

The Commercialisation of University Research Outputs: A Review of Literature

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Abstract

Universities are presently experiencing rapid transformation, shifting emphasis from pure teaching to equal their strength in teaching and research to increase their capacity to commercialise. The universities are not only accountable for teaching and research accomplishments but they are expected to commercialise their research outputs into marketable products and services. This paper identifies and ranks the factors that are influencing the commercialisation of university research outputs. A Systematic Review of Literature (SLR) was made on 59 articles that were published between 2000 and 2022. The findings indicate that the significant factors influencing the commercialisation of research outputs included; collaboration/networking, research funding, regulative factors both by government and university, entrepreneurial culture, availability of research infrastructure, the competence of researchers, motivation and attitude of researchers, transformational leadership culture, technology suitability for commercialisation, protection of Intellectual Property Rights, the effectiveness of Technology Transfer Office (TTO) and closeness to industry.

Keywords: Commercialization, Factors, Research outputs, Systematic literature review.

Introduction

The growing attention on turning research outputs into marketable products to generate yield value as the way to build a sustainable and inclusive future has taken a special theme in different foras [1-4]. The commercialisation of university research outputs is vital for knowledge transfer from theory to practice to accelerate innovation [5]. Commercialization of university research outputs is associated with the transformation of technology and ideas into consumable products and services that create wealth through licensing, joint ventures, spin-offs, consultancy, patenting, dissemination, and backstopping [6-8]. The transformation of new knowledge and innovations into new products

and systems necessary to solve society's challenges is a key driver for economic development [9]. Universities worldwide have recognised the significance of vigorously contributing to knowledge and technology's application and utilisation arena. The creation, protection, and commercialisation of innovations are crucial in powering commerce [10]. Universities need to spearhead research and innovation to create new and high-value products and services for a country to retain a competitive superiority in the 21st-century global economy [11]. The country's competitive index depends on universities' and research institutions' capacities to transform research into innovative products desired by the

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government [12]. Thus, the commercialisation of university research outputs has become an area of solid policy attention across the world [13-14].

Despite the importance associated with the commercialisation of university research output, evidence suggests low commercialization [15-16]. Globally, universities register large amounts of research outputs with limited commercialisation, resulting in low returns on investment [15, 17-19]. Studies reveal different findings on the factors influencing the commercialisation of university research outputs [16, 20-24]. The mixed findings could be attributed to the complex set of institutional processes unique to each country, level of commercialisation, and different methodologies and definitions considered [20, 22, 25-27].

In addition, the extant research on the factor influencing the commercialisation of university research outputs is fragmented and lacks coherent frameworks and conceptualisations [7, 20, 28]. There is an enormous volume of existing literature describing in detail specific aspects of university research commercialization (e.g., the role of heads of departments in the commercialisation of university research [29], university-government collaboration [30], the role of the Technology Transfer Office in the commercialisation of university research outputs [31] but with little emphasis on the overall picture of the factors influencing the commercialisation of technologies. Accordingly, this paper provides a comprehensive and systematic overview of the current literature on the commercialization of university research outputs to provide a better understanding of the factors that have previously been researched in this field.

By ascertaining and consolidating the factors influencing the commercialisation of academic research outputs, the complexity of this process is reduced and the success rate increases through the identification of the right path for university commercialisation. In addition,

understanding these factors helps to bring more research results to practice. In this review, the study gives an overview of the research on these factors and in what context they have been researched already. This might assist investigators to find gaps in the literature and inspire practitioners to look at factors which may aid them in the commercialisation of university research. This SLR was conducted for two purposes: (1) to identify factors influencing the commercialisation of university research outputs, and (2) to rank the factors influencing the commercialisation of university research outputs. The findings will inform strategies at both government and university levels that govern a research framework that encourages researchers to produce outputs from their research results.

The present paper is structured as follows. Section 2 presents the conceptual background, section 3 gives the research design and literature review. Section 4 gives the results and discussion while the last section presents the conclusion and policy implication.

Conceptual Background

Research, development, innovation and entrepreneurship have been recognised as the basis for commercialisation [5, 7, 11, 32]. Two definitions of research commercialization were found helpful to our conceptualization: (1) [8] define research commercialisation as a process of transforming technology and ideas into consumable products and services that create wealth through licensing, joint ventures, spin-offs, consultancy, patenting, dissemination, and backstopping. (2) [33] defines commercialization of research as a process through which ideas or research are transformed into marketable products and services, income gains and other collaborative activities. In the same papers, the authors also stress the collaborative effort of research commercialization.

In the context of this study, research commercialization is defined as the process of

transferring research outputs from the university to an organization or individual utilizing and applying the research outputs for marketable products and services. The first major research aim is to establish which factors influence universities as important developers of research outputs to commercialize their inventions, either through licensing, patenting and spin-offs, dissemination [34-36].

