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Unlocking academic potential: framework for effective research utilization and commercialization in higher education institutions

John Joshua Federis Montañez[1,2], Anna Liza Mendrique Mateo[3]
[1]College of Engineering, Bicol State College of Applied Sciences and Technology, Naga City, Philippines
[2]Intellectual Property Management Office, Bicol State College of Applied Sciences and Technology, Naga City, Philippines
[3]College of Business and Entrepreneurship, Bicol State College of Applied Sciences and Technology, Naga City, Philippines

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ABSTRACT

Traditional academic research pathways in higher education institutions (HEIs) often emphasize publication and extension activities, while the utilization and commercialization of research outputs remain underdeveloped. This study aims to assess the institutional readiness, strategies, challenges, and success metrics related to research utilization and technology commercialization in state universities and colleges (SUCs), and to develop a framework to strengthen entrepreneurial and innovation-driven practices in HEIs. A mixed-methods approach was employed, combining case study analysis with a survey of nine SUCs in the Bicol Region, Philippines. The survey instrument was developed through key informant interviews (KIIs) and focus group discussions (FGDs) with experts in technology transfer and intellectual property (IP) management, and demonstrated excellent reliability (Cronbach's α=0.92). Results indicate that all participating SUCs have dedicated offices for IP management and technology transfer, reflecting a high level of institutional readiness. However, major challenges persist, including limited funding, weak industry linkages, gaps in IP policy implementation, and the absence of sustainable revolving funds. Success in commercialization is primarily measured through patent filings, licensing agreements, and revenue generation, with limited use of qualitative impact indicators. The study concludes that while SUCs exhibit strong structural readiness, strengthening policy coherence, funding mechanisms, industry collaboration, and commercialization culture is essential. The proposed framework provides a practical guide for enhancing research utilization and commercialization in HEIs.

Corresponding Author:

John Joshua Federis Montañez
College of Engineering, Bicol State College of Applied Sciences and Technology
Peñafrancia Avenue, Naga City, 4400, Camarines Sur, Philippines
Email: jjfmontanez@astean.biscast.edu.ph

1. INTRODUCTION

The productivity of higher education institutions (HEIs) or tertiary educational institutions is based on research. The vital force powers knowledge creation and propels intellectual development [1], [2]. Research fulfills a promise to society and spurs social development, opening the door for game-changing discoveries and developments [3]–[5]. The other three core roles of HEIs, namely instruction, extension, and production, are supported by previous research [6]–[8]. The crucial role of disseminating knowledge derived from study is the main focus of instruction [9], [10]. The extension works are intended to share and

contribute to the practical use of helpful technology and know-how for societal improvement [11], [12]. HEIs can pursue financial success through production by creating cutting-edge goods and services from their research activities [13], [14]. Universities and colleges play a crucial role in promoting innovation and technical development. These institutes' ultimate objective in doing research and development (R&D) is to utilize and commercialize the technology [15]–[17]. Utilizing and commercializing locally developed intellectual property (IP) has also been recognized as a top national development objective [15]–[17].

One of the main goals of R&D departments in universities and colleges is commercialization, the final step in the development process. Utilizing innovations and technology to create profitable businesses is one of their main objectives. However, previous studies have revealed a sobering truth: despite notable advances in research output commercialization, the level of commercialization in universities remains low and less effective [18]–[20].

Even though instruction and extension have attained a degree of stability widely acknowledged, the use and commercialization of technology in goods and services remain a problem for HEIs worldwide. To successfully harness the potential of research discoveries and translate them into practical, marketable solutions, new techniques and tactics are required, given the ever-changing nature of technology. By accepting this challenge, HEIs can contribute significantly to the societal and economic growth of their respective areas. As a result, this study aims to assess the progress of technology commercialization in state universities and colleges (SUCs) in the Bicol Region. It aims to gauge the extent to which these schools have embraced technology commercialization and to shed light on their best strategies and the challenges they face. Aside from going beyond the easy use and commercialization of technology, this research project has the potential to enlighten and improve IP management within these organizations. This study aligns with the college's strategic research goal. It focuses on assisting with the formulation and implementation of policies and plans, particularly to improve service delivery for the college and all related stakeholders. Additionally, it provides a thorough framework that state universities or colleges may use for future technology commercialization projects, supporting more effective and efficient procedures in this area. To guide the investigation, this study sought to answer the following research questions:

- How institutionally prepared are the SUCs in the Bicol Region for technology utilization and commercialization?
- What strategies and challenges do SUCs in the Bicol Region encounter in identifying, supporting, and commercializing research-based technologies?
- What mechanisms and metrics are used by SUCs to measure the success of their technology commercialization efforts?

