



Factors affecting researcher participation in technology commercialisation: A South African university case study



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Background: Research universities in South Africa are well-recognised sources of new knowledge, and their contributions to innovation are manifested through the creation, transfer and commercialisation of new technologies originating from academic research. Research collaboration between universities, industry and the community offers various benefits that include funding for students and researchers and third-stream income for universities. Additionally, the industry can gain access to new technologies to incorporate in improved products and services.

Aim: The aim of this study was to identify the factors that encourage academic researchers' involvement in technology commercialisation.

Setting: The growth in university technology transfer in South Africa can be attributed to the South African Intellectual Property Rights from the Publicly Financed Research and Development Act (Act 51 of 2008). The establishment of technology transfer offices at universities across South Africa aims to involve researchers in commercialisation activities, champion the innovation conversation within universities and to progress innovations from concept to application in the society.

Methods: The study followed a positivistic research philosophy and a deductive approach. Researchers ($n = 38$) in two faculties at the Nelson Mandela University participated in this exploratory study and completed an online survey. The respondents were selected through purposeful sampling.

Results: The findings indicated that a combination of incentives is necessary to enable and to encourage researcher involvement in the commercialisation of research. A set of recommendations based on the findings and implementation suggestions was proposed.

Conclusion: A combination of monetary and non-monetary incentives was required to enable academics' involvement in commercialisation activities.

Keywords: technology transfer; commercialisation; university; researcher involvement; incentives.

Introduction

Universities have traditionally been places of higher learning and research, where the dissemination of new knowledge was limited to producing new graduates and research publications (Rasmussen, Moen & Gulbrandsen 2006). Universities are presently expected to play a distinct role in uplifting social and economic conditions through the direct transfer of innovative knowledge products and artefacts to the private sector (Bercovitz & Feldman 2006; Guerrero & Urbano 2019). To address this transformed role from a research university to a more entrepreneurial one and to emphasise the boldness of this progression, Etzkowitz (2003a:109) coined the term 'entrepreneurial university'.

A definition of an entrepreneurial university is any university taking on activities to improve regional or national economic performance as well as the university's financial advantage and that of its faculty (Etzkowitz et al. 2000), which differs from the definition proposed by Baldini et al. (2014), which is academic entrepreneurship, which encompasses formal and informal mechanisms to commercialise research. The terms are inter-related and the entrepreneurial university concept applies at the institutional level, whereas academic entrepreneurship refers to the activities and roles undertaken by individuals (Baldini et al. 2014). Academic entrepreneurship

Note: †, 1980–2016.

effectively reflects the orientation and involvement of researchers in activities that lead to more significant interaction of the university with industry and the commercialisation of research outputs and artefacts.

The process by which universities can contribute is known as technology transfer and is directly linked to the extent of involvement of researchers in commercialisation activities (Bansi & Reddy 2015; O'Shea et al. 2005). The commercialisation of research has become a priority for many research organisations and universities, which has resulted in structural transformation to address the growing interest of governments in demanding universities to be more proactive in technology transfer (Munari et al. 2016). The ease with which knowledge is transferred depends on the characteristics of knowledge, similarities in knowledge background and knowledge management capabilities (De Wit-de Vries et al. 2019). However, a lack of understanding remains in the private sector about the role of innovative activity in public sector universities (Demircioglu & Audretsch 2019).

Several universities all over the world have started to invest in the creation of internal mechanisms (organisational procedures, incentives and regulations) and structures to support technology transfer in its different forms (Giuri et al. 2018). Technology transfer is the process by which intellectual property (IP) developed within a research environment is shared with businesses and society for application and use. The transfer of technology and knowledge from research institutions is important for stimulating economic growth in a country by increasing industry competitiveness and establishing new businesses (Martinez Sanchez & Pastor Tejedor 1995).

The definition of research commercialisation or technology transfer refers to the transfer of knowledge products and artefacts from a university to society for social or commercial benefit. The definition is drawn from the South African Intellectual Property Rights (IPRs) from the Publicly Financed Research and Development Act (Act 51 of 2008; Bansi & Reddy 2015). The involvement of researchers in commercialisation activities is considered entrepreneurial within the higher education and research environment and thus, whilst reference is made to commercialisation activities, the phenomenon of researcher involvement in such activities is considered entrepreneurial (Mars & Rios-Aguilar 2010; Trencher et al. 2014). Universities play a significant role in providing knowledge-intensive environments to support the exploration, exploitation and commercialisation of innovative and entrepreneurial ideas, especially in emerging economies, such as South Africa (Guerrero, Urbano & Herrera 2019).

Universities that have been successful in the commercialisation of research activities have used financial support from government and industry, provided university management support, established successful university technology transfer offices (TTOs), promoted an innovation climate and

implemented a reward system to promote innovation and technology transfer (Bansi & Reddy 2015). University-industry collaboration funding has been directly instrumental in universities' technological innovation (Tseng, Huang & Chen 2018).

