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DEVELOPING EFFECTIVE R&D MODELS IN HIGHER EDUCATION – CRITERIA AND STRUCTURED APPROACHES

A HATÉKONY K+F MODELLEK KIDOLGOZÁSA A FELSŐOKTATÁSBAN – KRITÉRIUMOK ÉS STRUKTURÁLT MEGKÖZELÍTÉSEK

This study provides a comprehensive framework for analysing and developing research and development (R&D) models in higher education. Despite the evolution of R&D management practices, there remains a lack of clearly defined models that ensure long-term flexibility and effective management within rapidly changing environments. Drawing on existing literature, this paper proposes criteria and structured approaches for higher education institutions (HEIs) to manage and facilitate R&D activities. By focusing on key dimensions such as mission alignment, research strategy, innovation strategy, and intellectual capital management, this study aims to offer practical guidelines to enhance the competitiveness and societal impact of HEIs. The goal is to move beyond general recommendations and provide a detailed criteria checklist to guide the development of effective R&D models.

Keywords: **R&D model, higher education, framework development, innovation strategy, institutional competitiveness**

A tanulmány célja, hogy átfogó keretrendszert nyújtson a kutatás-fejlesztési (K+F) modellek elemzéséhez és fejlesztéséhez a felsőoktatásban. Annak ellenére, hogy a K+F menedzsmentgyakorlatok fejlődtek, továbbra sincsenek egyértelműen meghatározott modellek, amelyek biztosítják a hosszú távú rugalmasságot és a hatékony menedzsmentet a gyorsan változó környezetben. A rendelkezésre álló szakirodalomra támaszkodva ez a tanulmány olyan kritériumokat és strukturált megközelítéseket javasol, amelyek segítik a felsőoktatási intézményeket (HEI-k) a K+F tevékenységek irányításában és elősegítésében. A tanulmány olyan kulcsfontosságú dimenziókra összpontosít, mint a misszióval való összhang, a kutatási stratégia, az innovációs stratégia és a szellemi tőke menedzsmentje, célja pedig gyakorlati útmutatások nyújtása, amelyek növelhetik a HEI-k versenyképességét és társadalmi hatását. A cél az általános ajánlások túllépése és részletes kritériumlisták biztosítása a hatékony K+F modellek fejlesztésének irányítására.

Kulcsszavak: **K+F modell, felsőoktatás, keretrendszer-fejlesztés, innovációs stratégia, intézményi versenyképesség**

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As academic institutions evolve into innovation hubs, the importance of research and development (R&D) models in higher education has become increasingly prominent (Radović et al., 2023). Higher education institutions (HEIs) play an important role in driving the growing demand for groundbreaking research, technological innovation and economic development. An example is the Massachusetts Institute of Technology (MIT), which is renowned for its innovative R&D collaboration approach with industry and government, highlighting the significant effect of collaborative efforts in advancing real-world solutions (Khan et al., 2022). In this study, R&D models are theoretical constructs for organising R&D activities within HEIs, while R&D strategies refer to the actual methods and strategies used to implement these models. This study explores the structured frameworks used by HEIs to manage and promote R&D, including research management organisational structures and ecosystem models which illustrate the interactions and connections between HEIs and industry, government and the community. The main goal of this paper is to explore how these models can innovate and function collaboratively.

The nature of HEIs which combine knowledge creation with real-world applications highlights the dual task of universities in academic advancement and practical solutions (McDonnell-Naughton, 2022). The functions of creating new technologies, cultivating critical thinking and stimulating economic growth through innovation and entrepreneurship make HEIs key players in addressing global challenges (Stolze et al., 2022).

The OECD's Oslo Manual and Frascati Manual have provided important guidance for the global interpretation of R&D and innovation. The Frascati Manual was developed in 1963 and has been regularly updated (OECD, 1980, 1993, 2002, 2015). It standardises R&D statistics and emphasises the inclusion of humanities and social sciences (OECD, 2015). Since 1992, the Oslo Manual has expanded from technological innovation to broader organisational and marketing innovation, emphasising the role of the public sector (OECD, 2005, 2018). These manuals provide research and innovation strategies for HEIs. The Frascati Manual aligns R&D activities with international standards and strengthens global cooperation, while the Oslo Manual guides technology transfer offices to commercialise research through various channels.

