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Exploring the effectiveness of commercialization pathways for university research outputs in Tanzania

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Abstract

In today's fast-changing world with increasing demand for innovation, universities play an important role in generating new ideas and technologies. However, in developing countries, particularly across Sub-Saharan Africa, turning university research into useful products or solutions is still a challenge. Moreover, there is limited research on the commercialization of university research outputs from developing countries. Most studies focus on developed countries, where R&D activities are more advanced and supported by robust innovation ecosystems, which are quite distinct from developing countries like Tanzania. As a result, only a few products from Tanzanian universities reach the market, making them lag in terms of their research and commercialization capabilities. The study explores the effectiveness of commercialization pathways, aiming to improve the translation of university research outputs into tangible societal benefits. Drawing on case studies from eleven (11) selected universities in Tanzania, the study found that the process of turning research into real-world products can be improved in several ways. These include strengthening collaboration with industries, streamlining intellectual property processes, and fostering a culture of entrepreneurship. The study offers recommendations for universities, industry, and policymakers to optimize the commercialization process and unlock the full potential of university research outputs. It proposes that each university should choose the appropriate commercialization pathway based on the type of innovation or technology developed, the university's strategic goals, capabilities, resources and the desired outcomes such as revenue generation, entrepreneurship, or societal impact. Eventually, improving how universities commercialize their research can help speed up innovation, boost economic growth, and solve pressing societal problems.

Key words: *Commercialization pathways; Incubation; Innovation; Technology transfer; University research outputs*

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Introduction

Society expects universities to produce knowledge, technologies, and inventions as outputs. These outputs can be taken by industry to turn them into products and services that drive the economy. This process depends on the suitability of the universities to generate such knowledge, technologies, and innovations, and the existence of mechanisms for sharing /transferring it to society (Perkmann *et al.,* 2013). This traditional role of the university as a creator, source, and diffuser of knowledge and learning needs to be revised, at least in terms of new methods to integrate innovativeness and entrepreneurship. There is a rising view that universities have a huge obligation, and a special capability, to support in converting their knowledge into potential fruits for economic and employment growth.

In Tanzania, there has been an increasing number of universities' innovative and entrepreneurial research projects that have the potential for commercialization, but most of them have not been translated into products, processes, and services. The reasons behind this include inadequate mechanisms for assisting the commercialization of research results in the country, weak linkages between academia and industries, leading to a low uptake of research results by the industry (Ibeme, 2020; Razwinani *et al.,* 2024). In addition, there is systemic misalignment where academic research prioritizes isolated, theory-driven projects over societal problem-solving.

However, there are efforts to establish incubator programs in the country that nurture the innovation spirits of young entrepreneurs, including start-up companies (Mmasi, 2020; Rwamuhuru and Tegambwane, 2021; Hassan, 2024). These include the Dar Teknohama Business Incubator (DTBi); SIDO Business and Technology Incubator; Tanzania Renewable Energy Business Incubator (TAREBI); University of Dar es Salaam Information and Communication Technologies Incubator (UDICTI), and Zanzibar Technology Business Incubator (ZTBI). Some of the challenges faced by these incubators include the insufficient fees paid by incubatees, which are inadequate to cover the operational costs of the incubator. Additionally, incubatees often conceal their actual turnover and profits to avoid high royalty fees. There are also issues with incubatees being reluctant to leave the premises after graduation, leading to low graduation rates. To address some of these challenges, ecosystem stakeholders such as the Tanzania Commission for Science and Technology (COSTECH) provides financial support to help sustain some of the incubators. Furthermore, angel and venture capital support for incubators in Tanzania is still in its infancy and not well understood by incubatees.

There are various pathways for the commercialization of university research outputs. The commercialization pathways can be organized to provide broader access to innovation, allow a greater volume of deal flow, support standardization, and decrease the redundancy of innovation and the cycle time for commercialization (Litan *et al.,* 2007; Peng, 2023). The broader act of commercialization entails production, distribution, marketing, sales, customer support, and other key functions critical to achieving the commercial success of the new product or service.