Ravi and Janodia [21] analyzed the factors affecting commercialization and technology transfer efforts with universities and colleges in India. The study focused on three significant aspects: encountered limitations in technology transfer between industry and universities, developed strategies for commercialization from concluded research activities, and increased awareness of the importance of IP among Indian universities for commercialization. The study concluded that there is a higher likelihood of receiving funding from industry partners. However, the products produced and services developed are far from industry demand. Universities must establish a technology transfer office to address commercialization challenges.

Ismail *et al.* [22] investigated the possible factors in the commercialization of research institutions and universities in Malaysia. The study interviewed four researchers who have successfully commercialized their products. The interviews aim to extract valuable insights and lessons from their commercialization endeavors. The elements identified in the interview included paths to commercialization, healthy relationships with future business partners, and the researchers' traits (i.e., skills, knowledge, and interpersonal attributes). These elements were found to be interdependent and interrelated, leading to effective strategies for commercializing Malaysian research outputs.

Sánchez-Barrioluengo and Benneworth [23] investigated the increasing interest of universities in the so-called "third mission", which pertained to the entrepreneurial university in the United Kingdom in conjunction with teaching or instruction (the first mission) and research (the second mission). With the diversified internal configuration of the United Kingdom HEIs, the gap was answered through the common vital indicators namely, academic heartland, internal coupling, administrative machinery and the steering core. These indicators allowed the analysis of the engagement of the United Kingdom HEIs research output in leading to commercialization, thereby concluding that it is an entrepreneurial university.

Mamedov and Bayramova [24] explained the importance of commercialization in shaping university structures in Azerbaijan through the concept of the "University of Economy". Distinctive significant transformations in Azerbaijan's universities primarily relate to the commercialization of research outputs, advocacy for protecting IP through licensing, and the creation of divisions of financial assets (i.e., companies). These elements were used to develop models for Azerbaijan's universities, leading them to

"University 3.0". The University 3.0 retains teaching (instruction) and research, and shifts towards retooling and developing human resources for the university's commercialization engagements.

Sutopo *et al.* [25] discussed the relationship between open innovation and technology transfer to accelerate commercialization in Indonesia. The study also determined a commercialization strategy based on data envelopment analysis, attributing the higher efficiency of technology transfer offices to their commercialization efforts and awareness. Several indicators were incorporated into the strategy, including improving physical facilities, enhancing internal university policies and regulations, expanding the business network, and improving business marketing support. These indicators enable Indonesian universities to increase their relative efficiency in commercializing research outputs.

Graf and Menter [26] explored the relationship between entrepreneurial universities and the production and commercialization of research, as well as the quality of inventions, thereby affecting regional embeddedness in Germany. The factors studied are the quality of research (i.e., generality, radicalness, network embeddedness, and originality), entrepreneurial orientation, and scientific orientation (i.e., engagement in basic or applied sciences). The study concluded that the scientific orientation affects the direction of novelty of patents among universities. The basic sciences cling to radicalism in patent production. Despite employee orientation, entrepreneurial drive in universities is challenging to manifest. These factors led to a policy recommendation to boost economic leverage at German universities.

Spithoven *et al.* [27] analyzed the roles of university and company location and their effects on the success of commercializing research output in Belgium. The factors studied are region and geographical location among universities and companies, and commissioning research leading to the concept of cognitive distance. There are four conclusions, namely, the most innovative regions where universities reside have a lower likelihood to be paired with companies, having the same region or location among universities and companies allows to embark in a linkage for commercialization, formation of clusters among exact geographical location negatively affects the success of commission of research, and cognitive distance showcases a positive relation in terms of commissioning and commercialization of research.

Kenzhaliyev *et al.* [28] discussed the commercialization of R&D studies in Kazakhstan, especially from universities and research institutions. The study depicts the role of government in the successful commercialization of R&D outputs. Government support is manifested through economic mechanisms, integrated arrangements, and human resource management and development, all of which stimulate employee innovation. Moreover, the government should devise programs to boost R&D among interested individuals from universities and research institutions. The study concluded with a range of recommendations for increased activity by universities and research institutions toward commercialization.

Pitsakis and Giachetti [29] argued for the role of technology transfer offices in the successful commercialization of research output, in conjunction with industry partnerships within universities in the United Kingdom. The technology transfer offices have the primary mandate to develop commercialization strategies and establish linkages with potential industry partners. The study concluded that the experiences of technology transfer offices are negatively related to their autonomy and to the commercialization strategies they currently use. Moreover, the membership of the technology transfer offices in associations significantly affects the commercialization of technologies in UK universities.