Building on the foundational works of scholars such as Bushaway (2003), Connell (2005) and the OECD (2005), this paper acknowledges that university research frameworks and management strategies are well documented but finds an observable deficiency in the existing literature regarding the particular models which HEIs may adopt. This paper seeks to address this deficit by proposing a set of criteria and structured approaches which may be employed in the development and analysis of R&D models which are specifically tailored to the distinctive requirements of HEIs.

This review critically analyses Bushaway's (2003) insights on university research operations management and Connell's (2005) and the OECD's (2005) extensive assessments of university research management challenges and strategies, providing a solid foundation for elucidating the structure of higher education R&D. Despite these foundational contributions, this paper argues that the rapid changes in the global research landscape, coupled with new technological and interdisciplinary challenges, necessitate further development of existing R&D models.

Research questions

To achieve the goal of improving the adaptability and applicability of R&D in diverse higher education settings, this paper aims to draw practical insights and recommendations from the literature. The research questions of this paper are as follows:

1. What are the essential criteria for developing effective R&D models in higher education?
2. How can these criteria be applied to create structured frameworks for managing R&D activities in HEIs?
3. What practical guidelines can be derived from existing literature to assist HEIs in developing and implementing these frameworks?

These questions are intended to stimulate empirical research that tests the theoretical constructs proposed in this paper, thereby increasing our understanding and enhancing the implementation of R&D models in higher education.

Methodology

This study utilised a systematic literature review with bibliometric and thematic analysis. The SLR followed Petticrew and Roberts' (2006) methodology to find, assess and combine relevant studies on R&D models in higher education.

Table 1

The quality rules of the study

• **Inclusion Criteria:**	• **Exclusion Criteria:**
• Studies published in peer-reviewed journals. • Articles focused on R&D models in higher education. • Publications written in English. • Empirical research providing data on higher education R&D activities.	• Studies not related to higher education R&D. • Non-peer-reviewed articles. • Publications not written in English. • Duplicates and articles lacking empirical data.

Source: own compilation

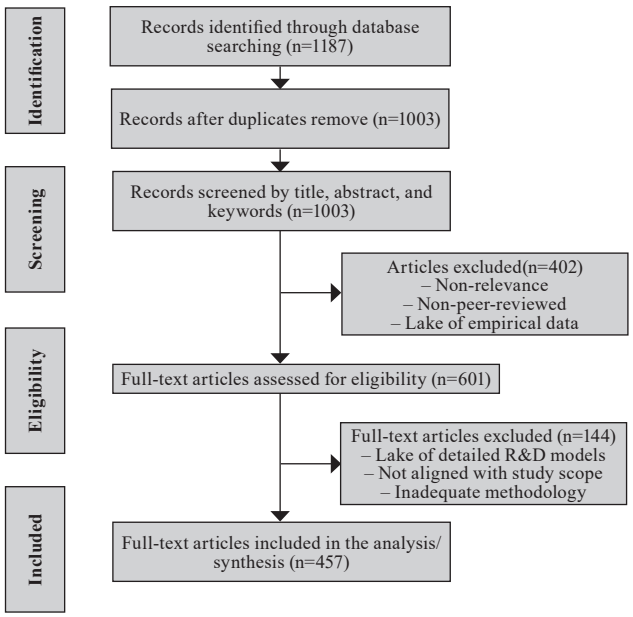
A literature search was conducted on major academic databases including JSTOR, Scopus and Web of Science. The search used keywords including 'R&D models of higher education', 'innovation in higher education institutions', 'technology transfer', 'innovation management', 'university-industry collaboration', 'intellectual property management in academia' and 'R&D models'. Additionally,

Vos Viewer (Van & Waltman, 2010) was used to create and show bibliometric networks. This facilitated exploring the relationships between key terms and themes in the literature. To ensure the studies in this review are relevant and of high quality, the following rules were followed (Table 1).

A systematic literature review (SLR) was conducted to identify relevant studies and included the steps shown in Figure 1.

Figure1

Screening Process and Filtering Criteria



Source: own compilation

This study employed a two-step coding process consisting of open coding and axial coding to systematically analyse the literature on R&D models in higher education. Each article was examined separately, focusing on the method, results and conclusions sections. Using the EFQM Facilitator Framework and the EUA Institutional Assessment Report Format, the relevant sections of each article were assessed and marked as either 'R&D Model (R&DM)' or 'Practical Suggestions (PS)' based on the established themes. During the open coding phase, key concepts were identified and sections labelled according to recurring themes, capturing a wide range of relevant insights without pre-imposing categories. Within the axial coding phase, these open codes were organised into broader categories, exploring relationships between themes and were grouped into higher-level constructs, such as 'innovation strategy' and 'research management'. These were later categorised under the broader concept of 'Effective R&D Models'. This approach ensured that the data were systematically coded and provided a clear framework for understanding key themes in the literature, which are summarised in Table 2 for further analysis.