Caulfield and Ogbogu (2015) consider the commercialization process of university research outputs to be through licensing patents to companies or creating start-up companies. Other commercialization pathways include Technology Transfer Offices, incubators and accelerators, outright sales, spin-offs, industry collaborations, and partnerships (Caviggioli *et al*., 2020; Baleeiro *et al*., 2023; Farrell *et al*., 2024). The generic pathway for commercializing university research outputs involves conducting market research, technology feasibility and development, commercialization, and business development (Baleeiro *et al*., 2023; Khademi *et al*., 2015). Each pathway has sub-pathways that are time-consuming, resource-intensive, and sometimes expensive. Furthermore, each pathway requires a different form of funding instrument from either the university, government, or private investor, and specialized human capital, facilities, and infrastructure.

The literature identifies various factors that influence the commercialization pathways for university research outputs, including market research, funding access, researcher incentives,

market readiness, time to market, university researchers' perceptions and attitudes towards commercialization, the complexity of the research and development process, composition of the commercialization team, networking and institutional support mechanisms (Cullen *et al*., 2020; Mmasi, 2020; Moolman, 2020).

Existing commercialization models predominantly reflect developed-economy contexts where robust TTO infrastructures streamline patent licensing (Siegel *et al*., 2003), mature industry partnerships enable spin-off ventures (Baldini, 2006), and policy frameworks incentivize researcher engagement (Perkmann *et al.,* 2013). However, the majority of studies on effective pathways tailored to resource-constrained ecosystems like Tanzania are conspicuously missing in the body of literature (Dyantyi and Ncanywa, 2022). Moreover, the assessment of commercialization pathways of university research outputs in these contexts remains unexplored. Therefore, this study aims to explore the effectiveness of commercialization pathways to improve the translation of university research outputs into tangible societal benefits.

Materials and methods

Research Design

This study employed a descriptive-explanatory design (Kothari, 2004) to document and analyse commercialization pathways for university research outputs in Tanzania. Primary data were collected from eleven (11) Tanzanian universities between March 2024 and May 2024. The surveyed universities included: Public universities, namely University of Dar es Salaam (UDSM), Sokoine University of Agriculture (SUA), Nelson Mandela African Institution of Science and Technology (NM-AIST), State University of Zanzibar (SUZA), Dar es Salaam University College of Education (DUCE), Mkwawa University College of Education (MUCE), Mbeya University of Science and Technology (MUST), Institute of Marine Science (IMS) - Zanzibar, Dar es Salaam Institute of Technology. The private universities were St. Joseph University In Tanzania (SJUIT) and Dar es Salaam Tumaini University (DarTU).

Data collection

The research employed a qualitative, multiple-case study design. Data was collected through semi-structured interviews with participants from eleven (11) universities in Tanzania. The interviews were conducted with the directorates/departments responsible for research and innovation activities at the participating universities. The purpose was to gather data on the universities' commercialization status, the pathways utilized for commercialization, the key factors influencing research commercialization, as well as the barriers encountered in the commercialization process. The initial two interviews served as a pilot phase, the information from which was then used to refine the interview protocol and procedures for the main phase of the study. This multi-phased approach, with an initial pilot study followed by larger-scale interviews, enhanced the internal validity of the research. It also enabled the researchers to explore potential patterns and themes across the university cases, leading to more robust and meaningful findings. The interviews averaged 45 minutes, audio-recorded with consent, and transcribed verbatim.

Data management and analysis

Transcripts were coded in NVivo 14, with field notes verified against recordings for accuracy and subsequently anonymized. Content analysis followed Krippendorff (2018), segmenting the data into meaningful units. Thereafter, deductive coding applied *a priori* codes from literature (e.g., pathway typologies such as licensing/spin-offs; barrier categories such as funding/skills/policy) based on Siegel *et al*. (2003) and Perkmann *et al*. (2013). Furthermore, inductive coding identified emergent themes through constant comparison, developing new codes for contextual factors (e.g., cultural risk aversion, informal industry gateways). Finally, codes were grouped into core categories and validated using six participants.