This exploratory study aims to determine the factors that influence the commercialisation of research and encourage academic researchers' involvement in research commercialisation. It is important for university management to understand the factors that encourage researchers to participate in research commercialisation activities, in collaboration with the university's TTO. At the time of the study, limited research had been conducted on the commercialisation of research at South African universities. Specific factors investigated include managerial support, the role of the TTO and incentives for researchers involved in research commercialisation. The article proceeds as follows: the next section discusses the literature review, to be followed by the research methodology. The results and discussion sections are presented, and finally the conclusions, recommendations and future research are presented.

Literature review

Innovation and technology transfer

Innovation and entrepreneurship are described as key drivers for economic development (Mamabolo, Kerrin & Kele 2017). An innovation is an idea perceived as new. It can be described on four different levels with increasing novelty according to the guidelines provided by the Organisation for Economic Co-operation and Development (OECD): innovations that are only: (1) new to the organisation, (2) market and the organisation, (3) country and (4) the world first (OECD/Eurostat 2005).

Universities are facing growing pressure to contribute towards innovation and entrepreneurship, which has commercial value and social impact and contributes to economic development. Legislative frameworks can stimulate the development of local practices for the management and exploitation of IP (Weckowska et al. 2015). The implementation of the IPR from Publicly Financed Research and Development Act 51 of 2008 (IP Act) granted South African universities the right to register IP. Public-funded universities are expected to play a distinct role in uplifting social and economic conditions through the direct transfer of innovative knowledge products to industry and the private sector (Bercovitz & Feldman 2006). This contrasts with Egypt, for example, which is also an emerging economy. They have no broad, national co-ordinating policy that encourages universities and industry to collaborate, particularly on research and to engage in the transfer and commercialisation of technology (Kirby & El Hadidi 2019).

The process by which universities make this contribution is known as technology transfer and is directly linked to the extent of involvement of researchers in commercialisation

activity (O'Shea et al. 2005). Technology transfer at universities effectively reflects the orientation and involvement of researchers in activities that lead to more significant interaction of the university with industry and the commercialisation of research outputs. Industry evaluates potential university partnerships based on factors such as the comprehensiveness and knowledge of researchers (Johnston & Huggins 2018). De Wit-de Vries et al. (2019) indicate that partner selection should be taken into account as similarity in knowledge background is important for collaboration. This involvement, in turn, positions the university as a critical partner with industry, contributing to economic and social developments and not just a generator of knowledge (De Wit-de Vries et al. 2019; Etzkowitz 2003b).

The process of technology transfer is described as a series of events from the discovery or development of an innovation to the use of the innovation or practice of the technology by consumers. To facilitate and enable the process of commercialisation of knowledge, universities worldwide and specifically in South Africa have established TTOs to manage the legal protection, as well as the formulation of strategies, which lead to the commercialisation of promising technologies. South African TTOs, in terms of the IPR Act (Act 51 of 2008), are responsible for the identification, protection, management and commercialisation of IP.

The components that enable technology transfer include technological innovations, scientific knowledge and IP. The involvement of researchers is critical in the process, and the extent of involvement can determine the success of the transfer (Colyvas et al. 2002). The primary agent for technology commercialisation in universities is the TTO. They have implemented key performance indicators, such as disclosures, patents, licenses, licensing revenue and the number of spinoff companies to measure the innovation-based contributions of research universities (Gulbrandsen & Rasmussen 2012).

Academic entrepreneurship

Academic entrepreneurship includes formal and informal mechanisms to commercialise research and refers to the activities and roles undertaken by individuals (Baldini et al. 2014). The concept of academic entrepreneurship has arisen from the process of entrepreneurship as defined by Shane (2000) with several widely recognised characteristics as follows:

- The activity involves bearing risks on the part of the entrepreneur as risk implies uncertain outcomes;
- It involves an organising effort in that it involves creating a new way of exploiting an opportunity and
- The activity must have some inherent aspect of novelty or innovation that has not been done before.

Shane (2000:4) narrowly defines academic entrepreneurship almost exclusively related to university spin-offs as 'a new company founded to exploit a piece of IP created in an

academic institution'. Sharma and Chrisman's (1999:18) definition of entrepreneurs 'as individuals or groups of individuals, acting independently or as part of a corporate system, who create new organisations, or instigate renewal or innovation within an existing organisation' is appropriate for academic entrepreneurship. There are two main elements of an emergent entrepreneurial university; the first is the development of organisational mechanisms to progress commercialisable research across institutional borders and the second is the integration of academic and non-academic elements in a common framework (Klofsten & Jones-Evans 2000).

Etzkowitz (1998) first described the entrepreneurial scientist as someone with an entrepreneurial perspective where results are examined for commercial and intellectual potential. Income benefits do not always motivate academic entrepreneurs, who often define their success in terms of technology diffusion, technology development, public service and peer motivations, which result in a mismatch between the motivations for participating in university-industry knowledge exchange and the outcomes typically assessed (Hayter, Rasmussen & Rooksby 2018). Creativity and innovation are also not explicitly taught in faculties at universities in South Africa (Pitso 2019).