This study does not promise to identify and compare multiple existing models. Instead, it provides a framework for developing such models. It examines key dimensions including mission alignment, research strategy, innovation strategy, intellectual capital management and so on. This helps institutions design and implement effective R&D models. This approach improves how R&D is managed and also ensures that R&D is aligned with the institution's overall mission and goals. This increases R&D's effect on academic excellence and societal development.

Research and development management in higher education institutions

Managing R&D in higher education is complex. Prior research reveals that effective evaluation is important. This includes calculating return on investment (Aziz & Tran, 2022), conducting performance evaluations (Jalaliyoon & Taherdoost, 2012) and monitoring through performance indicators (Tijssen, 2011).

A bibliometric analysis was conducted using VoSViewer to reveal the relationships between key terms.

Table 2

Key Themes and Findings Based on EFQM Enablers

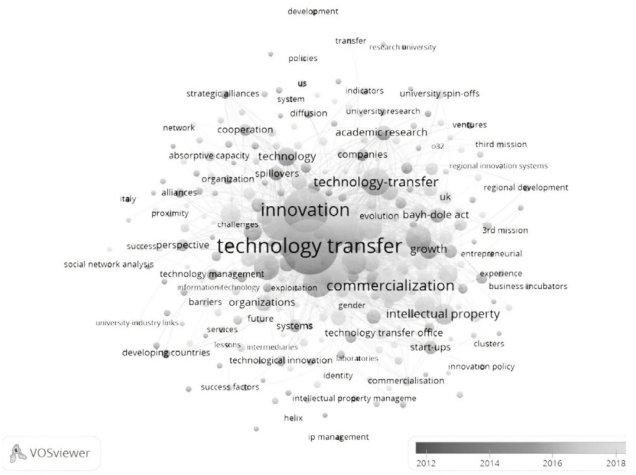
EFQM Enablers	Key Themes and Findings	Connection to University R&D
Leadership	Incorporation of sustainability into core values and objectives, along with active stakeholder engagement.	University Mission: Aligns sustainability and core values with the mission. Research Management: Coordinates research activities with institutional goals.
Strategy	Development of integrated quality systems, process integration, future stakeholder needs.	Research Strategy: Aligns research agenda with quality systems and stakeholder needs. Innovation Strategy: Integrates innovation into strategic objectives.
People	Policies for personnel management, fostering engagement and accountability and individual development plans.	Research Strategy: Ensures motivated and aligned researchers. Research Management: Enhances research efficiency and success.
Partnerships and Resources	Sustainable partnerships, resource efficiency, technology use.	Innovation Strategy: Drives innovation through partnerships. Research Funding: Secures and manages funding efficiently.
Processes, Products and Services	Process approach, measurement systems, stakeholder feedback.	Research Management: Ensures efficient management and continuous improvement. Research Funding: Monitors funding utilisation and accountability.

Source: own compilation

The keywords were selected to fit the research focus. The terms appeared in at least 10 publications from 2000 to 2023. This approach identified the main trends and points of discussion on R&D models.

Figure 2

Bibliographic map (WOS) in technology transfer field till 2023 - Keyword co-occurrence