Results

Commercialization status

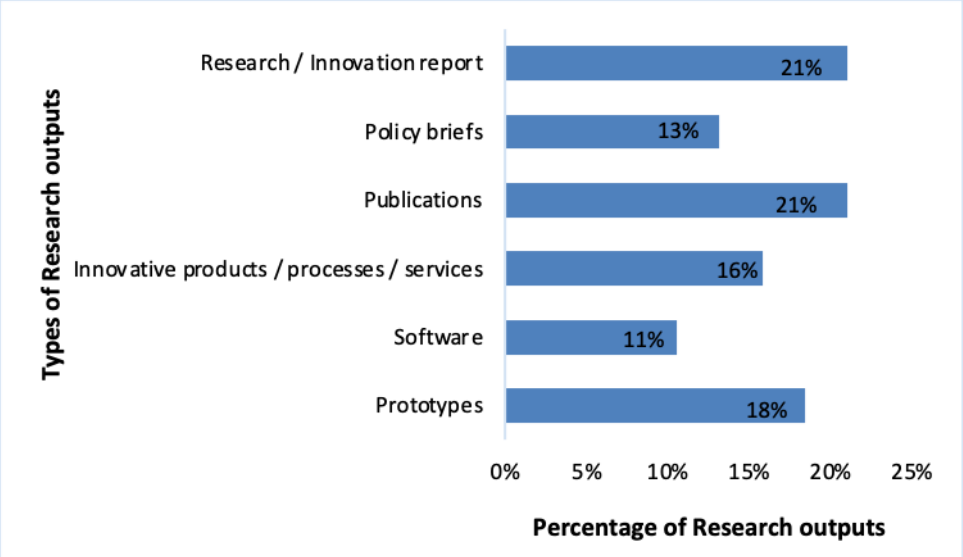
Among the 11 universities in Tanzania, only 3 were involved in commercializing their research. Examples of the commercialized products include biogas plants, electric three-wheelers, health

devices, and educational kits, just to mention a few. While the remaining 8 have not engaged in any commercialization efforts, but they have produced a wide range of research outputs, including publications, prototypes, and software.

Moreover, the study observed the types of research outputs that have been developed by the universities for the past ten years (Figure 1). The results indicate that the predominant research outputs are in the form of research and innovation reports, paper publications, followed by prototypes and innovative products, processes, and services, whereas policy briefs and software were the least reported.

Figure 1

Extent of research outputs from selected universities in Tanzania



The findings reveal a significant disconnect between the perceived commercial potential of the research outputs and their ultimate market realization. While a notable proportion of the research outputs (33%) were assessed as having above-average commercial potential, with a reported commercial viability score ranging from 51% to 100%, however, the translation of this potential into tangible market products remains markedly low. Importantly, only a small minority of the research outputs (9%) have successfully navigated the path to full commercialization, with their research outputs materializing as products currently available on the market. This contrast highlights a substantial gap, often termed the "commercialization valley of death," between the beginning of promising research within academia and its final application in the commercial sphere.

Commercialization pathways

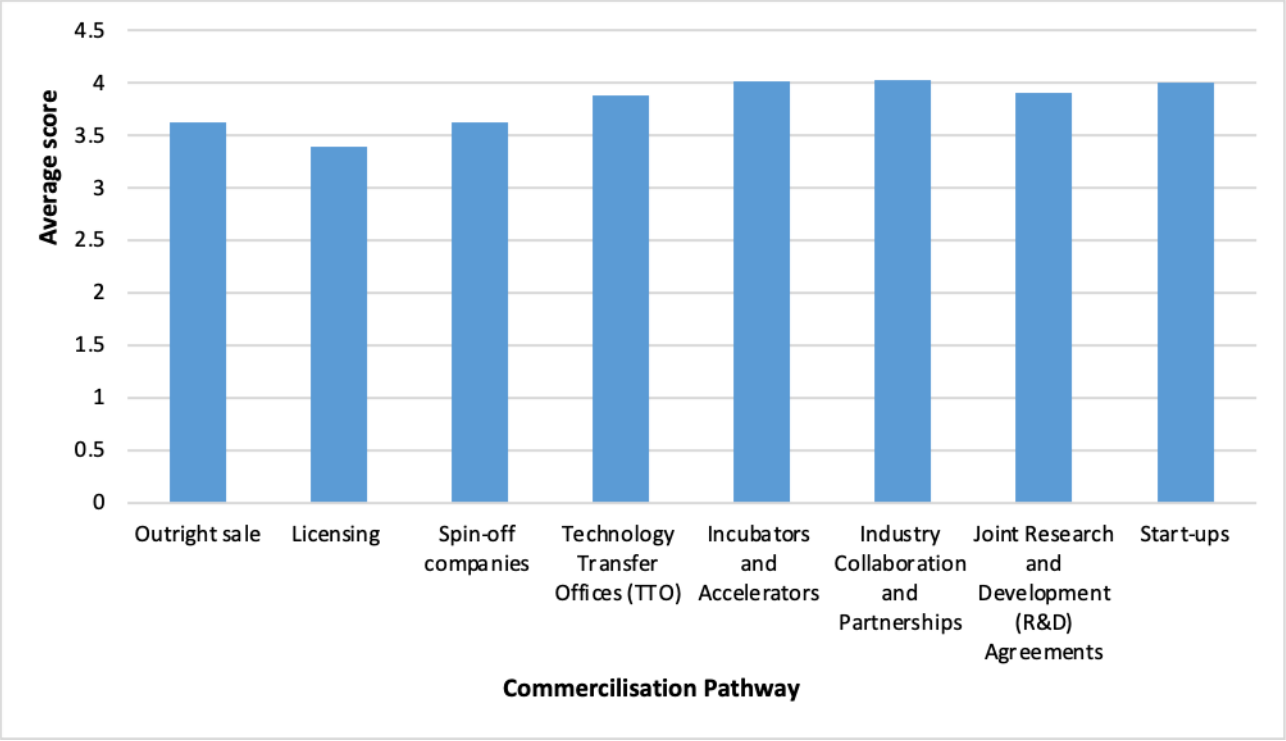
The study identified several commercialization pathways utilized by the participating universities, including outright sales, licensing, spin-off companies, technology transfer offices, incubators and accelerators, industry collaborations and partnerships, joint research and development agreements, and start-ups. However, it was observed that these universities have attempted to apply all these commercialization pathways, but only to a moderate extent, suggesting that efforts are dispersed rather than focused or fully developed.