Malwina and Hubert [30] expounded on university management as a predictor for potential engagement toward the commercialization of research outputs among universities in Poland. The research methodology used in the study is a critical literature review and intensive data analysis, with a focus on data correlation. Several factors negatively affect commercialization, namely the need for brokerage staff, scientists' and entrepreneurs' attitudes towards collaboration, the bureaucratization of Polish universities, and the limited number of high-quality practices available on the market. The study concluded by proposing a helpful model or framework to guide a concrete, stable commercialization journey for Polish universities. Thus, the studies explore various facets of commercialization, including entrepreneurial orientation, IP protection, and regional factors, while also highlighting country-specific challenges and sharing common themes of technology transfer, collaboration, and university management. These studies suggest improving commercialization procedures while providing insights into how research is used and commercialized across diverse contexts.

2. METHOD

This section outlines the methodologies employed by the study to accomplish its goals. Additionally, it outlines the techniques used to create the research tool and the process by which its validity was established.

2.1. Research methods used

Both case studies and questionnaires were utilized as the principal techniques of investigation in this study. Case studies provide a comprehensive investigation of specific locations in relation to the research

aims [31], [32]. Within the Bicol Region, nine SUCs are the focus of this study. The behaviors and experiences that are associated with the exploitation and commercialization of technologies are investigated. There are two Level IV state universities, three Level III state universities, three Level III state colleges, and one Level II state college among these educational establishments, as indicated by the Philippine typology for universities and colleges.

The primary objective of the survey research technique is to collect pertinent information for analysis through a questionnaire distributed to respondents. This major technique has the potential to depict their location as a primary source of data that is obtained directly from the source [33]–[35]. The purpose of the survey research technique, on the other hand, is to gain an understanding of Bicol SUCs as a whole in terms of the fundamental goals of the technologies developed from research initiatives.

2.2. Sample size and sampling method

The study involved nine SUCs in the Bicol Region of the Philippines. These institutions represent the entire population of SUCs in the region, comprising two Level IV state universities, three Level III state universities, three Level III state colleges, and one Level II state college, according to the national typology of HEIs. A purposive sampling technique was employed. This non-probability sampling method was deemed appropriate because the study required respondents with direct knowledge and involvement in research utilization, technology transfer, and commercialization activities.

2.3. Sample selection criteria

Institutional inclusion criteria were as: i) the institution must be a recognized State University or College in the Bicol Region; ii) the institution must have ongoing or established R&D activities; and iii) the institution must have designated offices, units, or personnel responsible for IP management, technology transfer, or income-generating projects. Respondents were selected based on the these criteria: i) holding managerial, coordinative, or technical roles related to research, innovation, IP, or technology transfer (e.g., IPMO heads, technology transfer officers, REPED directors); ii) possessing direct experience in research utilization, commercialization, or policy implementation; and iii) being officially designated by their respective institutions to represent commercialization-related functions. Each participating SUC was represented by at least one qualified respondent who met these criteria, ensuring that the data reflected institutional-level practices rather than individual opinions.

2.4. Development of the survey questionnaire

Before deploying the survey questionnaire among targeted Bicol SUCs, it must be relevant, concise, reliable, and validated. A survey questionnaire with those characteristics yields accurate and reliable data from respondents. The survey questionnaire development began with key informant interviews (KIIs) to gather information from individuals directly involved in the utilization and commercialization of technologies in their respective communities, who possess first-hand knowledge of the subject matter. In this case, the focal persons were experts in the field, usually the technology managers at the Bicol SUCs, especially the directors or heads of technology transfer, business, income-generating projects, and IP.

Another input for developing the survey questionnaire is the conduct of focus group discussions (FGDs), which stimulate ideas and elicit diverse perspectives on expanding the utilization and commercialization of technologies. The administration and stakeholders are usually the participants in the FGDs to strike a balance among the interested parties. The survey questionnaire was composed of four sections, namely: i) Bicol SUCs' technology utilization and commercialization initiatives; ii) identification and assessment of potential activities for technology utilization and commercialization; iii) financial aspects of technology utilization and commercialization; and iv) best practices and difficulties towards technology utilization and commercialization.

2.5. Qualitative validation of the survey questionnaire

The survey questionnaire underwent a rigorous validation process prior to deployment. Initial validation was conducted through KIIs and FGDs involving 15 experts with direct experience in research utilization, IP management, technology transfer, and commercialization. These experts evaluated the relevance, clarity, and representativeness of each item, thereby establishing content validity in accordance with the content validity index (CVI) framework.