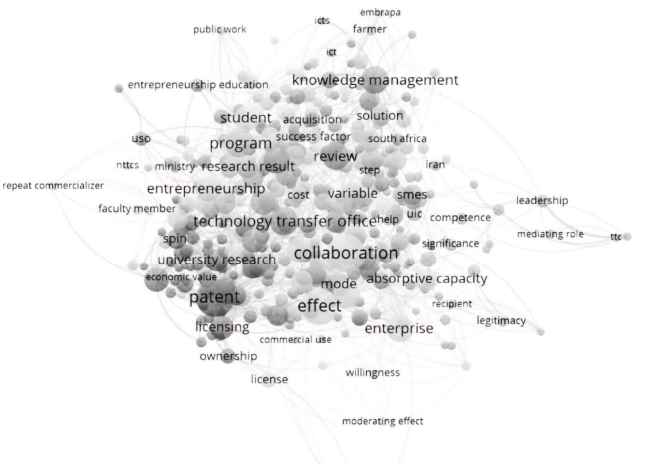
Source: own compilation

Figure 2 presents a comprehensive overview of the technology transfer process, encapsulating the broad spectrum of activities and interactions involved. The central nodes for 'technology transfer', 'innovation', 'commercialisation' and 'intellectual property' indicate these as foundational concepts in the field. Their proximity underscores the core process in HEIs, translating academic research into marketable products or services. Terms like 'technology transfer offices', 'start-ups' and 'intellectual property management' are shifting from blue to yellow, indicating their growing importance in recent discussions and the maturation of HEIs' infrastructure to support these activities. Nodes such as 'university-industry linkages', 'strategic alliances' and 'collaborations' emphasise the crucial role of academia-industry collaboration in effective technology transfer. Links with 'regional development' and 'regional innovation systems' highlight HEIs' contribution to socio-economic growth. The emergence of terms like 'gender' and 'developing countries' reflects the diversification of research, considering broader socio-economic factors and inclusiveness. Furthermore, it demonstrates that technology transfer in HEIs is not linear, but rather a multifaceted process influenced by many things, including policy, collaboration and the economic situation. It is also affected by new ideas and benefits associated with them, as well as partnerships with other organisations.

The university administrative system is important for ensuring research and management offices collaborate with other departments. Using information and communication technology can increase efficiency by making systems easier to use (Krishnaveni & Meenakumari, 2010). Successful R&D projects depend on cooperation and support from all stakeholders (Pinto & Slevin, 1989). Technology can make research and management activities more efficient but can also complicate them. The literature reveals that planning and evaluation are important (Łącka & Brzezicki, 2020; Qin & Du, 2018), but increasing R&D efficiency remains difficult. More research is needed on how HEIs manage their R&D. Examining factors such as the university mission, research strategy, innovation strategy and intellectual property management can help identify better ways of doing things. These studies demonstrate that structured management can improve R&D efficiency and effectiveness, helping to achieve institutional goals and better results.

Figure 3

Text map (WOS) in research and development in technology transfer in HEIs till 2023



Source: own compilation

Figure 3 shows the main topics related to technology transfer in HEIs. Terms like 'technology transfer', 'patent', 'spin' and 'licensing' are associated with legality and commercialisation. Patenting and licensing are part of technology transfer. Intellectual property is important in transferring research to industry. Clusters featuring 'entrepreneurship', 'spinouts' and 'university research' show how entrepreneurship can create economic value from academic research.

The term 'collaboration' is linked to 'enterprise', 'effect' and 'absorptive capacity'. It shows that partnerships between HEIs and businesses are important for effective technology transfer. References to 'students' and 'entrepreneurship education' show that HEIs can help create future innovators and entrepreneurs. The map shows regions like South Africa, which highlights the focus on regional contexts.

This analysis reveals that technology transfer in HEIs is complex and involves R&D, intellectual property (IP) management, entrepreneurship and collaboration. These factors, along with educational programmes, regional factors and entrepreneurial mindsets, are all important for successful technology transfer.

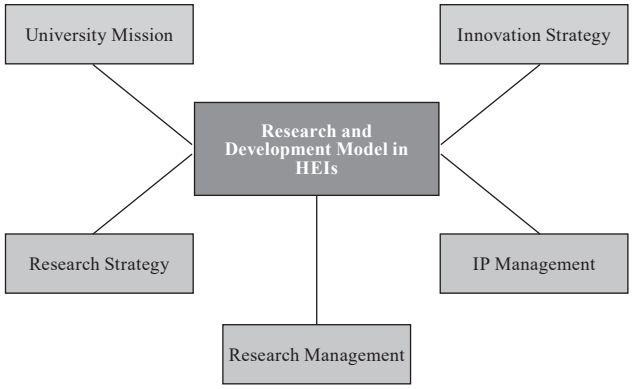
Synthesis of thematic analysis and visual representation

Figures 4–15 were created by reading and coding relevant literature, then analysing it thematically and using mind mapping. These figures show the main ideas and results, giving a complete picture of the changing R&D models in this paper.

In higher education, R&D is a key part of turning academic research into commercial products (Etzkowitz & Leydesdorff, 2000). This change from theory to practice requires a strong and complete system, as shown in Figure 4.

Figure 4

Research and Development Model in HEIs



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A university's mission statement outlines the institution's purpose and objectives. An institution's mission is linked to its R&D. Knowing a university's goals helps to plan academic work and achieve social benefits. Their mission guides all other activities, ensuring they fit with the wider institutional ethos (Clark, 1998; Rana et al., 2022).