Technology transfer office commercialisation activities

In studying academic entrepreneurship, Wood (2011) describes a process of activities involving researchers and the TTO in identifying, protecting and ascertaining the commercial potential (which includes social and financial return) and licensing of research artefacts. Whilst Wood's process model of academic entrepreneurship supports the technology transfer process, developed by Rogers, Takegami and Yin (2001), academic entrepreneurship literature has considered researcher involvement in these stages as commercialisation activities. The process of progressing innovative research outcomes from the laboratory to practical use by an industry partner, society or a newly formed company involves a complex process of diverse activities performed by various role players. However, it definitively starts with the researcher disclosing the innovative findings or output to the TTO. Methods to assess the innovation and exploitation perspectives of university research have been used in recent years to select commercially viable projects (Cartalos, Rozakis & Tsiouki 2018).

Research universities are well-recognised sources of new knowledge, and their contributions to innovation are manifested through the creation, transfer and commercialisation of new technologies originating from academic research (Hayter et al. 2018). The role players include the researchers, the TTO, the licensee or entrepreneur of a new spin-off company, funders and other peripheral role players such as intermediaries, consultants, business incubators and science parks (Guerrero et al. 2019).

The provision of government and university institutional management support can influence researchers' involvement in commercialisation activities. Critical impediments to better technology transfer performance tend to be organisational in nature. These include incentive mechanisms, cultural differences between universities and firms and staffing and compensation practices in TTOs (Siegel 2018). Each component of a university technology transfer strategy must be established and committed to at an institutional level. A defined mission statement is critical for the alignment of the TTO (Necoechea-Mondragón, Pineda-Domínguez & Soto-Flores 2013). Technology transfer office activities should be coordinated alongside and integrated into the core missions of education and research of the university. Successful TTO office business models can further assist a university's TTO to increase their impact on society. The business models that leverage high-quality research and business start-up creation are associated with higher economic performance (Baglieri, Baldi & Tucci 2018).

University leadership should provide the TTO with the necessary level of governance autonomy, strategic flexibility and financial autonomy within the university structures. The low rate of academic start-ups and low levels of commercialisation in South Africa has been attributed to a lack of institutional and organisational factors. As a result, scientists' and academics' intentions to start a business are often negative, as they perceive inadequate organisational support mechanisms and institutional constraints (Haeussler & Colyvas 2011). Urban and Chantson (2019) hypothesised that perceptions of institutional barriers in terms of capital availability, government regulations and the national IP regime will negatively influence research scientists and academics to have lower levels of entrepreneurial intentions in the South African context.

Technology transfer office's support is critical for successful commercialisation activities. The mission of a TTO should also be defined, or at least supported, at the top levels of the institution's administration. The alignment of TTOs' activities with the broader goals of the institution justifies the investment of resources required to achieve the expected returns (Pitso 2019; Warren, Hanke & Trotzer 2008). The TTO staff must have a thorough, in-depth understanding and experience of the academic environment. In addition, a profound understanding of the needs of industry and business is an absolute necessity (Debackere 2018). The autonomy, structure and experience of the TTO trigger creativity and TTO strategies (Pitso 2019; Pitsakis & Giachetti 2019).

Monetary and non-monetary incentives can have a positive effect on researcher's involvement in commercialisation activities. Necoechea-Mondragón et al.'s (2013) study on Mexican academic researchers revealed that one of the reasons why technology transfer is limited in Mexico is that Mexican public universities do not consider providing more

significant rewards for faculty involvement in technology transfer. Mexican researchers can choose between allocating time to publishing, to patenting or to teach. Perhaps these activities complement each other, but if not, then the current reward system may be giving fewer incentives to those activities that produce a higher social payoff (Gonzalez-Brambila & Veloso 2007). Research scientists working at universities, which explicitly allocate rewards for entrepreneurial endeavours, were found to possess higher levels of a spin-off and patenting or licensing intentions (Huyghe & Knockaer 2015).

University–industry collaboration programmes in South Africa

Financial support for university–industry collaboration directly affects universities' technological innovation (Tseng et al. 2018). The South African government has established many initiatives, organisations and programmes to enable commercialisation activities between universities and industry. Notable organisations and programmes in South Africa include the following:

- *The Council for Scientific and Industrial Research (CSIR)* was established to address the scientific and technological needs of state-owned entities (such as Eskom, the South African power supplier), large industry (such as the mining sector) as well as new or established enterprises by undertaking state-funded research programmes in specific areas of importance. The CSIR now undertakes contract research for the industry as part of its mandate and administers certain funds to sustain enterprises in key economic sectors (CSIR 2011).
- *National Intellectual Property Management Office (NIPMO)* functions as an agent within the Department of Science and Innovation (DSI) and the primary function is to protect IP and IPR that are created with public funds.
- *Technology and Human Resources for Industry Programme (THRIP)*. The Department of Trade and Industry in partnership with the National Research Foundation (NRF) operates the THRIP fund to leverage the projects undertaken by university–industry collaborations financially. This programme has been successful in its model – where the fund matches or exceeds the contribution by the industry partner to the project to support the development of technology and graduates (NRF 2013).
- *Technology Station Programme* is by the DSI. Technology stations were designed to engage with industry and small enterprises to assist with technical problem solving. Many of the technology stations were housed or located near existing universities. Each technology station specialised in a particular field; generally, the most prominent and innovative research area that was a specific university competence. Many of these have failed because of a lack of entrepreneurial skills required to promote services and attract business, but the few that remain are relatively prosperous and continue to be supported by the DSI.

