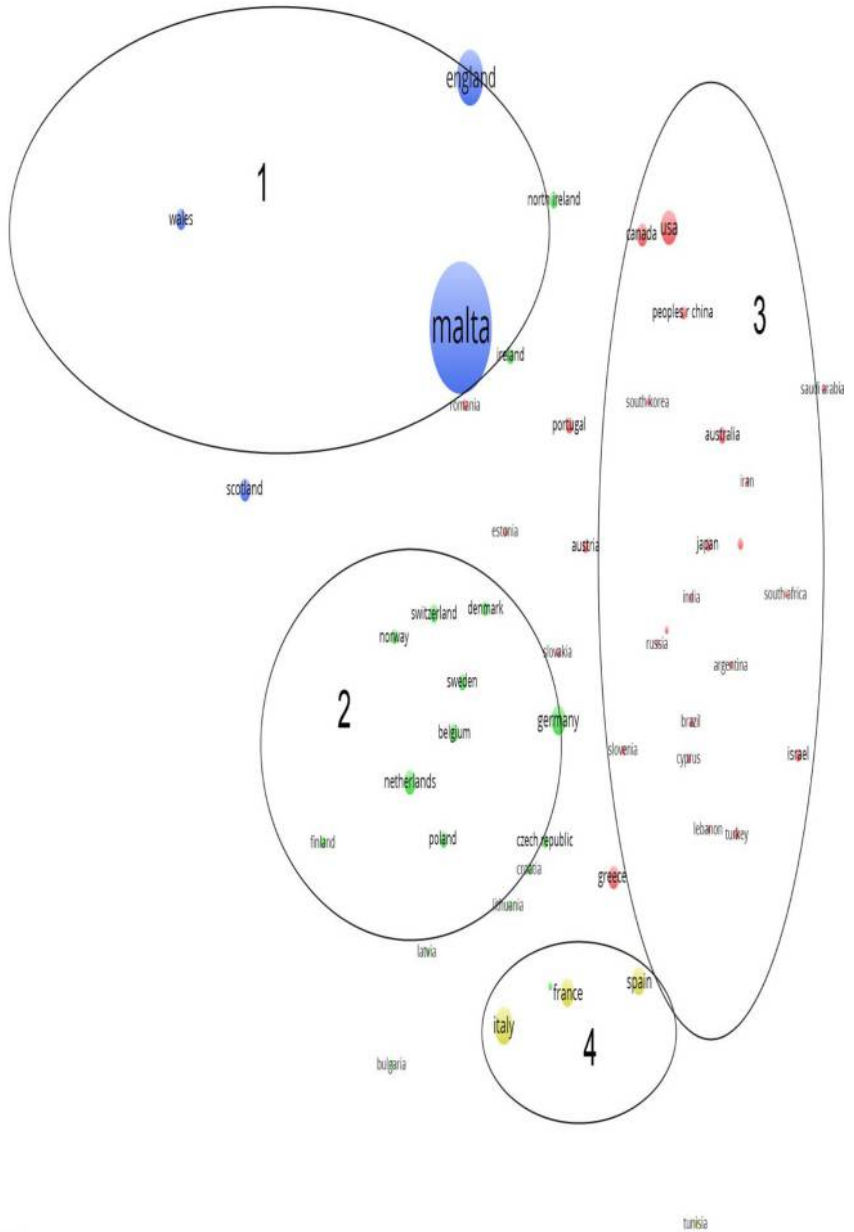


Figure 10.
Bibliographic
coupling of countries
2005-2014



It is clear comparing Figures 9-12 that the university has greatly expanded its reach in international collaborations both in terms of countries and organizations. In particular, Figure 12 illustrates that Malta's international collaborations are much tighter as indicated by closer clustering of the other organizations.

7. Conclusions, contributions and future research

Malta has at times struggled since its independence in 1964 to develop its economy beyond tourism and aquaculture. While both of these industries still figure prominently in Malta, recent years have seen some success in diversifying its economic base. With its accession into the EU and the accompanying R&I opportunities, Malta has made great strides in the area of R&I. Leading the way has been its sole tertiary institution, the University of Malta.

The findings of this study indicate that the university has moved quite rapidly into developing scientific capabilities to take a strong position in the Triple Helix model. While some may view the university's results as modest, one must remember when the university came. Having only five highly cited papers may seem small in absolute terms, but it is a strong step toward developing science that might eventually be patented. Perhaps, more importantly, the increase in scientific results suggests that the university will need a more extensive technology transfer office and academic liaison function (Bakouros and Samara, 2010).