The research strategy is based on the university's mission and plans how to improve research and development. It helps determine how to utilise resources, select research topics and work with other groups inside and outside the university. This means that the R&D efforts are in line with the university's overall goals and can have a significant effect (Geuna & Muscio, 2009; Rasli et al., 2022).

Innovation strategy in HEIs must incorporate how research can be used to create new solutions. This means identifying ways to use research to create new products or services and ensuring these ideas are put into practice (Solievich, 2022).

Effective research management involves controlling budgets, managing staff and sharing technology. Good management is key to using resources well and moving research into practice (Namara, 2023).

Management of intellectual property is a valuable asset for HEIs. It is often created through R&D. Institutions must have good policies to protect and manage their intellectual property. This helps them benefit from their work while respecting the rights of the researchers involved (Siegel et al., 2003, Ravi & Janodia, 2022).

For HEIs, the journey from research to impact is complex. It requires a coordinated strategy which aligns with the institution's mission and considers all aspects.

University mission

A university mission incorporates the changing values of a university by exploring the underlying mechanisms of the university's social influence (Carl & Menter, 2021). A sound university mission enables the development of a research strategy which focuses on the institution's mission and its overall goals. It also encourages the development of innovative strategies to help remain competitive in a rapidly changing world.

Research and education have always been the two main tasks of HEIs. However, higher education has been given a third mission. This so-called 'third mission' is transforming the academic value of HEIs into the value of actively contributing to society (Zomer & Benneworth, 2011). The 'third mission' thus refers to the social, entrepreneurial and innovative activities which universities undertake in addition to their educational and research activities, which aims to transfer knowledge and technology from academic institutions to society in order to solve real-world problems. While the process of commercialising technology transfer can be income-generating and potentially very lucrative, the resulting start-ups, spin-offs, incubators, etc., can further support technology transfer and thus enhance an HEI's reputation. While the benefits of commercialisation can be a great incentive for both stakeholders and technology owners, the aim of pursuing a 'third mission' is to make a valuable contribution to society (Mars & Burd, 2013; Tien et al., 2022). Technology transfer centres help experts, inventors, staff and students in HEIs to create and develop ideas for technology transfer. As a result, there is a growing consensus to increase the social value of technology transfer.

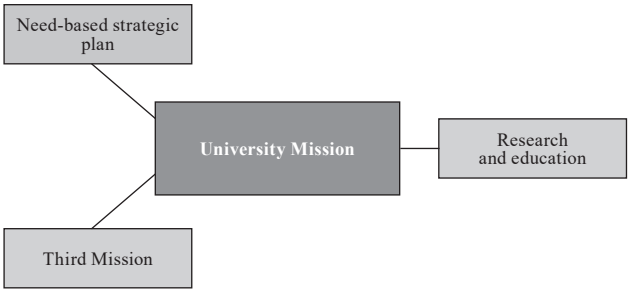
The definition of 'third mission' (TM) is also guided by references to S3 strategies of Europe 2020, which aims to promote smart, sustainable and inclusive growth in Europe and its regions. Despite widespread recognition by universities, governments, industry and society that TM is increasingly important, the concept of TM remains ambiguous. Indeed, it has been defined in various ways, covering a wide range of models, dimensions, functions and activities, all of which have led to extensive debate among scholars and policy makers. There is no doubt that the growing body of research and interest in TM is reflected in the increasing government pressure on universities to add TMs to their programme syllabuses, labelled 'contribution to society' (Compagnucci & Spigarelli, 2020).

Thus, the mission of universities has changed from maintaining their two major tasks of education and research to also contributing to society. Within this process, technology transfer or knowledge transfer has played an important role. Universities must maintain continuous innovation and output in order to continuously contribute more technology and knowledge to society. Before universities plan how to better contribute to society, they must

have a needs-based strategic plan. This means committing to funding, human resources, research capabilities and partnerships (Tumwebaze Alicon, 2022), as shown in the Figure 5.

Figure 5

Research and Development Model – University Mission



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Research strategy

A research strategy is the foundational step in effective research management. It should identify key research themes which align with the institution's mission and the broader national and global higher education landscape. This strategy should i) outline the policy environment, ii) include a SWOT analysis to identify strengths, weaknesses, opportunities and threats, and iii) establish clear priorities and objectives. While this process was traditionally informal, it is now recognised as a crucial element of good governance and management (Mittelmeier & Yang, 2022).