The instrument's content validity was quantitatively assessed using the CVI based on expert review (N=15). Experts rated each questionnaire item for relevance on a four-point scale, with ratings of 3 or 4 considered indicative of content validity. The results demonstrated strong content validity, with item-level CVI (I-CVI) values ranging from 0.87 to 1.00, indicating that at least 13 out of 15 experts judged each item to be relevant, and several items achieved universal agreement (15/15). At the scale level, the instrument

achieved a scale-level CVI (S-CVI/Ave) of 0.93, signifying that, on average, 93% of expert judgments supported the relevance and representativeness of the questionnaire items. These findings provide robust evidence that the instrument adequately captures the constructs necessary to assess institutional readiness, strategies, barriers, and success measures related to technology utilization and commercialization in SUCs.

Following content validation, the instrument's internal consistency was examined using Cronbach's alpha, yielding a coefficient of 0.92, which indicates excellent internal consistency. Given the limited number of participating institutions (N=9), Cronbach's alpha was interpreted strictly as a measure of internal consistency rather than a standalone indicator of validity. The combined application of expert-based content validation (CVI) and internal consistency analysis enhances the methodological rigor, reliability, and construct coverage of the survey instrument in this institutional-level study.

3. RESULTS AND DISCUSSION

The study results include responses from SUCs in the Bicol Region regarding their approaches to technology identification, assessment, and commercialization. The data includes insights on IP management, criteria for technology viability, prioritization processes, steps taken to protect IP rights, dedicated offices, methods for facilitating technology transfer, support services available to researchers, and examples of successful commercialization projects.

Results captured valuable insights from respondents representing diverse positions and departments within nine SUCs in the Bicol Region. In terms of familiarity, three of the nine respondents reported being very familiar with the concepts of technology utilization and commercialization. All institutions reported having dedicated departments or units responsible for these activities, with various strategies employed, including IP management, collaboration with industry partners, and entrepreneurship programs [21], [23]. Two respondents shared notable success stories, including a university-developed digital application supporting local government transactions and agri-based food products. Respondents also emphasized the need for additional training, human and material resources, funding, robust policies, and collaborations to enhance the utilization and commercialization of technology across SUCs.

Based on the study's results, it is evident that SUCs in the Bicol Region employ various strategies and processes to identify, assess, and prioritize technologies for utilization and commercialization. These include evaluating submitted R&D projects, feasibility studies, marketability assessments, and IP protection considerations. The institutions actively protect IP rights by encouraging IP submissions, providing funding for IP applications, and offering mentoring during the application process. Notably, each institution has dedicated offices, such as IP management offices and university-based technology transfer and enterprise development units, responsible for managing IP and technology transfer.

Success stories like the university-developed digital application supporting local government transactions and agri-based food products mirror localized innovation outcomes as seen in Indonesian and Malaysian universities, where commercialization is driven by IP protection, market relevance, and entrepreneurial support [22], [25]. However, as in Poland [30], challenges such as limited funding, a lack of commercialization culture, and gaps in IP policy were identified. These are not unique to the Philippines but are recurring barriers across developing academic institutions.

3.1. Institutional readiness for technology commercialization

Most respondents (55.56%) were familiar with technology utilization and commercialization, indicating a substantial understanding within the surveyed group. All participating SUCs demonstrated high institutional readiness for technology commercialization. The survey revealed that each institution has dedicated departments or units responsible for technology utilization and commercialization. This indicates a strong foundation and commitment to fostering innovation within the academic environment. This supports findings by Mamedov and Bayramova [24], who emphasized the transformation of HEIs into entrepreneurial institutions as part of the "University 3.0" model. The readiness of Bicol SUCs reflects the structural adaptations also seen in Kazakhstan's universities, where institutional mechanisms were reinforced by national R&D policies [28].

Furthermore, most respondents were highly familiar with technology commercialization, suggesting a pervasive awareness among faculty and researchers. The survey underscores the commendable institutional readiness among the participating SUCs for technology commercialization. The existence of dedicated departments or units responsible for this purpose reflects a proactive approach to fostering innovation within the academic setting. The high familiarity respondents report with the concept of technology commercialization suggests pervasive awareness among faculty and researchers, laying a solid foundation for advancing these initiatives.

3.2. Technology identification and evaluation

The institutions employ a range of technology identification and evaluation strategies, with a notable emphasis on IP management. Collaboration with industry partners and entrepreneurship programs also emerged as prevalent approaches. The technology evaluation process was perceived as moderately effective (80%), suggesting a generally positive view of the efficacy of respondents' institutions' methodologies. The technology evaluation process was generally perceived as moderately effective, suggesting room for improvement in the efficiency of identifying technologies suitable for commercialization. Strategies like feasibility studies, technology readiness level (TRL) assessments, and market analysis were widely adopted. Similar approaches were highlighted in Belgium [27], where geographical proximity and cognitive distance between universities and industries influenced the effectiveness of research identification and evaluation.