Factors impacting the involvement of researchers in commercialisation activities

The enablers of academic entrepreneurship include factors that contribute to encouraging and improving commercialisation activities. This can be analysed at three levels as follows:

- *National policy level:* These are incentives at the national level, for example, the discontinued Patent Incentive Fund that was operated by the DSI and government policies and legislation, such as the IPR from Publicly Financed Research and Development Act 51 of 2008 (IP Act) managing IP at universities (Bansi & Reddy 2015; Sibanda 2009).
- *Institutional level:* Institutional policies play an important role in communicating the institution's principles, values and philosophies (Bansi & Reddy 2015). Institutional incentives can be monetary, such as percentage of revenues paid to the inventor, percentage of revenues paid to the work group of the inventor(s) and non-monetary incentives, for example inclusion of patent counts in academic performance assessments and awards for granted patents and commercialised research.
- *Individual level:* Universities generally allocate a portion of the funds received for publications and inventions from the government to the researchers responsible for the development of artefact. Monetary rewards such as once-off payments for granted patents and revenue share from the commercialisation of research outputs impact researchers at the individual level.

Research in the fields of technology transfer and research policy emanates mostly from developed countries, such as the United States, the United Kingdom and European countries. In these developed countries, programmes exist to educate researchers on the process and implications, and thus awareness is not a need or a challenge amongst researchers (Urban & Chantson 2019). These countries have also been commercialising research outcomes for a much more extended period compared to emerging economies, such as South Africa where the oldest TTO is about 15 years old. Alessandrini, Klose and Pepper (2013) reported that there was a distinct lack of awareness of IP, the function of the TTO and benefits of commercialisation amongst researchers in South Africa.

This article suggests that the factors can be actively managed by an institution to encourage the desired direct effect on the involvement of researchers in commercialisation activities. Therefore, the organisational incentives and individual motives need to be congruent. Understanding what researchers perceive as the important factors for their involvement in commercialisation activities will inform a strategy that can be applied to an academic institution.

Universities in South Africa identify researchers involved in commercialisation activities in the following ways:

- Formal publications such as the annual research report, which is distributed internally and nationally to other universities and national stakeholders and national reports submitted to the Department of Higher Education and the NRF;
- Informal publications such as newsletters, websites and local news articles;
- Formal award ceremonies such as research, teaching and engagement awards; and
- Recognition by the TTO awarding small honours, such as certificates of recognition for their contribution to innovation (Chetty 2016).

In emerging economies, university transformation is slow, because there is no strong base to build upon and obtain high-quality research outcomes, whilst enterprises interested in partnerships usually face challenges in terms of communication, expectations and agreements (Guerrero et al. 2019). The factors investigated in this study are institutional support, management support, TTO support and monetary and non-monetary incentives (Alessandrini et al. 2013; Siegel 2018; Urban & Chantson 2019).

Theoretical framework

Universities are positioning themselves favourably with potential commercial partners to convert research opportunities into funded projects that may ultimately lead to long-term, sustainable collaborations (Philbin 2010). This positioning requires an assessment of resources and capabilities. The theory of resource-based view (RBV) argues that when an organisation's resources are valuable, rare, non-substitutable and non-copyable, they can create competitive advantage, which adds to the value of the organisation (Mata, Fuerst & Barney 1995). The focus of RBV is on an organisation's internal resources as a means of organising processes and obtaining competitive advantage. Resources are defined as anything that could be thought of as a strength for an organisation and may be tangible (infrastructure, equipment and materials) or intangible (IP, culture, skills and abilities, knowledge, professional integrity, contracts and efficient procedures and processes). The RBV measures the business value derived from a resource in contributing to creating competitive advantage (Ruivo, Oliveira & Neto 2015).

In addition, they must be difficult to replicate because they are either tacit or socially complex (Dutta 2008). From the university perspective, the ability to collaborate with industry will also be dependent on the resources that can be accessed. These include the academic and scientific records of accomplishment of the faculty member as well as other resources, including physical ones such as laboratories and experimental equipment as well as organisational processes such as those related to research administration (Philbin 2010). The theory of RBV provides a theoretical framework to analyse technology transfer and university–industry collaborations.

The RBV provides a means of evaluating potential factors that can be deployed to create competitive advantage. In the RBV, a strategy or competitive position is identified that best exploits the internal resources and capabilities. In an academic environment, these factors or resources could include human resources, knowledge, organisational processes and financial incentives. In this study, managerial support, researcher knowledge, the role of the TTO and financial incentives were considered as potential factors.