The participating universities indicated several reasons for selecting particular commercialization pathways, including available resources, market demand, competitive landscape, time to market, collaboration opportunities, competencies and experience, ease of doing business, and the university's innovation and entrepreneurial culture. In the opinion of the participating universities, the most effective commercialization pathways include industry collaboration, incubators, accelerators, and start-ups, while

licensing ranked the lowest (Figure 2).

Figure 2

Effectiveness of commercialization pathways in selected universities in Tanzania

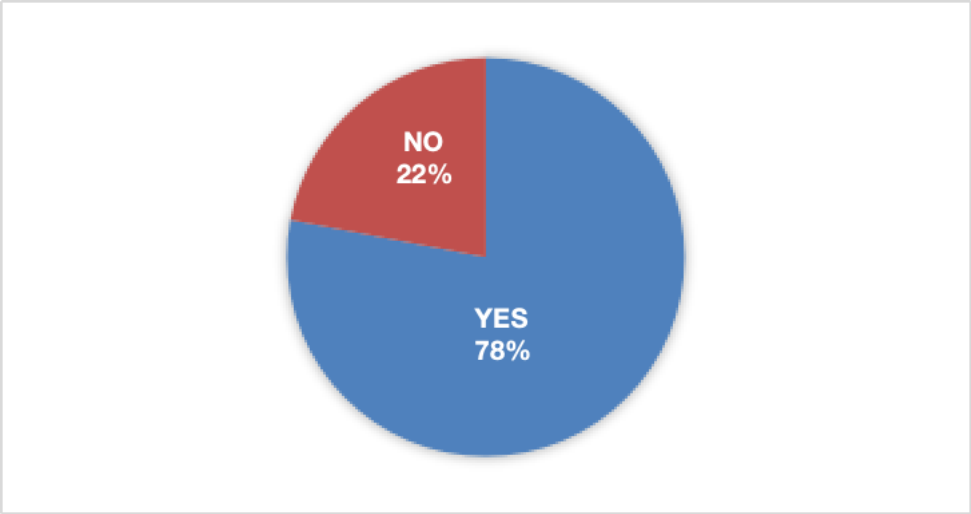


The study revealed that 78% of the participating universities had ongoing Intellectual Property Rights (IPR) initiatives (Figure 3). The IPR initiatives play a critical role in enabling researchers to secure appropriate forms of IP protection (e.g., patents, trademarks, copyrights, industrial designs) before commercialization, thereby safeguarding ownership and enhancing the value of innovations. These IPR initiatives include raising awareness about IPR among staff and students, developing or reviewing IP policies, and providing training and expert assistance on IP issues such as patent drafting and registration.