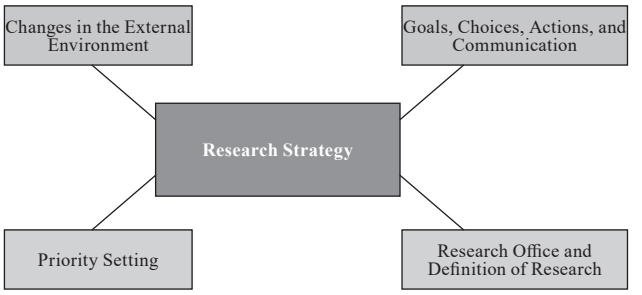
A research office plays a central role in this increasingly professionalised approach to research management, offering support to researchers and performing audit functions for both its institution and government agencies. A technology transfer office (TTO), often a newer and separate unit, is typically responsible for the commercialisation of intellectual property, including patents, licensing and company formation. This paper contends that integrating the TTO with the research office would better align research efforts with external demands, enhancing the overall impact and relevance of research activities.

Changes in the external environment, such as policy, support the transformation of university research from personal pursuits to academic careers requiring management. With research management and research offices playing an important role, it is increasingly important how a university defines its research strategy, sets priorities, and responds to emerging challenges (Hazelkorn & Herlitschka, 2010).

The reasons for developing research strategies vary between universities, but also have commonalities, such as external pressures, increased competition and budget cuts, and a desire for quality. Thus, there is a need for a more coherent approach and institutional support for dialogue with external partners. The increasing differentiation of sciences also creates a need to increase opportunities for interdisciplinary research. Likewise, traditionally organised universities struggle to meet the 'grand challenges' of modern society. Goals, choices, actions and communication are intermingled in the strategic plans of European universities (Gunnarsson, 2012) as shown in Figure 6.

Figure 6

Research and Development Model – Research Strategy



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Innovation strategy

Schumpeter (1934) defined innovation as launching a new product or service, using new methods, opening a new market, or creating or destroying a monopoly organisation. He referred to innovation as new combination of thins or operations. Innovation is both a process (Thompson, 1965) and an outcome (Barnett, 1953), encompassing new ideas, technology or practices (Van De Ven, 1986)).

An innovation strategy is an essential part of any organisation looking to drive innovation and achieve long-term success. By outlining the goals and priorities of an organisation's innovation activities, an innovation strategy helps the organization focus its efforts and resources to achieve those goals (Gulamov et al., 2022). One of the primary benefits of an innovation strategy is that it promotes alignment within an organisation. With a clear plan in place, different departments and teams can work together to achieve common goals rather than pursue individual priorities, this is about communication and collaboration in the organisation. This alignment helps maximise the effects of an organisation's innovation efforts and can lead to better results. Another important benefit of an innovation strategy is that it prevents organisations from becoming complacent. As new technologies and competitors continue to enter the market, organisations must stay ahead of their competitors and innovate. By directing an organisation's innovation efforts toward its goals, an innovation strategy can help ensure that an organisation remains competitive, maintains its position and continues to drive long-term growth and success (Mohamed Hashim et al., 2022).

The specific approach to innovation in higher education will depend on the mission, goals and needs of the individual university. Nevertheless, a university's innovation strategy may typically encompass the following elements:

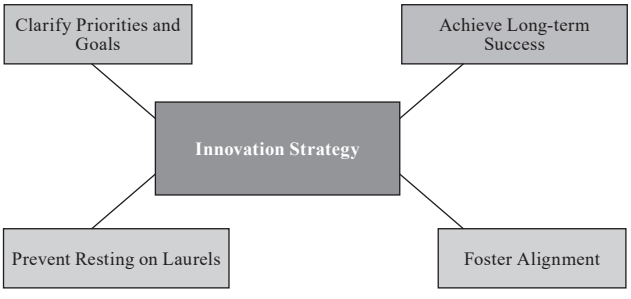
- The fostering of interdisciplinary collaboration between faculty, students and researchers is a key strategy for driving innovation and promoting creative thinking (Bromham et al., 2016).
- The formation of new collaborative relationships with businesses and organisations represents a core objective, with the aim of accelerating the transition of research and innovation from the laboratory to the market (Ankrah et al., 2015).
- To drive innovation in the university's focus areas, investment must be made in R&D initiatives (Bozeman et al., 2013).
- The provision of support for commercialisation and entrepreneurship initiatives for students, faculty and researchers (Hayter et al., 2017) represents a key objective.
- The cultivation of an environment conducive to innovation and creativity within the university community (Jackson, 2011).