Research methodology

This research is conducted in the positivistic paradigm using a deductive approach where the hypothesised relationships between selected independent factors and researchers' involvement in commercialisation activities were tested. South Africa presently has 26 public universities and conducting research amongst academics and students requires ethics approval from each institution. The decision was made to conduct an exploratory research study using a single case study strategy at the Nelson Mandela University in South Africa.

The research instrument

To explore the relationship between selected factors and researchers' involvement in commercialisation activities, a survey was conducted amongst the identified target population. A semi-structured questionnaire (Chetty 2016), which was operationalised from the literature, was used to measure the independent factors in this study. The questionnaire included seven sections that captured the 38 respondents' profile, their research activity characteristics, their involvement in commercialisation activities, perception of TTO support, perception of the university's institutional support for involvement in commercialisation activities, perception of personal incentives for involvement in commercialisation activities and perception of interventions, which could increase researcher involvement in commercialisation activities.

The following hypotheses were formulated for the study:

H1: There is a significant positive relationship between institutional support provided and researchers' involvement in commercialisation activities.

H2: There is a significant positive relationship between management support and researchers' involvement in commercialisation activities.

H3: There is a significant positive relationship between TTO support and researchers' involvement in commercialisation activities.

H4: There is a significant positive relationship between researchers' monetary incentives and researchers' involvement in commercialisation activities.

H5: There is a significant positive relationship between institutional non-monetary incentives and researchers' involvement in commercialisation activities.

The questionnaire made use of a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) and included open-ended questions. A pilot study was conducted

amongst five academics to test for content validity, and the university statistician checked the questionnaire for face validity.

The sample

Urban and Chantson's (2019) study recognised that research on academic entrepreneurship and commercialisation was mainly conducted on Western studies and they thus performed their study in an under-researched emerging market context, such as South Africa. This study also focuses on an emerging market context with the sampling frame consisting of researchers resident in the Faculty of Science and the Faculty of Engineering, Built Environment and Information Technology (EBEIT) at a comprehensive university in South Africa. The two faculties host approximately 137 academics across several disciplines at the university. The Faculties of Science and EBEIT constitute disciplines most likely to give rise to new inventions and, as such, were chosen as suitable for the target population.

The study used a non-probability sampling, specifically purposive sampling, also known as judgmental, selective or subjective sampling, in which the researchers rely on their judgment when choosing members from the population to participate in their study. The Deans of the Faculties were approached by email to offer their support for the distribution of the link to the electronic questionnaire. A request to participate in the study was distributed to all 137 academics in the Science and EBEIT faculties at the Nelson Mandela University. In total, 36 researchers agreed to participate in the study; 20 researchers involved in commercialisation activities and 16 researchers were not involved in commercialisation activities.

Data collection and analysis

Data collection for this study was conducted by desktop research and an online survey. The literature review informed the items developed for the questionnaire. The questionnaire was distributed through an email, containing an URL link and a cover letter, captured on QuestionPro. The questionnaire link was open and accessible for responses for 2 weeks.

Descriptive statistics and inferential statistics were used for the data analysis. Pearson's Product Moment Correlations analysis was conducted in this study. Correlations are statistically significant at the 0.05 level for $n = 36$ if $|r| \geq 0.329$ and practically significant if $|r| \geq 0.300$ (Gravetter & Wallnau 2009:534). Thus significant (both statistically and practically) if $|r| \geq 0.329$ (Gravetter & Wallnau 2009:534). Thus, for the sample size of 36, a result will be deemed both statistically and practically significant if $|r| \geq 0.329$ (Gravetter & Wallnau 2009:534). The reliability of the questionnaire was tested using Cronbach's alpha values; however, because of the small sample size ($n = 36$), these values must be interpreted with caution. The Cronbach's alpha coefficients for the factors were all in the range 0.60–0.69 (Fair), 0.70–0.79 (Good) and 0.80+ (Excellent).

To determine whether there was a statistical difference between the two groups, namely, staff members involved and not involved in commercialisation activities at the university, the Kruskal–Wallis test was used to compare two or more independent samples of equal or different sizes. The Kruskal–Wallis test was used to determine whether there were statistically significant differences between two or more groups of the independent factors on the dependent factor (Zar 1999).

Ethical consideration

Ethical approval for the study and distribution of the research questionnaire was granted by the university's Ethics Committee (H15-BES-BUS-028).

Results

Participants' demographic statistics

The majority of the respondents (44%, $n = 16$) were in the age category of 45–54 years. Just over two thirds (69%, $n = 25$) of the respondents were male. Of the respondents, 61% ($n = 22$) stated that they had previous employment in industry and 78% ($n = 28$) said that they were employed on a full-time permanent basis by the university. It was important to ensure that a significant portion of the sample held permanent full-time positions because short-term contract positions are generally assigned larger teaching loads and, therefore, have limited time left for research. Of the respondents, 53% ($n = 19$) indicated that they have worked in the research environment for over 14 years. Table 1 summarises the key demographic information of the respondents.