Furthermore, the study noted various policies, procedures, and guidelines developed by the participating universities towards the commercialisation of their research outputs. They include the Rural Technology Park Policy; Innovation and Technology Transfer Policy; Intellectual Property Policy; Innovation and Entrepreneurship Policy; Guidelines for Commercialization of Research products, Innovation and IP; Research and Innovation Policy; IP Policy, Research and Innovation Guidelines.

Figure 3

Presence of Intellectual Property Rights (IPR) initiatives as reported by selected universities in Tanzania



Additionally, the participating universities reported that they manage their commercialization processes through various initiatives. These include conducting business idea and plan competitions, incubation programs, and start-up support. They also organize seminars and public lectures to raise awareness. The commercialization efforts are further supported by dedicated units such as Directorates for Research, Innovation, and Entrepreneurship, Technology Transfer Offices, Intellectual Property Management Offices, and Subsidiary companies.

Factors influencing the effectiveness of the pathways for university research commercialization

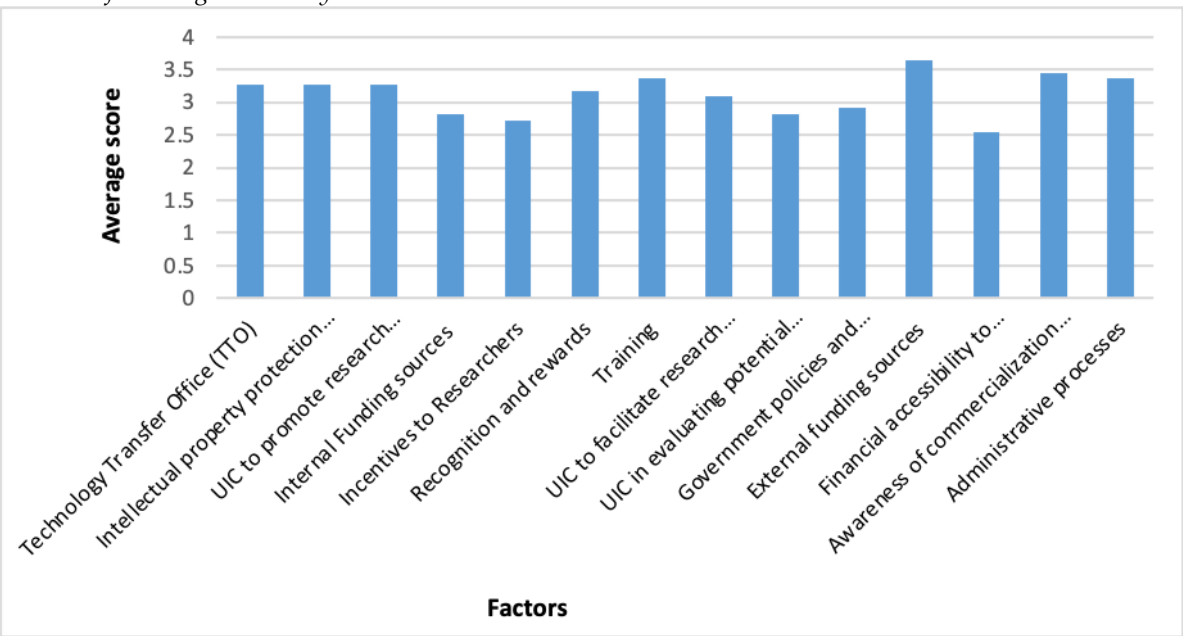
The analysis of interviews across 11 Tanzanian universities reported several factors that influence their research commercialization (Figure 4). The study revealed that institutional support mechanisms are critical determinants of commercialization success. Technology Transfer Offices (TTOs) emerged as fundamental infrastructure, with the universities highlighting their role in bridging research and market applications. However, TTO's effectiveness was dependent on complementary systems such as intellectual property protection mechanisms and streamlined administrative processes.

University-industry collaboration (UIC) was identified as a multifaceted catalyst. The universities reported that UIC facilitated opportunity evaluation for commercialization, while they also emphasized its role in the joint development of research outputs. This synergy was further enabled by government policies and regulations, which the universities described as either accelerators or barriers depending on their alignment with academic innovation cycles.

Resource accessibility significantly influenced outcomes. Internal funding sources and external financial support were deemed essential for de-risking commercialization. Concurrently, researcher engagement was driven by incentive structures and formal recognition and rewards systems, with entrepreneurial training programs noted as key capacity-building tools.