While the specific concerns and core issues of a university's innovation strategy may vary, some common concerns include the following:

- Guaranteeing that innovation activities are aligned with the university's mission and objectives is of the utmost importance (Cantwell & Kauppinen, 2014).
- The attraction and retention of top talent is of paramount importance for the advancement of innovation within the university (Franzoni et al., 2012).
- The securing of funding and resources for innovation initiatives is a further key issue (Geuna & Muscio, 2009).
- The promotion of collaboration and partnerships between academia, business and government is recommended to enhance the impact of innovation activities (Perkmann et al., 2013).
- The construction of a framework for commercialising and transferring innovations to the market is advised (Siegel & Wright, 2015).
- These elements and concerns are intended to provide a general overview and may vary considerably depending on the specific needs and goals of a university, as illustrated in Figure 7.

Figure 7

Research and Development Model – Innovation Strategy



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This framework helps universities identify and focus on the most important factors involved in creating a good environment for innovation. Each part of the checklist involves a different aspect of the university's innovation system, from working with different subjects to acquiring the funding and resources needed.

The alignment of these strategic elements with the broader goals of a university's innovation strategy is inextricably linked to the institution's mission and objectives. For example, the promotion of interdisciplinary collaboration (Bromham et al., 2016) is designed to eliminate internal barriers within a university, thereby facilitating the generation of new ideas and applications. Moreover, the establishment of collaborative relationships with industry partners (Ankrah et al., 2015) and a focus on the commercialisation of academic research (Hayter et al., 2017; Siegel & Wright, 2015) are crucial for the transformation of academic insights into marketable innovations. These initiatives not only advance the university's mission but also significantly contribute to the broader economic development of a region.

Research management

Mico University (2019) defines research management as the coordination and optimisation of research activities and outcomes in research-focused organisations. It operates between the professional and academic domains to maximise research impacts by integrating the efforts of diverse constituencies. This requires support functions at distinct phases of the research process, including funding, proposal assistance, research execution and impact assessment (OECD, 2005).

Effective communication and the optimal tools and processes are key to successful research management. Research management is not the job of one person or institution. The approach must involve different people at different levels of the research system. Those involved include researchers, funding organisations, research institutions and government agencies (Mico University, 2019). A clear structure in research management is important for getting everyone involved and working together to optimise research.

To produce high-quality, impactful research, institutions frequently focus their efforts on monitoring their research capacity. This entails assessing the capabilities, expertise and infrastructure present within an institution to ensure that the available resources are aligned with the research goals. Such monitoring facilitates the identification of areas of strength and enables the determination of where further investment or development may be required (Hicks, 2012).

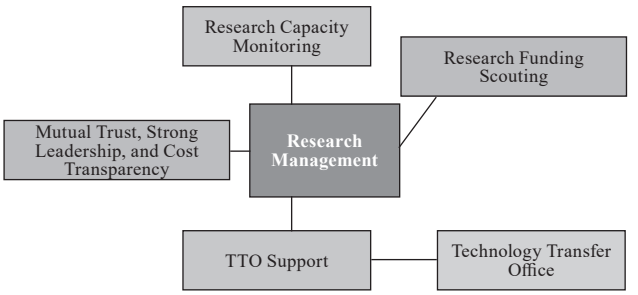
Securing research funding is important. Because research grants are competitive and funding is important for research, institutions seek funding opportunities. This means understanding new research trends, matching strengths with funding priorities and knowing about traditional and new funding sources (Geuna & Nesta, 2006).

An effective research management strategy requires support from TTOs. These help ensure that new ideas from research labs are used in the real world. They also help protect intellectual property, develop commercialisation strategies and form industry partnerships, making it easier to turn research into useful products (Siegel et al., 2004).

Effective research management hinges on three key factors: mutual trust, robust leadership and cost transparency. By fostering trust, research environments can be created which encourage collaboration and ensure all stakeholders work together toward common goals. Strong leadership provides direction, motivation and clarity, guiding research activities towards meaningful outcomes. Transparency, especially regarding costs, ensures accountability and efficient resource allocation, which are vital in the often resource-constrained research landscape. Effective oversight requires a balance of capacity monitoring, proactive funding strategies, efficient technology transfer mechanisms, and a foundation of trust, leadership and transparency. Figure 8 illustrates this complex landscape and the interconnected elements that are essential for successful research management.