3.3. Support for researchers and faculty

Institutions demonstrated robust support for researchers, with funding for prototyping, business incubation programs, mentorship, IP protection, and networking opportunities commonly provided. SUCs demonstrated robust support mechanisms for researchers and faculty engaged in technology commercialization. Figure 1 shows that IP protection assistance (100%) receives the highest support from researchers, while mentorship and guidance from industry experts (22.22%) receive the least support. Funding for prototyping and proof-of-concept development, coupled with assistance in IP protection, was identified as a common form of support. However, the study also highlighted opportunities to enhance business incubation programs and mentorship initiatives, ensuring a comprehensive ecosystem that empowers innovators at various stages of technology development. Support structures for faculty and student inventors included prototyping, mentorship, and IP assistance. These institutional supports are consistent with the recommendations of Pitsakis and Giachetti [29], who argued that support mechanisms and technology transfer office (TTO) autonomy influence the efficiency of commercialization. Funding limitations, however, limit the continuity of such services, as observed in transitional economies such as Latvia [20].

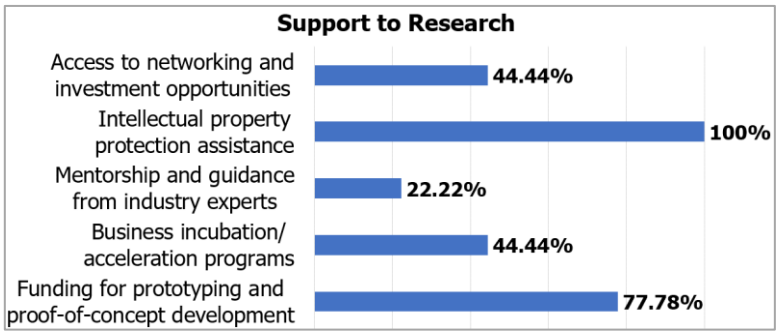

Figure 1. Support for researchers

3.4. Barriers and challenges

Notable challenges faced by SUCs, as shown in Figure 2, included a lack of funding, limited industry partnerships, a deficient entrepreneurial culture, insufficient IP protection, limited market access, and regulatory hurdles. The study highlights the need for strategic interventions to overcome these barriers and foster an environment conducive to successful technology commercialization. These challenges underscore the multifaceted nature of technology commercialization in academic settings. Addressing these barriers will require strategic interventions, collaborative efforts with external stakeholders, and potential policy adjustments to create an enabling environment for successful technology transfer. Identified barriers—such as a lack of funding, weak industry links, and limited market access—echo findings from Ravi and Janodia [21] and Graf and Menter [26], who found that structural bottlenecks, cultural gaps, and inadequate entrepreneurial orientation hinder commercialization.

3.5. Success measurement

Various metrics were utilized to measure the success of technology commercialization efforts, with the number of patents filed/granted being the most common, followed by the number of licensing agreements signed, as shown in Figure 3. The success of technology commercialization efforts was primarily measured using tangible metrics such as the number of patents filed/granted, licensing agreements signed, and revenue generated. This emphasis on quantifiable outcomes aligns with the economic impact of technology transfer

activities. The results suggest a pragmatic approach to assessing success, emphasizing sustainability and economic contribution. SUCs should continue prioritizing these metrics while considering qualitative indicators to capture broader socio-economic impacts. While not all institutions had notable success stories, a university-developed digital application supporting local government transactions and agri-based food products were cited as examples of successful technology commercialization projects. Metrics such as patent count, licensing agreements, and revenue were commonly used. This practice aligns with the global standards discussed by Belitski *et al.* [18] who highlighted the role of quantifiable indicators in justifying institutional investment in commercialization. However, qualitative success indicators such as social impact remain underutilized.

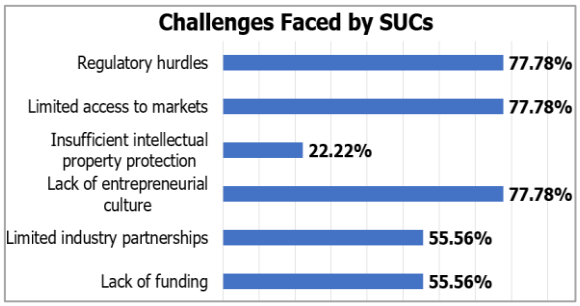

Figure 2. Challenges faced by SUCs

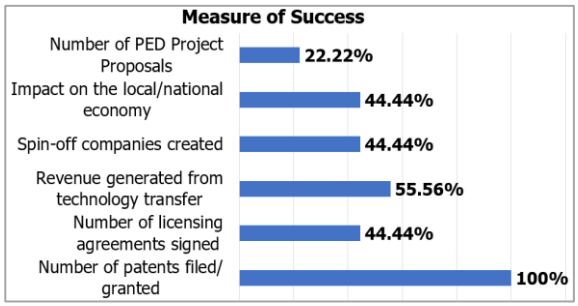

Figure 3. Measure of success

3.6. IP/IPR management and policies

All surveyed institutions have IP/intellectual property rights (IPR) management policies and technology transfer protocols in place. However, gaps remain, particularly in addressing royalty issues and differences between licensors and licensees. This calls for a thorough review and enhancement of existing policies to ensure they are comprehensive and effectively address potential challenges. Enhancing existing policies will ensure they address emerging challenges and provide a solid framework for managing IP in the context of technology commercialization.