Figure 4

Factors Influencing University Research Commercialization in selected universities in Tanzania



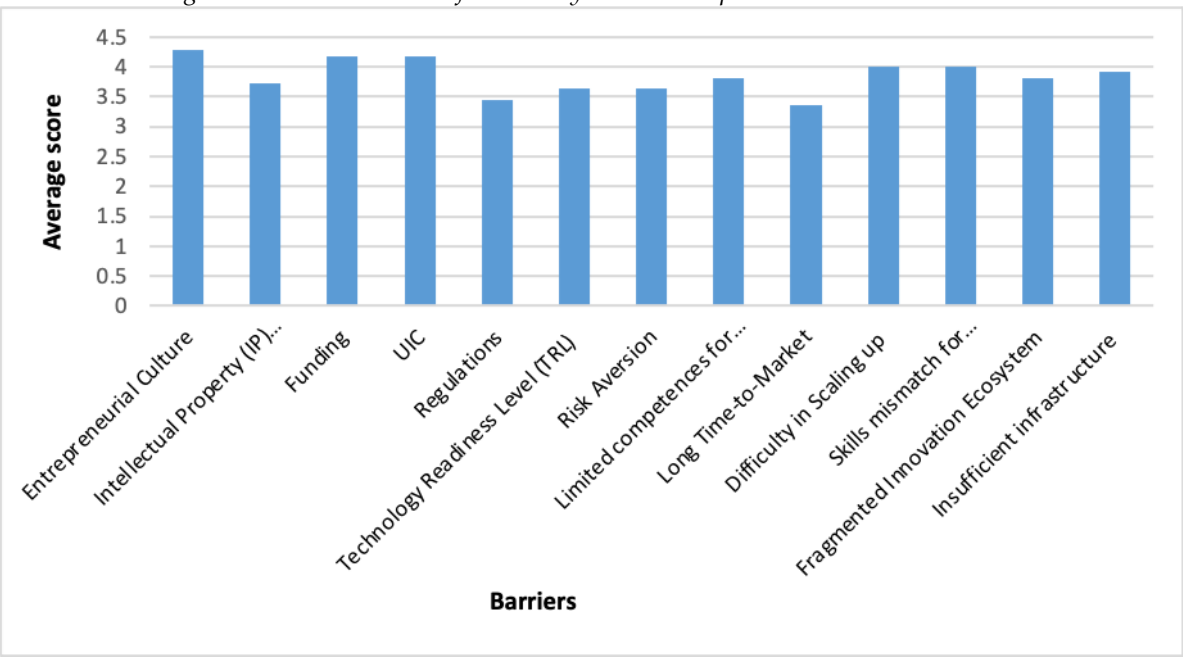
Barriers hindering the commercialization of university research outputs

The participating universities reported that the following barriers hinder their research commercialization (Figure 5). They consistently identified ecosystem fragmentation as the primary barrier, manifested through weak university-industry-government linkages. This systemic challenge amplified resource constraints, including inadequate funding, insufficient physical infrastructure for prototyping and scaling, and a shortage of human resources specifically responsible for commercialization roles.

Cultural and skill gaps presented significant hurdles. The universities observed an underdeveloped entrepreneurial culture characterized by risk aversion and misalignment between academic training and industry requirements (skills mismatch). Operational inefficiencies further impeded progress, with complex IP management, low technology readiness levels (TRL), and long time-to-market cycles reported as recurrent bottlenecks.

Figure 5

Barriers hindering the commercialization of university research outputs in selected universities in Tanzania



The participating universities reported various mitigation initiatives towards addressing the commercialization barriers, including establishing and strengthening academia-industry linkages, establishing a supportive environment for commercialization, writing fundable proposals for commercialization, and training of innovation and entrepreneurship to staff and students.

Moreover, the participating universities recommended utilizing non-academic professionals in managing the commercialization process since academic staff are fully engaged with teaching, research, and consultancy works. Other recommendations include building strategic partnerships with industry, government, and other stakeholders to leverage resources, expertise, and networks. Furthermore, they reported the importance of focusing on market research and validation; developing entrepreneurial skills and mindset; tailoring commercialization strategies; facilitating technology transfer through technology transfer offices; streamlining intellectual property processes; providing legal and business support; offering financial incentives for commercialization; promoting a culture of innovation and entrepreneurship among students, and staff; and rewarding innovative research.