Universities are perceived as vital vehicles for innovation transfer and a channel through which knowledge exchange is made more effective [22, 37, 38]. The resultant entities include, in addition to IP, licensing, patenting, spin-out companies and spin-in companies into university incubators and other technology bridge foundations or intermediaries which support the codification and commercialisation of knowledge in the university context for commercialisation purposes [29, 39-41]. The commercialization path depends on the type of innovation and the risk that is run with the commercialization of the technology [42, 43]. Thus, besides the possibility of entering the market on their own, universities always explore options to commercialize their inventions through collaboration (e.g., [34-36]).

With the factors influencing the commercialisation of university research outputs, the study refers to causes that either make commercialization possible or improve its commercial outcome. Understanding these factors helps to convert more research outputs to consumable products and services [4, 7]. Though research on the factors influencing the commercialization of innovations, in general, is increasingly popular, literature review on the factors influencing the commercialization of university research outputs is limited [20, 23, 44].

Methodology

The paper adopted a systematic literature review (SLR) methodology of peer-reviewed articles which focus on the commercialisation of university research outputs. The SLR

establishes the state of current knowledge in a given field [17, 20, 25]. The SLRs are progressively being adopted in the social sciences to ensure a reliable and rigorous procedure to reduce both subjective bias and the risk of overlooking relevant literature [46]. Additionally, a SLR is a structured and multiple-stage system for reviewing a large volume of literature over long periods [25, 32, 47]. For scholars, a SLR can enhance methodological rigour as well as suggest further avenues for research [20, 41, 48]. For practitioners, a SLR can help address managerial issues by creating a reliable knowledge base by putting together findings from a range of studies [25, 32, 47].

SLR involves several steps, specifically: identifying relevant literature; assessing the quality of the studies; summarizing the evidence and interpreting findings [45]. However, an SLR is neither a formal full-length literature review nor a meta-analysis, because it conforms to a rigorous set of core principles. This kind of review is: systematic (organized according to a method designed to address the review questions); transparent (explicitly stated); reproducible and updatable; and synthesized (summarizing the evidence relating to the review questions) [25, 32, 47]. Depicting on [45], the findings of this SLR have been articulated in two analyses. Firstly, a descriptive analysis of the field and, secondly, a content analysis to identify and code the factors [25, 32, 47]. The methodology used for this SLR is detailed below.

Stage 1. Formulating Research Questions and Search Terms

To identify the key search terms of the subject, experts in the area of commercialisation of university research (namely Directors of graduate studies, researchers and coordinators of incubation centres) were purposely consulted. This approach yielded seven core search terms, which include “commercialisation of research“,

“third mission“, “universities and licensing“, “university and spin-offs“, “patenting and universities“, “knowledge transfer“ and “entrepreneurship culture and universities“.

Stage 2. Database Search and Article Selection

Google Scholar, Elsevier’s Scopus and Research Gates were the three main sources for bibliometric data. We refined the search to journal articles published in English. Research on the commercialisation of university research is both broad and multidisciplinary. As a result, we did not start by restricting the search to specific academic journals as it was important to include all peer-reviewed journals to make sure we had captured every mention of the concept. To do this, we searched using the

terms “commercialisation and universities“, “third mission and universities“, “universities and licensing“, “university and spin-offs“, “patenting and universities“, “knowledge transfer and universities“ and “entrepreneurship culture and universities“. The search was limited to the period from 2000-to date. At this point, we had 176 downloaded journal articles in our sample. 37 papers were for commercialisation and universities, 24 for third mission and universities, 19 for universities and licensing, 14 for universities and spin-offs, 23 for patenting and universities, 25 for knowledge transfer and universities and 34 for entrepreneurship culture and universities as shown in Table 1 below.

Table 1. Distribution of Articles by Key Phrases/Words used

Phrases used	Frequency
Commercialisation and universities	37
Third mission and universities	24
Universities and licensing	19
Universities and spin-offs	14
Patenting and universities	23
Knowledge transfer and universities	25
Entrepreneurship culture and universities	34
Total	176

In the next step, duplication of the articles was checked and a total of 13 papers were eliminated leaving the study with a total of 163 articles. It was important to include only articles from peer-reviewed journals, the articles were checked and only peer-reviewed were considered. A total of 38 non-peer-reviewed articles, conference papers, books and book chapters were excluded from the analysis. The study remained with 125 peer-reviewed

articles. All the listed 125 papers were then manually checked by reading the abstracts to check if the articles were addressing the main topic or addressing our research question in any way specifically in the university set-up. 66 articles were excluded at this stage. The review found 59 relevant journal articles published in 34 different journals for final review as shown in Table 2. The flow chart of the inclusion and exclusion is detailed in Figure 1 below.