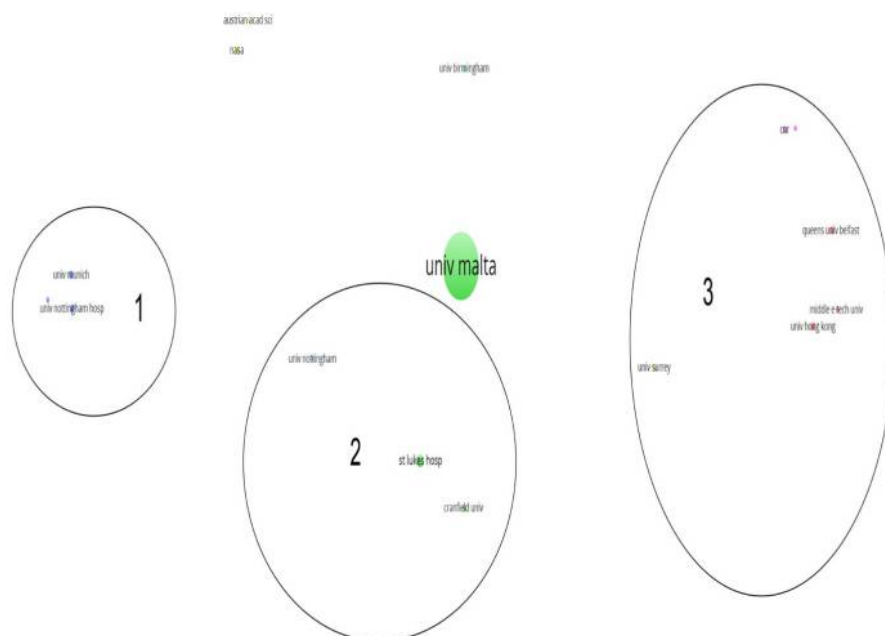


Figure 11.
Bibliographic
coupling of
organizations
1995-2004

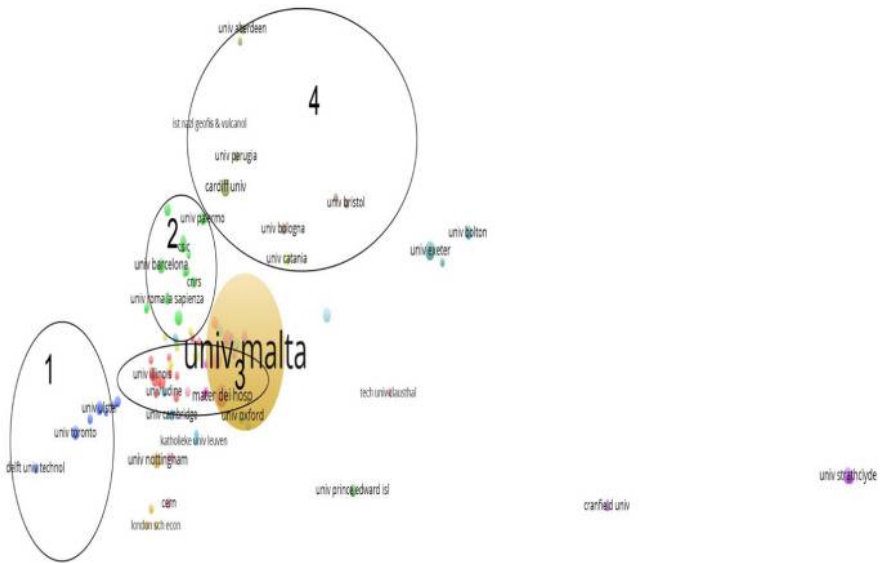


Figure 12.
Bibliographic
coupling of
organizations
2005-2014



As noted previously in the [Hadjimanolis and Dickson \(2010\)](#), smaller countries face difficult challenges in the area of R&I. In particular, there is usually an absence of a technological infrastructure. Malta is attempting to address this shortcoming with its Life Sciences Centre and the development of the Malta Council for Science and Technology. However, measuring the effects of such changes is paramount.

Finally, Malta and its university hope to participate more fully in funding available from the EU. To do this, they must not only present research proposals that can be achieved but also demonstrate that they have been successful in previous research efforts. Measurement studies such as this one can prove very beneficial in documenting such accomplishments.

There are a number of possible avenues for future research on Malta and other smaller countries. First, this paper, as with most bibliometric efforts, is primarily descriptive in nature. Research that takes a more predictive or explanatory approach would certainly be valuable. Second, a longitudinal approach would be worthy and would also help answer some temporal questions this paper suggests. Third, a multi-country research effort with comparisons across countries would be helpful to have a more holistic view of how different countries rank with each other. Finally, human resource policies at the university strategically designed to support the Triple Helix model could be evaluated.

Malta and its university clearly still have challenges to meet. However, these results indicate that such trials can be met and that the University of Malta can become the “university of the future” while leading Malta into becoming the “economy of the future”.

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Discipline	1995-2004 publications	1995-2004 ARC	1995-2004 ARIF	2005-2014 Publications	2005-2014 ARC	2005-2014 ARIF
Applied sciences	71	0.77	0.89	261	1.10	1.15
Arts and humanities	40	0.47	0.51	86	1.00	0.90
Economic and social science	45	0.82	0.80	104	0.47	0.87
General	3	0.33	1.17	17	1.91	0.84
Health sciences	228	1.17	0.79	553	1.22	0.97
Natural sciences	82	0.94	0.99	317	0.94	0.88
Unclassified	56	N/C	N/C	251	N/C	N/C
Total	525			1589		

Notes: *Publications:* The number of papers produced by the University of Malta in Web of Science; *Average of Relative Citations (ARC):* Measures the scientific impact of the University of Malta based on the amount of citations received by its scientific publications. A score above one indicates that the scientific “impact” of the university is above the world average. A score below one means the opposite; *Average of Relative Impact Factors (ARIF):* A measure of the expected scientific impact of publications produced by the University of Malta based on the impact factors of the journals in which they were published (measured by the journals’ citations). A score above one indicates that the research “quality” of the university is above the world average. A score below one means the opposite

Source: Computed by Science-Metrix using WOS data (Thomson Reuters)

Table AI.
Citation analysis by
discipline

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