Discussion

The study found that while universities in Tanzania produce a substantial volume of research outputs, primarily in the form of academic publications, these are not predominantly oriented toward commercialization. Despite the efforts to commercialize their research outputs, the findings revealed that only 33% of these outputs have commercial potential, and a mere 9% have fully realized their potential by-products that have reached the markets. This highlights a significant disparity between research production and its practical application in the marketplace. These findings are consistent with Mouton and Waast's (2009), who argue that the focus of academic research in such contexts often leans toward academic prestige rather than market-oriented innovation, whereas Cunningham and Link (2015) emphasize the persistence of a substantial gap between research outputs and market readiness in resource-constrained environments. Similarly, Bercovitz and Feldman (2006) argue that the orientation of academic research toward commercialization often requires a cultural shift

within universities. They point out that in many cases, academic incentives are not aligned with commercialization goals, which may discourage researchers from pursuing market-driven projects. This perspective aligns with the findings of this study, which suggest that there is a need to bridge the gap between research outputs and their commercial application.

Contrary to this, some scholars caution against over-prioritizing commercialization at the expense of fundamental research. Philpott *et al*. (2011) warn that excessive focus on revenue-driven pathways might risk sidelining research that contributes to broader societal and scientific advancement but lacks immediate market appeal. Therefore, universities must strike a balance between commercial and academic priorities, fostering an innovation ecosystem that accommodates diverse objectives.

The respondents identified various barriers that hinder the commercialization of university research outputs, impeding the translation of the research outputs into market-ready products or services. These barriers can be categorized to include institutional and structural barriers, regulatory and policy barriers, cultural and behavioural barriers, skill and knowledge gaps, financial constraints, and technological and process-related barriers.

The study findings on these barriers align with previous scholars such as Perkmann *et al.* (2013), who argue that weak institutional frameworks and misaligned policies frequently undermine the ability of universities to serve as effective drivers of innovation. Furthermore, resource limitations in universities, especially in developing economies, have been widely recognized as a critical constraint, as found in the results of this study. This is also supported by Litan *et al*. (2007), highlighting that this barrier hinders universities' capacity to sustain commercialization initiatives. In addition, the absence of strong university-industry partnerships creates a "commercialization valley of death," where promising ideas fail to advance due to a lack of resources and mentorship (Wright *et al.,* 2004).

In support of the above, Siegel *et al*. (2003) argue that fostering strategic university-industry partnerships can help overcome many of these barriers. They suggest that such collaborations enable resource sharing, provide market information, and create avenues for technology transfer, thereby accelerating commercialization. Etzkowitz and Leydesdorff's (2000) Triple Helix model advocates for closer collaboration between universities, industries, and governments to foster a conducive environment for research commercialization. However, critics like Philpott *et al.* (2011) caution against over-reliance on university-industry partnerships, pointing out that these arrangements may sometimes prioritize commercial interests over academic freedom and the pursuit of fundamental research. They argue that a balanced approach is necessary to ensure that commercialization efforts do not compromise the broader mission of universities as centers of learning and discovery.

Moreover, the study revealed that research commercialization in participating universities is carried out through several pathways, showing that there is no single "most effective" method that works for all. This aligns with Rasmussen and Wright (2015), who argue that the suitability of a commercialization pathway is highly context-dependent. They caution against adopting a "one-size-fits-all" approach, emphasizing that factors such as local market conditions, the university's strategic goals, and the desired outcomes - whether revenue generation, entrepreneurship, or societal impact, as well as the stage of technological development significantly influence the appropriateness and success of a given pathway.

Grimaldi *et al*. (2011) argue that certain pathways, such as spin-off creation and patent licensing, tend to achieve higher commercialization success rates. These approaches are particularly effective when supported by robust technology transfer offices, substantial investment, and favourable regulatory environments, which are often lacking in resource-constrained contexts like Tanzania. This contextual challenge is reflected in the study's findings, which show that the participants rated these very commercialization pathways the least. Instead, they exhibited a clear preference for mechanisms that provide a more direct route to market and foster internal entrepreneurship, such as business incubators and accelerators.

Each commercialization pathway has its own

strengths and opportunities, as well as its own weaknesses and challenges. The study sought a need for universities to conduct a thorough SWOC analysis (Table 1), which can help universities identify pathways that maximize their strengths while mitigating internal and external challenges, ensuring that their efforts in commercialization are both efficient and impactful, as supported by Rothaermel *et al*. (2007). Thus, universities should carefully assess their capabilities, resources, and strategic goals to determine the most suitable approaches for commercializing their research.