Table 2:. Number of Papers Per Journal

Journal	Number of papers
African Journal of Economic and Management Studies	1
African Journal of Science, Technology, Innovation and Development	2
American Journal of Business	1
Arabian Journal of Business and Management Review	1

Asian Journal of Innovation and Policy	1
Canadian Journal of Administrative Sciences	2
Cross-Cultural and Strategic Management Journal	1
Energy Procedia	2
European Journal of Innovation Management	4
International Journal of Economics and Management Engineering	1
International Journal of Higher Education	1
International Journal of Information Science and Management	1
International Journal of Innovation and Technology Management	3
International Journal of Innovation Science	2
International Journal of Innovation, Management and Technology	2
International Journal of Innovative Technology and Exploring Engineering	4
Journal of Business and Industrial Marketing	1
Journal of Business Economics	1
Journal of Business Research	1
Journal of Engineering and Technology Management - JET-M	1
Journal of Knowledge Management	6
Journal of Management Development	1
Journal of Pharmacoeconomics and Pharmaceutical Management	1
Journal of Science and Public Policy	1
Journal of Science and Technology Policy	3
Journal of Science and Technology Policy Management	3
Journal of Technology Management in China	1
Journal of Technology Transfer	1
Jurnal Teknologi	1
R and D Management	3
Technological Forecasting and Social Change	3
Technovation Journal	1
World Review of Business Research	1
Total	59

Stage 3. Data Extraction

The 59 papers were coded, imported into Mendeley software for reference, fully read, and analysed. The aim of the analysis here was to minimize researcher subjectivity. Hence, based on [42], a standardised data extraction process was performed employing a protocol, which was carried out for all 59 articles. The protocol was based on assigning the following codes to each paper and recording them in a table: (1) Author(S); (2) Title; (3) Year published; (4) Journal; (5) Research question(S) and objective(S); (6) Methodology and where

the paper employed multiple methods we tried to select the dominant one; (7) Results; (8) Geographical area considered in the study; (9) Factors influencing the commercialisation.

Stage 4. Analysis of Papers

Content analysis was used to analyse the articles because of its capacity to analyse content from various source [32]. Factors influencing the commercialization of university research outputs were recorded from the 59 selected articles and then analyzed. The articles contained some information about what influences the commercialization of university

research outputs or what made it more successful. To get to the final 12 factors which are reported in this paper, three rounds of coding were necessary. In the first round we wrote down any new factors the paper reported, and this led to over 35 different factors. It was found that many articles report multiple factors. In the second round, we merged factors with different names but the same meaning (e.g.,

“collaboration with industry and ‘network with industry partners’”). In round 3 we further reduced the number of factors by creating constructs which were relatively comprehensive as per Table 3 below. Then, Microsoft Excel tabling was used to capture the frequency of the factor across different articles. This enabled the generation of frequencies and ranking of the factors.