The academic activities the respondents were involved in included teaching, research, research supervision and academic administration. Twenty respondents were involved in commercialisation activities and 16 stated that they were

TABLE 1: Summary of demographic findings from the respondents ($n = 36$).

Variable	<i>n</i>	%
Age (years)		
25–34	5	14
35–44	13	36
45–54	16	44
> 55	2	6
Gender		
Male	25	69
Female	11	31
Industry employment		
Yes	22	61
No	14	39
Employment status		
Permanent	28	78
Contract	8	22
Research experience (years)		
≤ 14	17	47
> 14	19	53
University employment (years)		
≤ 10	16	44
> 10	20	56

not involved. Of the respondents, 11% stated that their research had no relevance to external stakeholders, 44% stated that their research can be applied commercially and 17% stated that their research is applied commercially. Twenty respondents were involved in commercialisation activities and 14 of them reported that they spend up to 75% of research time on commercialisation activities.

In the following section, the categories Agree/Strongly agree and Disagree/Strongly disagree have been combined for reporting purposes. The responses were categorised into institutional and management support, the TTO support and financial and personal involvement.

Institutional and management support

Of the researchers, 75% ($n = 27$) perceives that faculty management should support involvement in commercialisation activities. Of the respondents, 61% agreed that university line manager support, for example the head of department (HOD), would improve involvement in commercialisation activities. However, only a third of the respondents ($n = 12$) agreed that the university environment is generally enabling for research activities and promotes the involvement in commercialisation activities.

Technology transfer office support

A lack of TTO awareness can be a barrier to involvement in commercialisation activities (Alessandrini et al. 2013). Only 20% of the respondents ($n = 7$) who are involved in commercialisation activities stated that they were aware that the TTO performs a service of filing of IP and provides funding for the construction of prototypes. Two of the respondents stated that they were not aware that the TTO provides support for new company formation, licensing of research outputs and the negotiation of commercialisation contracts. It can be concluded that the involved researchers are mostly aware of the functions of the TTO. Researchers not involved in commercialisation activities displayed a significant lack of awareness of TTO services, specifically services such as negotiating research contracts and administration process of the institution.

The effectiveness of the TTO can be viewed as an enabler or a barrier to involvement of researchers in commercialisation activities. It was important to assess the perception of the respondents as to whether the TTO functions effectively as an enabler for involvement or a barrier. In effect, it can be deduced directly from the response that the TTO functions effectively in offering enough support for researchers and can be considered an enabler consistent with findings by Jensen and Thursby (2001) and Jensen, Thursby and Thursby (2003).

It is important for the relationship between the TTO and researchers who are involved with commercialisation activities to be good. These findings support the research conducted by Debackere and Veugelers (2005) and Jensen

et al. (2003). The dissemination of relevant information on the process of commercialisation is essential for researchers to perceive that the TTO is there to support them. Understanding the process of commercialisation within the statutory legal framework is important together with the commercial options.

Financial and personal involvement

The university commercialisation revenue share for inventors, presently 30%, was generally seen as a sufficient incentive. The majority of involved respondents (70%) agreed that a patent incentive fund should be created to incentivise and reward researchers for patent activity. The results further indicated that 89% of all researchers indicated that an increased share of commercialisation revenue share (more than 30% of net commercialisation revenue received) would incentivise researchers to be involved in commercialisation activities. Of all the respondents, 87% agreed that the availability of funding for proof of concept demonstration would improve the likelihood of research involvement.

The majority of involved researchers (80%) and 50% of not involved researchers agreed that growing their wealth was one of their motives for involvement in commercialisation activities. Of all the researchers, 45% agreed that research provided an improved chance of promotion and was a motivating factor for involvement in commercialisation activities. An overwhelming 94% of all respondents indicated that intrinsic satisfaction is a motivating factor for involvement in commercialisation activities.

The respondents' perceptions of the influence of commercialisation activity involvement on traditional research activities, such as publication of research findings, supervision of postgraduate students and teaching commitments, resulted in more than half of all respondents indicating that involvement does affect traditional research activities. They further indicated that the involvement in commercialisation activities leads to increased collaborations with external organisations and industries. This indicates the perception that involved researchers engage with industry and derive benefits through their engagement, such as the growth of technical and scientific knowledge and sources of additional funding for collaborative projects.

The majority of all respondents (82%) agreed that patents granted in foreign territories should hold equal weight as journal publications in internationally accredited journals during performance valuation. The majority of all respondents (84%) agreed that a training intervention would increase the involvement of researchers. Additionally, most respondents (72%) agreed that the establishment of a Science Park or a business incubator would improve the likelihood of involvement of researchers in commercialisation activities.

Hypotheses

To test the hypotheses, a Pearson product-moment correlation coefficient was computed to assess the relationship between factors. Five hypotheses (Table 2) were evaluated in this study. The results indicate that there is a good positive correlation between institutional support, management support, the TTO support and monetary incentives and researchers' involvement in commercialisation activities. No significant relationship was found between non-monetary incentives and researchers' involvement in commercialisation activities.