All institutions reported having an IP/IPR management policy and technology transfer protocol, with varying stages of institutionalization and approval. Respondents indicated varying levels of awareness among institutional constituents, ranging from fully aware to not fully aware. Identified gaps included differing stakeholder views, issues with technology transfer procedures, and IP ownership concerns for student-initiated projects. Challenges included low institutional awareness of technology transfer, the need to commercialize technology, insufficient funding, and the absence of challenges reported by some institutions. Recommended measures included extensive training, policy enhancements, soliciting support from funding agencies, and focusing on IP management.

All SUCs had some form of IP policy, but inconsistencies in implementation were noted. These findings align with the Malaysian experience, where IP policy maturity significantly influenced commercialization outcomes [22]. Similar policy challenges were observed by Malwina and Hubert [30] in Polish institutions.

3.7. Revolving fund and funding sources

The survey indicated the limited presence of a revolving fund, with most respondents indicating its absence. This underscores the importance of exploring diverse funding sources to sustain technology transfer activities. Establishing and strengthening partnerships with government funding institutions, industry sponsors, and private investors can provide financial support for sustained success in technology commercialization. Respondents identified barriers such as a lack of funding, limited industry partnerships, and regulatory hurdles. They expressed the need for additional training, human and material resources, funding, robust policies, and collaborations to enhance the utilization and commercialization of technology. The limited availability of revolving funds underscores the importance of exploring diverse funding sources to sustain technology transfer activities. The absence of a robust revolving fund limits long-term commercialization. This issue parallels challenges documented in Indonesia and India, where commercialization relied heavily on government intervention and university-industry co-financing models [21], [25].

3.8. Role of SUCs in driving innovation

Results expressed the importance of SUCs in driving innovation, economic growth, and R&D advancement through technology commercialization. Figure 4 shows that publication (56%) is the primary strategy adopted by the SUCs, followed by extension work (33%), and commercialization (11%) is the last consideration. Technologies were generated across various disciplines, including engineering, agriculture, fisheries, industrial technology, science, and the arts. Respondents affirmed the existence of programs like the BS Entrepreneurship Program that encourage faculty and students to engage in entrepreneurship. While four institutions had units or committees for managing technology transfer, one indicated that it still needed to be handled at the university level. Individuals responsible for commercialization were identified, including directors, vice presidents, technology transfer officers, and institutional coordinators. The personnel ranged from two to four, with responsibilities spanning from directors to rank-and-file staff. Funding sources for personnel services (PS)/salary included PS and maintenance and other operating expenses (MOOE), the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCARRD), general appropriations (GA), Department of Science and Technology (DOST), and external and internal funding. The primary source of operating funds was the general appropriations act, with minimal contributions from other sources. While one institution had a revolving fund, four did not, citing reasons such as commission on audit (COA) rules, the lack of commercialized technologies, no revenue from tech transfer, the absence of policies, and the lack of tech commercialization.

Institutions employed diverse strategies, including creating spin-off units and encouraging startups, active IP management, assistance in IP application, participation in pitch fests and investor fora, and information campaigns. The underutilization of commercialization relative to publication and extension work underscores the need to strengthen universities' third mission. As seen in the United Kingdom and Azerbaijan, this shift in mission toward economic and societal impact requires systemic reforms and incentives [23], [24].

Although 100% of the surveyed SUCs reported dedicated offices or personnel for IP management and technology transfer, commercialization remains a low institutional priority, accounting for only 11% of reported research output dissemination strategies, compared to 56% for publication and 33% for extension activities. This apparent contradiction suggests a distinction between structural readiness and functional readiness for technology commercialization. Structural readiness refers to the presence of formal organizational units, policies, and designated personnel, which are evident across all participating SUCs. However, functional readiness—defined by the availability of operational funding, commercialization incentives, industry engagement, and financial sustainability mechanisms—remains limited. Most SUCs reported the absence of a revolving fund, which restricts their capacity to support prototyping, scale-up activities, and sustained commercialization efforts. As a result, technology transfer offices often operate in a compliance-oriented or administrative capacity rather than as revenue-generating or market-facing units. This gap is further compounded by limited industry mentorship (22.22%) and reliance on government appropriations for operational expenses. Consequently, while SUCs are structurally prepared for commercialization, the lack of enabling financial and market mechanisms constrains the translation of readiness into tangible commercialization outcomes.