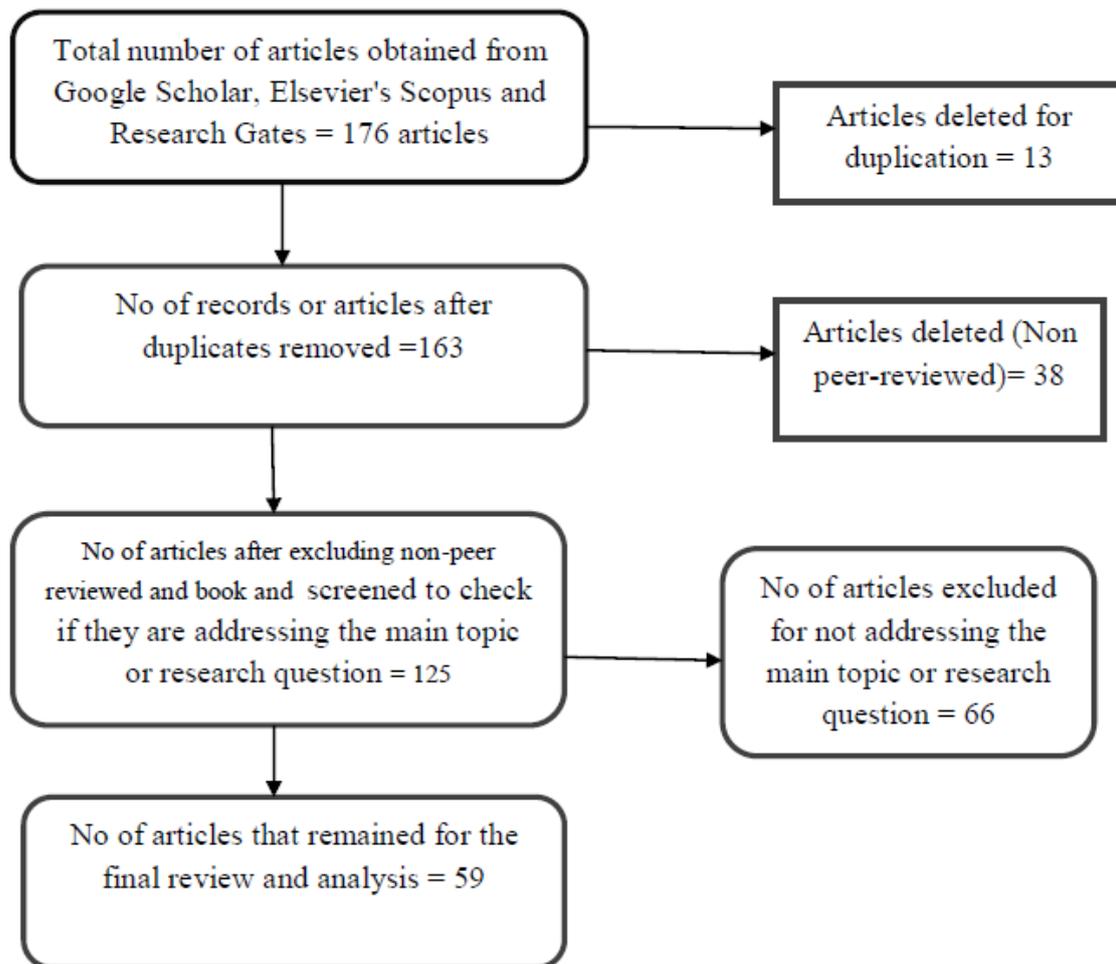


Figure 1: Flowchart Showing the Selection Procedure of the Articles for Analysis

Results and Discussion

Overview of Articles

The analysis indicated that 54 percent (31/59) of the reviewed articles were published between 2016 to 2020, 25 percent (14/59) were published from 2011 to 2015, 14 percent were published between 2006-2010, 5 and 3 percent

were published between 2001-2005 and 2021-2022 as per Figure 2 below. The results show a gradual increase in the number of articles published from 2001 to 2020. However, for the period between 2021-2022, the articles were few because the period is very small compared to others.

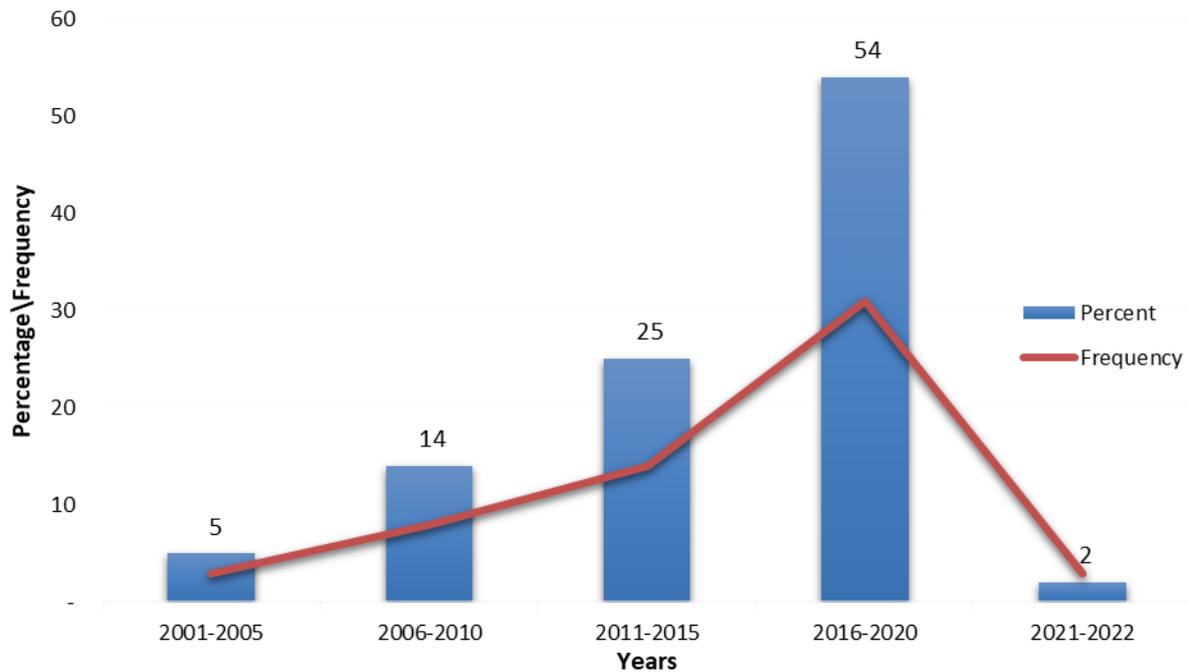


Figure 2.: Number of Reviewed Articles Concerning the Publication Period

Commercialisation Factors

The fundamental goal of this study was to identify and rank the factors that are influencing the commercialisation of research outputs in universities. It is striking that many articles employed several methodological approaches, but some came up with convergent factors.

Additionally, it is essential to stress that university research commercialisation is a very complex process and its success is dependent on many factors. The summary of the coded factors identified by the studies reviewed is presented in Table 3 below.