The 36 researchers in this study were grouped into *researchers involved* and *researchers not involved* in commercialisation activities. Respondents were asked to state whether they are involved or had been involved in commercialisation activities at the university. Twenty respondents (56%) were involved in commercialisation activities and 16 (44%) stated that they were not involved. Seventy per cent of the respondents involved in commercialisation activities reported that they spend up to 70% of research time on commercialisation activities. This indicated the level of involvement of involved researchers in commercialisation activities.

To determine whether there was a statistical difference between the two groups, namely, staff members involved and not involved in commercialisation activities at the university, the Kruskal–Wallis test was used to compare two independent samples of different sizes. A significant positive statistical difference ($H:18.581$, $df\ 5$, $p < 0.05$) was found between the perceptions held by *researchers involved* and *researchers not involved* with respect to institutional support provided to enable involvement in commercialisation activities at the university (H_1). No statistical differences were recorded between the two groups for H_2 – H_5 . Specifically,

TABLE 2: Hypotheses to determine significant relationships.

Hypotheses	n	r	p	Accept or reject
H1: There is a significant positive relationship between institutional support provided and researchers' involvement in commercialisation activities.	36	0.576	< 0.002	Accept
H2: There is a significant positive relationship between management support and researchers' involvement in commercialisation activities.	36	0.484	< 0.001	Accept
H3: There is a significant positive relationship between TTO support and researchers' involvement in commercialisation activities.	36	0.520	< 0.000	Accept
H4: There is a significant positive relationship between researchers' monetary incentives and researchers' involvement in commercialisation activities.	36	0.458	< 0.000	Accept
H5: There is a significant positive relationship between institutional non-monetary incentives and researchers' involvement in commercialisation activities.	36	0.208	< 0.218	Reject

TTO, technology transfer offices.

no statistically significant difference ($H:3.138$, $df 2$, $p < 0.247$) was found between the perceptions held by researchers involved in commercialisation activities and monetary incentives at the university.

Discussion of results

The key findings indicated that institutional support (top management), faculty support and line management support are critical for researcher involvement in commercialisation activities. Researchers may be reluctant to be involved in commercialisation activities, but managers should encourage it (Bercovitz & Feldman 2006). The results indicated that all researchers agreed (60%) that management support proved to be an enabler in encouraging involvement in commercialisation activities. Eighty per cent of the involved researchers at the university perceived that there is insufficient recognition given to researchers involved in commercialisation activities. Recognition of research groups for their contribution and involvement in commercialisation activities would also prove useful to sustaining research groups.

To sustain research groups, researchers indicated that none of the research entities has received commercial income from commercialised inventions significant enough to sustain partial operations of entities. The reputational enhancement for the entity because of commercially relevant research may prove beneficial to attract industry-related contract research projects and grant funding from public funders.

Technology transfer office support and efficiency are critical for researchers' involvement in commercialisation activities (Bansi & Reddy 2015). The support received from the TTO by researchers involved in research activities (70% agreed) appeared to be sufficient, whilst researchers (12%) not involved felt that there was insufficient information on the process of commercialisation provided by the TTO. This result is supported by previous studies on the impact of a dedicated TTO on the progression of commercial initiatives at an institution. Siegel and Phan (2005) pointed out that the TTO can propel commercialisation activity and significantly reduce the cost to the faculty in terms of time spent on IP administration.

Monetary incentives were identified as enablers to involvement in commercialisation activities, which is consistent with the findings by Lach and Schankerman (2008). Researchers generally agreed that a patent incentive fund would increase the likelihood of involvement in commercialisation activities. The majority of researchers agreed that the current state of 30% of commercialisation revenues paid to the inventors should be increased. Issues regarding researchers' self-motivation and intrinsic satisfaction indicated that the researchers felt that they had strong personal motives including career progression, wealth creation and reputational enhancement for being involved in commercialisation.

Enhancing institutional involvement in commercialisation activities

At an institutional level, a combination of monetary and non-monetary incentives is necessary to enable involvement in commercialisation activities. The following recommendations are made:

- *Increasing the commercialisation revenue share from 30%:* university researchers generally agreed that the percentage of revenue allocated to inventors, which currently stands at 30%, should be increased. The policy has been in place since 2011 and precedents have been set in terms of how commercialisation revenue is managed. The university's IP policy should be revised following a process of stakeholder engagement. A benchmarking exercise should be undertaken to establish which universities offer a more significant percentage than the legislatively prescribed minimum of 30%.
- *Institutional culture and management support:* Management support is critical to enable the involvement of researchers in commercialisation activities. The majority of respondents stated that management generally supported and encouraged their involvement in commercialisation activities.
- *Education:* Urban and Chantson (2019) indicated that academic entrepreneurship education, which is mainly concerned with attitudes, intentions and the business start-up creation process, is important. This study found that involved researchers stated that a formal education and training programme would be an enabler to encourage greater involvement amongst researchers. The TTO, through its collaboration with SARIMA (Southern African Research and Innovation Managers Association), currently provides access to IP WISE™, a 1-day short course designed to improve researchers' understanding of IP and its role in research. A programme of local and international speakers can be devised and planned to match the needs of researchers.
- *Lack of TTO awareness:* It was clear from the response that researchers involved in commercialisation activities were not aware of the full spectrum of support services offered by the TTO. This represents one of the more significant barriers to commercialisation of research (Siegel & Phan 2005). The TTO needs to provide additional material on the operations and services carried out by the office to researchers, particularly those not involved.
- *Marketing of TTO:* Comprehensive marketing strategy is required to enhance the awareness of the TTO.
- *Establishment of a Science Park or Business Incubator:* Researchers perceived that the establishment of such facilities would enable involvement.
- *Perception of insufficient institutional support:* Researchers perceived that the university committee structures were not supportive. The TTO is required to champion the innovation agenda and needs of the research community within the university. Involved researchers generally

agreed that the TTO provides sufficient support to enable involvement. Investigating the specific aspects through a qualitative study would prove useful specifically to identify why researchers perceive that there is insufficient support and what can be done to improve their perception.

Conclusion

Universities are facing growing pressure to contribute towards innovation, which has social impact and which contributes to economic development. Researchers mainly in the Science and Engineering fields are the primary sources of innovation outputs from universities, and as such, their involvement in commercialisation activities directly adds to the growth of innovative outputs from publicly financed research. This study focused on understanding the factors that influence the involvement of researchers in commercialisation activities at a university in South Africa. The key elements examined in this study include the researchers' perception of factors they perceive to influence their involvement in commercialisation activities at institutional and individual levels.

The results of the exploratory study indicate that the factors that affect researcher involvement in technology commercialisation at the NMU include national level support, specifically from government institutions, such as the NRF, THRIP and NIPMO, and specifically institutional management support. The awareness of TTO support, commercialisation activities and processes are important factors that need to be strategically addressed. Other factors include personal incentives, such as promotion and monetary and non-monetary rewards. The establishment of Science parks and participation in national award events are also important factors.

The study proposed several recommendations to improve researcher involvement in commercialisation activities at a national and at an institutional level. The following are the key recommendations by researchers from this exploratory study:

- *Patent incentive fund*: a national patent incentive fund that operates on an equal basis as the publication incentive fund should be re-established to reward and incentivise researchers for patents granted. The research publication incentive, operated by the NRF and paid to the institution, should ideally pay approximately two thirds per article published in an accredited journal to the individual (www.nrf.gov).
- *Technology showcase events*: Events where technology innovations can be showcased provide recognition to institutions for their innovative outputs by highlighting the innovative capabilities within specific research fields to the attention of large industries, for example the annual SA Innovation Summit.
- *National innovation awards and competitions*: Recognising innovators and institutions on a national stage for their contribution to innovation in the country is important. Currently, there are the NSTF Awards that honour

and celebrate outstanding contributions to Science, Engineering and Technology innovations in South Africa. Individual universities, through their websites and local publications, attempt to highlight the innovative achievements and the impact innovation makes on society. The prestige of national innovation awards would play an important role in giving not only local recognition but also international recognition.

The following limitations of this study were identified:

- Only researchers of two faculties in one Higher Education Institution (HEI) were targeted because these are the faculties that use the TTO services the most and are the most likely research fields, which give rise to innovation and commercialisation activities. Expanding the survey to other faculties such as Health Sciences may be advisable in the future.
- Using purposive sampling could have introduced a bias in the sample. Repeating the study using non-probability sampling including all academics and researchers in the faculties is suggested.
- The research was only undertaken at one university. Ethics approval should be applied for at the other 25 public universities in South Africa and the research study extended.

The NIPMO is responsible for the establishment of TTOs in relevant academic institutions. Universities in South Africa, in collaboration with the NIPMO, should implement assessment methods and support structures to improve the efficiency of TTOs and the identification of viable entrepreneurial projects, as suggested by Cartalos et al. (2018). Continued future research will aim to explore the factors that affect stakeholders' decisions to be involved in commercialisation activities at other universities in South Africa. Future research will also investigate how senior post-graduate students can become the driving force for academic entrepreneurship with faculty as mentors and advisors.

Universities have tangible assets (infrastructure, equipment and materials) and intangible assets (IP, culture, skills and abilities, knowledge, professional integrity, contracts and efficient procedures and processes), which in terms of the RBV theory can create competitive advantage if properly managed. This article has highlighted the areas where university management need to improve to create that advantage, supporting the RBV theory. In addition, this can be achieved by leveraging a network of relationships that are valuable for both individuals and organisations, which have built up the social capital of the institution.

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Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

M-A.C. planned and conducted the MBA research. M.D.M.C. supervised the MBA research project of M-A.C. M-A.C. passed away after graduation. A.P.C. and M.D.M.C. were responsible for writing this research paper.

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Data are stored securely and can be made available from the corresponding author, upon reasonable request.

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