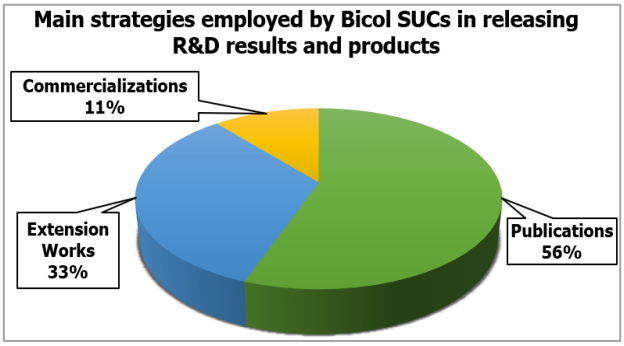

Figure 4. Main strategies in releasing R&D results

3.9. Best practices and difficulties

Success stories demonstrate the potential impact of technology commercialization, such as the university-developed digital application supporting local government transactions and agri-based food products. However, challenges related to compliance and funding gaps indicate areas requiring attention.

Identifying and sharing best practices and targeted strategies to address specific challenges will contribute to a more resilient and thriving technology commercialization ecosystem within SUCs. The results highlight a dynamic landscape of technology commercialization strategies among SUCs in the Bicol Region. Success stories, such as university-developed agri-based commercialization initiatives and licensed software projects, underscore the potential of effective technology transfer. However, challenges such as low awareness, funding constraints, and policy gaps have yet to be identified. Addressing these challenges needs recommendations, including ongoing awareness programs, formalizing technology transfer protocols, fostering collaborations, and establishing a revolving fund.

While SUCs show readiness, refining strategies based on identified challenges can further enhance the overall technology commercialization process. Collaborative efforts between academia, industry, and government agencies are pivotal. Aligning the results with previous studies emphasizes the global relevance of the challenges faced by SUCs. Studies from India, Malaysia, the United Kingdom, Azerbaijan, Indonesia, Germany, Belgium, Kazakhstan, and the United Kingdom again provide a comprehensive overview of the multifaceted nature of technology commercialization. Insights into factors like governmental support, the role of technology transfer offices, and regional influences underscore the complexity and importance of these endeavors. While local successes like university-developed agri-based commercialization initiatives and licensed software demonstrate potential, the SUCs face challenges similar to those in Eastern Europe, Southeast Asia, and Central Asia. Comparative studies from Kazakhstan, Germany, and the United Kingdom confirm that sustained commercialization is shaped by multi-stakeholder collaboration, funding continuity, and institutional leadership [26], [28], [29].

3.10. Framework for technology commercialization in SUCs

Figure 5 illustrates the intricate interconnectedness of the various factors within the developed framework. This framework comprehensively integrates key elements derived from our study, demonstrating how each component interacts and contributes to the overall effectiveness of research utilization and commercialization in HEIs. The visual representation in Figure 5 clearly conveys the complex relationships and synergistic effects among the identified factors, offering a holistic view of the proposed framework's dynamics.