Table 3. Coded Factors

Final factor	Initial factors
Collaboration/networking	Academic networks, interaction with society, joint research projects, alliance building, contact between the community and academic researchers, social network ties, community engagement, research cooperation, creation of networks between commercializing organizations, relationships/linkages with appropriate industrial and commercial stakeholders, organizing open days to showcase university innovations, lack of effective communication between students and industry sector's activists, network characteristics, partnership's dynamic and intra firm networks.
Research funding	Funding at the university, seed capital for research, availability of research funds, financial support, venture capital availability, expenditure on research and development, established National Research Fund, and poor fund management in the university.
Regulative factors both by government and university	Government policy framework, government initiatives, open innovation strategies, regulative changes, Government

	commitment, published policies regarding the internal regulation on commercialisation, technology transfer policies and procedures, university administrative structure, absence of university entrepreneurial missions, Organization structure, Organizational support structure, Government influence, and inefficiency and ineffectiveness of the rules and regulations for commercialisation.
Entrepreneurial culture	The business culture of researchers, entrepreneurial culture characteristics, weakness of universities in wealth creation, entrepreneurial education, entrepreneurial team, developing entrepreneurial skills, entrepreneurial activity and culture, absence of university entrepreneurial missions, and forming risk-taking team.
Availability of research infrastructure	Presence of physical infrastructures such as laboratories and incubation centres, supporting infrastructure needs, the existence of a science park, establishment of incubation centres, lack of research facilities, industrial parks and laboratories, and research equipment.
Competence of researchers	Skills of researchers, qualified and skilled staff, professional expertise, capabilities of researchers, limited knowledge, developing skills of staff, inadequate knowledge of the faculty members, and researchers' project management capabilities.
Motivation and attitudes of the researchers	Reward of staff, the attitude of staff towards commercialisation, positive attitude towards commercialisation, perceived social influence, rewards system for technology transfer, researchers' perception, staff promotion policies, inadequate knowledge of the faculty members, lack of regulation for the apportionment of financial gain from commercialization among scholars, lack of mutual recognition between university and industry, knowledge characteristics, and researchers' attitudes and motivation.
Transformational leadership	vision of administration, strategic leadership, encouraging institutions to attempt new initiatives, changing the patterns of thinking, organization and professionalism, power relationships, leadership influence, support of senior management, forming risk-taking team, university leadership style, advanced management skills, and roles of champions.
Intellectual Property rights	Patent protection, patent acquisition, perceptions that patent is too cumbersome, the availability of a patent stock, information relating to patents among the citizens of the member States, earlier patenting and IP protection, Intellectual capital, growing importance of Intellectual Property Rights and lack of understanding of Intellectual Property Rights.
Technology suitability for commercialisation	Producing innovative research products, Producing quality and reasonable research products, prices of research product, producing research product that benefits the nation, producing a unique research product, producing a market-ready research

	product, immature entry into the market and development stage of technology.
Technology Transfer Office (TTO)	Technology transfer office, coordination office for knowledge transfer, employing Industrial Relations Officer(s).
Industry closeness	Location, geographically concentration, proximity to high-tech clusters, closeness to the industry and local industrial base.

The articles were further reviewed, and as a result, the main factors that significantly influence the commercialisation of university research output were tallied up and ranked based on the frequency into twelve (12) factors. The factors include; collaboration/networking (19%), research funding (16%), regulative factors both by government and university (15%), entrepreneurial culture (10%),

availability of research infrastructure (9%), the competence of researchers (8%), motivation and attitudes of the researchers (7%), transformational leadership (6%), technology suitability for commercialisation (3%), protection Intellectual Property Rights (3%), Technology Transfer Office (TTO) effectiveness (2%), and industry closeness as per the Figure 3 below.