Table 1

Evaluation of university research output commercialization pathways in selected universities in Tanzania

Commercialization Pathways	Strengths	Weaknesses	Opportunities	Challenges
Licensing	Generates recurring revenue for the university through royalties. Retains the university's ownership of the intellectual property (IP). Can build long-term relationships with industry partners.	Requires ongoing management and monitoring of licenses. Risk of IP misuse or infringement. The university has limited control over the licensee's commercialization efforts.	Potential for multiple licenses across different industries. Opportunity to expand into new markets.	Negotiation challenges with licensees. Economic downturns can reduce demand for licenses. Licensee may not dedicate sufficient resources to commercialization.
Outright Sales	Provides immediate revenue generation Simplifies the commercialization process. Transfers risk and responsibility to the buyer.	Potentially lower long-term revenue compared to other methods. Loss of control over future development and use of the technology. Difficult to accurately value early-stage technologies.	Can attract buyers looking for fully developed technologies. Potential for future partnerships or consulting opportunities.	Market demand fluctuations can affect the ability to sell technologies. University forfeits long-term benefits and potential upside. Buyers may undervalue the technology.
Spin-Off Companies Start-Ups	Encourages entrepreneurship and	High risk and potential for failure. Requires substantial	Attracts venture capital and other funding sources.	Market competition and

Commercialization Pathways	Strengths	Weaknesses	Opportunities	Challenges
	innovation. Potential for significant long-term revenue and growth. Creates job opportunities and economic impact.	support and resources.	Can bring new technologies to market more rapidly.	technological obsolescence. Regulatory and operational challenges.
Technology Transfer Offices (TTOs)	Centralizes management of IP and commercialization activities. Provides expertise and resources for commercialization efforts. Facilitates connections between researchers and industry.	Can be resource-intensive to operate effectively. Potential bureaucratic hurdles and delays.	Can improve the success rate of commercialization projects. Potential for revenue generation through successful transfers.	Inadequate funding or staffing can limit effectiveness. External competition for IP and commercialization opportunities.
Incubators and Accelerators	Provides comprehensive support for start-ups and spin-offs. Accelerates time to market for new technologies. Fosters innovation and collaboration.	High operational costs. May require significant time and commitment from faculty.	Can attract external investments and partnerships. Enhances the university's reputation as a hub for innovation.	Market saturation of incubators and accelerators. Economic downturns impacting start-up funding.
Industry Collaborations and Partnerships	Leverages industry expertise and resources. Enhances practical application of	Potential conflicts of interest. Negotiation and management of agreements can be complex.	Long-term strategic partnerships. Joint ventures leading to innovative products and services.	Dependence on industry partners can limit flexibility. Changes in industry trends or economic

Commercialization Pathways	Strengths	Weaknesses	Opportunities	Challenges
	research. Can provide funding and real-world problem-solving opportunities.			conditions.

Conclusion and recommendations

The findings of this study reveal a significant challenge facing universities in Tanzania when it comes to the commercialization of their research outputs. However, a modest portion of participating institutions report research outputs with significant commercial potential, with only a small fraction of these outputs reaching the market successfully. This suggests that much of the research being conducted remains disconnected from market demands and scalable production pathways.

To address these commercialization challenges, a multi-faceted approach is recommended. Universities must prioritize proactive engagement with industry and customers from the outset. This will help ensure that research projects are aligned with real-world problems, market demands, and have a higher likelihood of commercial success. Internally, they should strengthen technology transfer capabilities, diversify their commercialization pathways beyond a single approach, and actively foster an entrepreneurial mindset among researchers and students, encouraging them to view commercialization as a viable and valuable outcome of their research activities. Crucially, securing adequate funding from diverse sources is identified as essential to support these activities and bridge the gap between research and market success.

This study has certain limitations that present opportunities for further research. Future research could focus on exploring the effectiveness of university-industry partnerships in facilitating research commercialization, particularly in resource-constrained environments, utilizing larger sample sizes and longitudinal data. Additionally, there is a need to develop and test frameworks that simplify and streamline intellectual property processes, thereby encouraging researchers to protect and commercialize their innovations. Such studies would provide valuable information for universities, policymakers, and industries, equipping them with actionable strategies to unlock the full potential of university research outputs and contribute to sustainable development.

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