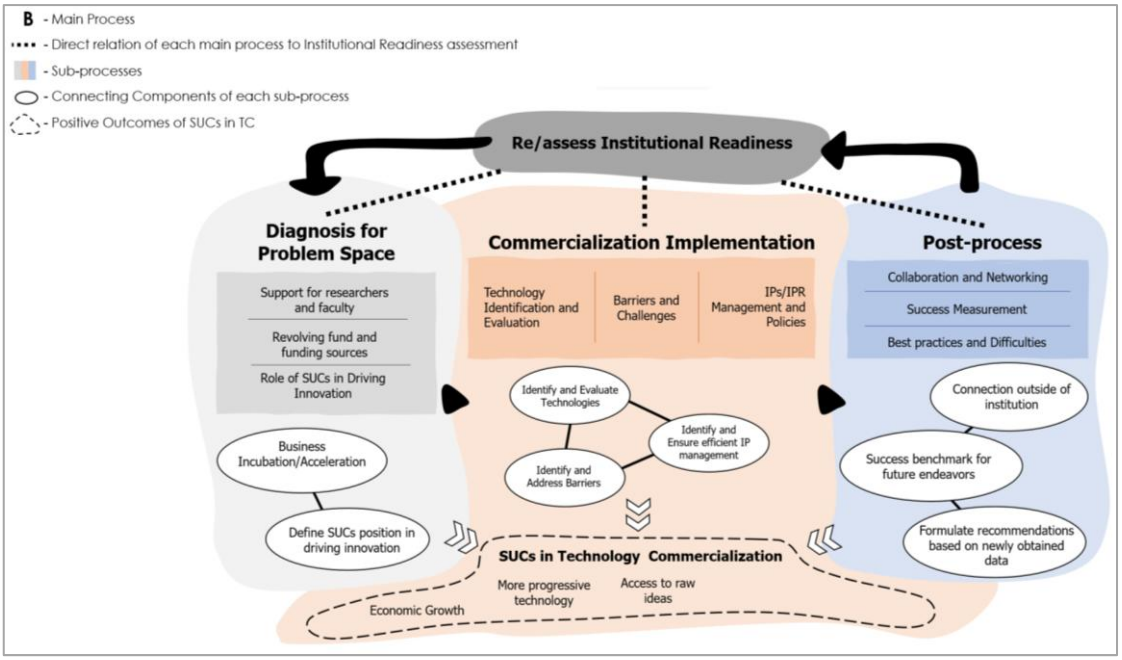

Figure 5. Framework in technology commercialization in SUC: interconnectedness of the factors

4. CONCLUSION

This study examined research utilization and technology commercialization practices in nine SUCs in the Bicol Region, focusing on institutional readiness, commercialization strategies and challenges, and success measurement mechanisms. In response to the first research objective, the findings show that institutional readiness for technology commercialization is generally strong, with 100% of SUCs having

dedicated offices or designated personnel for IP management and technology transfer. However, only 55.56% of respondents reported familiarity with technology commercialization concepts, indicating uneven institutional capacity. Addressing the second research objective, SUCs employ feasibility studies, marketability assessments, and IP protection in evaluating technologies. These processes were rated as moderately effective by 80% of respondents. Despite this, commercialization efforts are constrained by limited funding, weak industry linkages, policy gaps, and a limited entrepreneurial culture. Notably, only 22.22% of respondents reported mentorship from industry experts, highlighting a critical support gap. With respect to the third research objective, commercialization success is primarily measured through patents, licensing agreements, and revenue generation. Research dissemination remains dominated by publication (56%) and extension activities (33%), while commercialization accounts for only 11%, underscoring the underdeveloped third mission of SUCs.

These findings emphasize the significance of SUCs as drivers of regional innovation and economic development, while also highlighting the need to strengthen IP management, formalize technology transfer protocols, enhance collaboration and networking, invest in entrepreneurship programs, improve impact metrics, and establish sustainable revolving funds. This study is limited to nine SUCs within one region, relies on self-reported data, and uses a cross-sectional design, which may limit generalizability and temporal analysis. Future research may conduct comparative and longitudinal studies across regions or institution types and integrate in-depth case studies of successful spin-offs or licensing initiatives to refine best practices in academic technology commercialization.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce dispute and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
John Joshua Federis Montañez		✓	✓			✓			✓		✓	✓	✓	
Anna Liza Mendrique Mateo	✓	✓		✓		✓	✓	✓		✓	✓			✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [JJFM], upon reasonable request.

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BIOGRAPHIES OF AUTHORS

John Joshua Federis Montañez obtained his Bachelor of Science in Electronics Engineering at the Ateneo de Naga University cum laude. He completed his Master of Engineering at the Bicol State College of Applied Sciences and Technology (BISCAST), where he is also a faculty member in the College of Engineering's (CEng) Electronics Engineering Department. He is a student of the Straight Master's-Doctorate in Electronics Engineering at the Batangas State University, the National Engineering University. He is designated as the Director of Intellectual Property Management Office and CEng Research Coordinator. His research interests are electronics engineering, signal processing, computer vision, artificial intelligence, engineering education, and intellectual property. He is also a regular member of the Division VII (Engineering and Industrial Research Division) of the National Research Council of the Philippines. He can be contacted at email: jjfmontanez@astean.biscast.edu.ph.

Anna Liza Mendrique Mateo holds a BS in Business Administration major in Management (1992) from Ateneo de Naga University, a Master of Science in Resource Management major in Entrepreneurship (2014) from Central Bicol State University of Agriculture, and a Doctor of Business Administration from Ateneo de Naga University, supported by the K to 12 CHED Scholarship for Graduate Studies–Local. She spent nearly 16 years in the private sector, serving in various supervisory roles at RFM Corporation, a food and beverage company based in Mandaluyong City. She transitioned to academe in 2009 as a non-teaching staff member at BISCAST and joined the BS Entrepreneurship faculty in 2016. She currently serves as associate professor IV under the College of Business and Entrepreneurship. She is also an associate member of the National Research Council of the Philippines (NRCP) under Division VIII–Social Sciences. She can be contacted at email: almmateo@biscast.edu.ph.