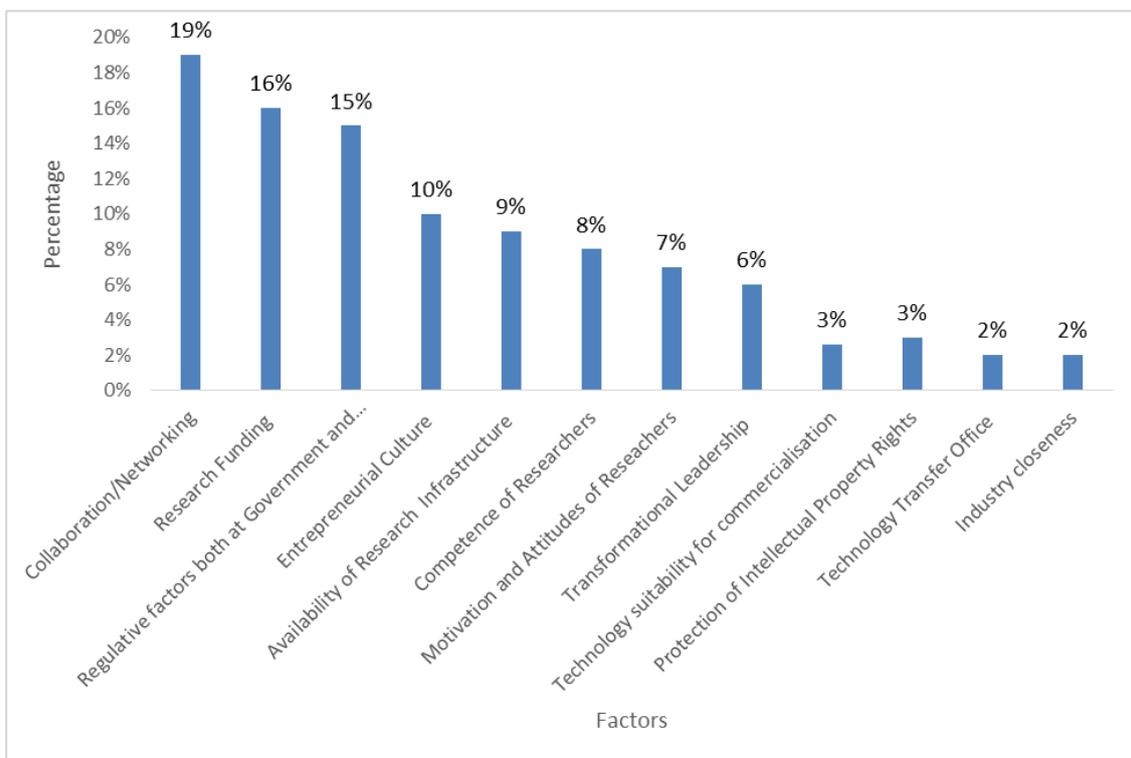


Figure 3. Factors Influencing Commercialisation of University Research outputs

The result in Figure 3 indicates the significant factors influencing the commercialisation of research outputs in universities. These factors are arranged based on the frequency they appeared in the articles reviewed, and they include;

Collaboration/Networking

Collaboration assists researchers to intermingle their innovations into the supply

chain and supports intra-organizational knowledge discussion [10, 35, 49, 50]. Research showed that strong social networks that connect university researchers help to increase the output of technology commercialization [10, 35, 49, 50]. Collaboration expands the relevance of research carried out in universities and fosters research outcomes' commercialisation [44, 51, 52]. Early networking and collaboration with the

industry and other vital stakeholders create a greater chance of commercialising the invention [53-56]. Collaboration reduces the risk of mismatch between university research outputs and market needs and poor diffusion of knowledge [14, 42, 57]. The successful commercialisation of research outputs depends on the inclusiveness of business ecosystems [58]. The different players in the business ecosystem provide different incentives and capabilities that help the product or service reach greater scale and impact [58]. However, researchers should be mindful about losing their IPRs during collaboration [10, 59].

Funding for Research

The commercialisation activity is a long and complex process involving initial investment before success [60, 61]. The commercialisation of university research outputs is associated with many costs that are mainly spent on startup operations without any return at the early stages, which in part are high risks and uncertainty [43, 62]. Conventional loans from banking systems cannot fund the commercialisation of university research outputs because of the risk of failure involved and the gap between producing research findings and getting commercial partners [13, 63]. The funding for the commercialisation of research outputs should be seed funding that covers all product/service development value chains from prototyping, marketing, and incentives to support private-sector research and commercialisation [22, 34]. Therefore, for commercialisation to succeed, sufficient and reliable funding is critical.

Regulative Factors both by Government and University

The commercialisation of university research outputs is shaped by the evolution of regulatory and funding frameworks of higher education. [60, 64]. The government through its regulatory function plays a vital role in research, collaborations, and commercialisation as a

funder, infrastructure developer, and strategy moderator [4, 65]. Government formulates and reviews policies concerning the commercialisation of university research outputs and reforms in higher education [44]. At the national level, the vital role of government in the formulation and implementation of innovation policies that allow systematic approaches to the commercialisation of research and self-reinforcing innovation systems [55, 66]. These policies include funding schemes for research, tax incentives and commercialisation, institutional capacity strengthening for universities and industry, and security for innovations such as protecting intellectual property rights [4]. National policies such as the Bayh-Dole Act in the United States and the abolition of “professor privilege“ in European countries transformed the commercialisation landscape in universities [7, 44]. Additionally, the universities have changed their structure and policies to improve the rate of commercialisation of their research outputs. Most of these policies focus on setting up structures [22, 33, 67], while others are concerned with funding strategies for commercialisation [13]. However, the successful commercialisation of university research depends on adopting a synergistic policy mix and creating an environment favourable to learning and collaboration among the triple helix model actors [37, 52]. Therefore, policies must be encompassing and tough all players in the commercialisation chain.

Entrepreneurial Culture

The process through which innovation is transferred from universities to the marketplace requires high levels of entrepreneurial skills to ensure that the desired results are achieved for economic growth and competitiveness [20, 33, 44, 63].

The entrepreneurial culture of the university is necessary for the successful

commercialisation of university research innovations [20, 33, 44, 63].

Top-level assurance is important and managers should be directly involved in the technology transfer process to ensure fast decision-making [44]. Universities' leadership must inspire their people to venture into research efforts that involve a certain level of risk and at the same time, universities must be prepared to accept failures [68]. Risk-taking encourages researchers to attain potential returns on their research outputs such as intellectual properties and knowledge surge even though the likelihood of success is low [68]. In addition, entrepreneurial culture helps shape organizational working relations by encouraging teamwork, sharing common goals, and effective communication [64, 69]. Entrepreneurial culture shapes researchers to be more effective in the creation of research-based ventures which increases the commercialisation of research outputs [64, 69]. The entrepreneurial culture can be fostered through entrepreneurship courses and programs for students [44, 53].

Availability of Research Infrastructure

University commercialisation environment in terms of infrastructure that drives research, development and commercialisation such as laboratories, and incubation centres are vital to accelerating the commercialisation of university research outputs [57].

There is a need for sufficient funding to support the required commercialisation infrastructure for universities to achieve this agenda [43, 62, 64, 70]. Countries such as the Netherlands, Ireland, UK, USA, Sweden, Norway, Finland, China, and India have gained leverage in the commercialisation of their research outputs as a result of heavy investments in research infrastructure [16, 44]. Therefore, infrastructures such as laboratories, technology parks, incubation centres, and mechanisms are critical in accelerating the commercialisation of research.

Competence of Researchers

The lack of quality research skills among university researchers is a significant hindrance to the successful commercialisation of research outputs [34, 42, 63]. Most universities in developing countries still have capacity gaps in skills and are run with junior staff without doctoral degrees [70]. A highly skilled and experienced faculty leads to higher involvement in technology commercialization activities in general [26, 43, 48, 57]. The quality of the academic staff is more important than the quantity when it comes to the commercialisation of research [26, 57]. Moreover, researchers or universities are not able to produce Innovative Research Products that benefit the nation [71].

Motivation and Attitudes of the Researcher

There is a strong positive correlation between researchers' attitudes and the successful commercialisation of research outputs [33, 58, 62]. The motivation and attitudes for academics to engage in research are about contributions to society than financial returns [57]. However, incentives in form of promotions, and financial and non-financial rewards like recognition do matter [28, 57, 51], categorizes factors that motivate researchers in commercializing research outputs into three concepts which they name "ribbon" (reputational/career rewards); "puzzle" (intrinsic satisfaction) and "gold" (financial rewards). She concluded that researchers who are entrepreneurial by nature are driven by "puzzle" and "gold" factors while traditional researchers who cannot link research and business more often are motivated by "ribbon" factors. The capacity for universities to adapt to Academic-Commercial Demand is still a big challenge. Most of the staff promotion policies demand prolific publications and dissemination of research results at conferences thus losing the patentability of inventions and commercialisation [13]. However, a shift from

“publish or perish“ to “innovate or perish“ is necessary to move forward with the commercialisation agenda.

Transformational Leadership

Transformational leaders have manifested their capability to impact their followers by reinforcing the perception and significantly influencing employee perception of the jobs and job performance [68, 73, 74] find that CEO ownership of the technology increases commercialisation success. Transformative leadership is vital for universities in shaping their institutional pressures to enable increased commercialisation of research outputs [75, 76]. By keeping their ego in check, and managing themselves, through their ability to take the right risks, transformational leaders can shape institutional factors which leads to enhanced commercialisation as followers are inspired [29, 75]. Universities require staff with transformational leadership skills to influence the commercialisation drive [55].

Technology Suitability for Commercialisation

University research outputs should be based on strong market values to succeed in the commercialisation process [61, 62, 71]. Market alignment and understanding the customer needs is seen as the key factor for successful commercialization. Inventing a cutting-edge product with unique features does not necessarily guarantee that the product will have a commercial or market value [14, 62]. The incorporation of the requirements of the users of the technology when choosing new technology has a positive impact on technology transfer success [61, 71]. Therefore, commercialisation is about taking the solution (not only the product) into the market [77, 78]. Concerning this, [71] outlined four important considerations for successful commercialisation: focus on inventing a solution to customers' problems; identify the technology within its eco-system; consider the

possible competitors of the invention from the solution perspective, not from the product perspective; and focus on efficiency, effectiveness and cost saving of the market solution in comparison to existing competitors. In addition, the timing to introduce the product/service in the market is very critical. The timing for the commercialization of research outputs determines the competitive advantage [61, 71]. The fact that university researchers sometimes hold back commercialisation awaiting opportunities for better deals from the business sector could backfire [31]. However, extremely innovative technologies are embryonic and require the licencing company to work closely with innovators at the early stages of technology development [31, 71].

Protection of Intellectual Property Rights (IPRs)

The ownership of IPRs defines and determines the economic use and sale of an innovation [59, 66, 76]. For the universities owning them, they form part of their intangible assets [21, 42]. In other words, it is necessary to define who is the owner of the intangible asset.

[7, 59] indicates that protection is one of the basic assumptions to ensure marketing rights. However, with more advanced technology intellectual property (IP) rights are less important [7, 66], and these have resulted in conflicts at the commercialisation stages of innovations leading to loss of commercial value [7, 66]. Some of the loopholes arose from inconsistencies in the policies at different levels while others are a result of implementation challenges [7, 66].

Technology Transfer Office (TTO) Effectiveness

Universities may tussle to win at both academic and commercial frontiers. To avoid the struggles of interest and traditional bias, academic and commercial research activities should be strictly separated [37, 79, 80].

TTOs can assist in setting up such a dual structure that helps to better distinguish between both activities [37, 80]. Universities need to have strong TTOs to encourage inventors to implement the commercialisation strategies and support them through the commercialisation process [20, 33, 79, 81, 82]. The TTO should enable the commercialisation of knowledge or technological diffusion conveniently through cost-saving measures that positively influence licensing [10, 83]. The TTO is critical in translating discovery into impact through transparent, flexible intellectual property management services and partnerships with commercialisation programs [10, 81]. However, most TTOs lack experience, sufficient resources, and competencies and are understaffed to spearhead the commercialisation agenda of universities [13, 33].

Industry Closeness

Industrial closeness in terms of geography, proximity to high-tech clusters, and closeness to the industry and local industrial base impact the commercialisation of research outputs [7, 20, 34, 67]. The regional characteristics such as culture, and population are critical in determining the market potential of start-up companies [20, 34]. The presence of high-tech clusters and closeness to the local industrial base enhances the relevance of the commercialisation of research outputs [7, 20, 34, 67].

In addition, the co-existence of universities and industries in the same location promotes skills exchange culture, sufficient technical capacity, market strength, and existing links to key business partners as advantages of established companies when it comes to technology commercialization [7, 20, 34, 67].

However, there specialization differences between universities and industry differ depending on the discipline. For a university to transfer technology to the industry and vice versa, they must be dealing in related fields.

Conclusions and Policy Implications

Implications

World over, universities have produced a range of innovations that have found their way into the market and have helped launch new companies. However, many research concepts and results produced in universities fail to align with firms' business strategies. This makes technology transfer a high-risk process. The successful commercialisation of university research depends on adopting a synergistic policy mix and creating an environment conducive to learning and interaction among the triple helix model actors. Therefore, there is a need for supporting researchers to develop industry engagements at an early stage of their research careers to enhance market alignment, understanding of customers' needs and the university's adsorptive capacity which are vital for successful commercialisation. Universities should integrate community and industrial engagement into their curriculum, student internship and industrial engagement should start with first-year students not waiting until the final year of students. There is a need for clear reward and recognition systems for researchers who commercialise their research outputs in terms of promotions and other monetary rewards from their patents. The management and sharing of proceeds resulting from research commercialisation must be streamlined to reduce conflicts at the commercialisation stages of innovations leading to the loss of commercial value of IPS. Additionally, mentoring and educational support for new entrepreneurs by the different actors in the educational ecology to support the ambidextrous organizational culture across the triple helix actors to transfer knowledge and technologies is critical for successful commercialisation. This will strengthen the transformational leadership skills of researchers in universities which are critical in driving commercialisation.

The universities need to strengthen their regulative framework by developing and customising national policies and strategies into guidelines that govern research at the university level. The funding for the commercialisation of research outputs should be seed funding that covers all product/service development value chains from prototyping, marketing, and incentives to support private-sector research and commercialisation.

Lastly, the university commercialisation environment in terms of infrastructure that drives research, development and commercialisation such as laboratories, and incubation centres need to be availed.

Suggestions for Theory and Practice

Given the diverse nature of the research area, this literature review contributes in several ways to advance the theoretical knowledge about how the commercialization of university research outputs can be scaled up. Firstly, this paper provides a coherent framework and conceptualisation of university research outputs commercialisation factors which are fragmented in different papers. Secondly, the study ranked the factors influencing the commercialisation of university research outputs according to the frequency of appearance in different articles. All factors are defined and substantiated by papers from the sample. This can serve as a starting point for future empirical work on university research output commercialization.

In addition to these theoretical implications, this study also has practical implications. The SLR can serve as guidance for university researchers, on which factors and characteristics influence the commercialization of their research outputs, given the diverse channels of technology commercialization. This will guide them on what path of commercialization is most suitable in their case based on their capabilities.

Limitations

The results of a systematic literature review are dependent on the quality of the data used in the primary studies that are included in the review. We were not able to check the quality of the data for empirical studies included in our review. Certainly, our coding also leaves room for dispute. We tried to describe our steps as transparent as possible, but of course, we needed to use our judgment in some cases.

Areas of Future Research

In this review, we have shown that there is a considerable amount of studies on technology transfer and commercialization. Future empirical studies should focus on investigating what magnitude of change of one of those factors is necessary to change the commercialization of university research outcomes.

Moreover, little is known about the measurement of successful commercialization of university innovations and, especially, the ability to compare these measures across the different modes of interaction. Future studies could work on a scale of university commercialisation commercialization success. The result shows that there is still an inconsistency in the factors influencing the commercialisation of university research outputs. The inconsistent results can be explained by the exclusion of mediators and moderators in the research design since most of the articles were bivariate studies.[20], pointed out that the relationship between two variables of interest is worrisome if an indirect effect is not given adequate attention. Thus, based on this gap, further investigation of both the mediating and moderating effects of factors influencing commercialisation should be conducted.

Lastly, the majority of the studies focused on the external factors affecting university commercialization with less attention to internal factors. There is a need to focus much on internal factors such as transformation leadership, entrepreneurial culture of the universities and the required staff competencies for commercialisation of research outputs.

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Conflict of Interest

The author certifies that there is NO affiliation with (or involvement in) any organization or entity that has any financial interest or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or the materials discussed in this manuscript.

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