Figure 8

Research and Development Model – Research Management



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Research funding

The allocation of financial resources to research is a crucial aspect of the operations of a university. It enables the institution to engage in novel research endeavours and contribute to the advancement of society. The manner in which a university is regulated influences the avenues through which it can obtain research funding and enhance its operational efficiency. To illustrate, if universities can access data and information with ease and apply for funding in promptly, they are better positioned to utilise their resources in more efficacious manners and pursue new projects in more expedient ways. Colleges and universities frequently undergo operational changes when they receive external funding and endeavour to enhance their efficiency. It is imperative that higher education systems are efficient. It is also possible for universities to collaborate in order to reduce expenditures. Generally, universities concentrate their efforts on optimising processes, enhancing pedagogical practices and developing their workforce to enhance efficiency and provide greater value for money.

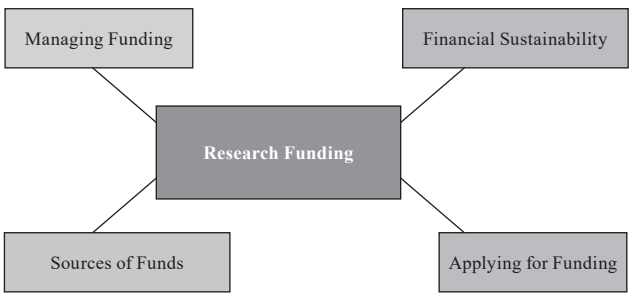
The extent to which a university is decentralised has a significant effect on its ability to operate effectively and secure funding for research. Universities which are afforded greater autonomy in decision-making are better positioned to respond to the needs and opportunities of their respective communities, and to utilise resources in a more efficacious manner. Centralised universities may encounter difficulties in adapting to novel environments and responding to emerging research demands.

Collaboration is also a crucial factor in securing research funding and enhancing efficiency. This can be achieved through utilising government funding, which encourages institutions to either collaborate or compete with one another. For such collaborations to be effective, they must be founded upon trust, strong leadership, transparency and open communication.

The securing of research funding and the enhancement of efficiency also necessitates cost transparency and the implementation of evidence-based decision-making processes. This may entail the allocation of funding in accordance with research outcomes, as well as more effective methods for monitoring and documenting research expenditure. By focusing on these pivotal elements, academic institutions can optimise the management of their resources, facilitate the undertaking of novel research initiatives and drive meaningful advancement. The process of obtaining and managing research funds is inherently complex and is shown in Figure 9.

Figure 9

Research and Development Model – Research Funding



Source: own compilation

This section explains where research funding can be obtained. Many studies have examined where research funding originates. These include government agencies, non-government organisations, private companies and charities (Hottenrott & Lawson, 2017). Additionally, there has also been greater focus on international funding, where countries work together to fund projects which interest them (Wagner et al., 2019).

Applying for research funding is competitive and complex. Research proposals must meet the funding body's objectives, show impact and use a sound methodology. Additionally, research is often interdisciplinary, so pro-

posals should be accessible to a wide audience (Bozeman & Boardman, 2014).

Once funding is acquired, it must be managed well. This means that finances must be managed openly, with regular reports and funds used for their intended purposes. Prior research has shown that research funding should be managed more efficiently and with fewer administrative costs (Hicks, 2012).

Ensuring research projects are financially sustainable has become more important. Laudel & Gläser (2014) examined the challenges researchers face in acquiring funding. They stated that it is important to get funding from different sources, to use funds from research to fund additional research, and to build strong networks to ensure funds are always available.

IP management

Managing intellectual property is important for innovation. It helps protect and generate income from R&D. An IP policy helps researchers, innovators and institutions manage and protect their intellectual property. Teixeira and Ferreira (2019) stated that the best-performing institutions have good IP management systems. How many and what quality and quantity of intellectual property rights does an organisation have? This is an important indicator of how well they innovate and compete. Intellectual property rights are important in the global economy and affect society as a whole (Grimaldi et al., 2021).

IP management helps research, development and innovation and involves ensuring that research projects are optimally conducted. The following are parts of managing IP: These elements include IP policies, IP scouting, IP protection, IP valorisation and training tools. The most successful institutions have good IP management. The quantity and quality of IP rights reveal how well an organisation is doing in terms of innovation and competition (Teixeira & Ferreira, 2019). In this period of economic globalisation, IP has increasingly become the core element of strategic resource utilisation and have a strong influence and effect on society at large.

The detailed focus on IP management within the R&D framework of HEIs is intentional, reflecting its critical role in safeguarding and commercialising research findings. The emphasis is due to the increasing importance of IP in a globalised academic environment where effective IP management is pivotal for fostering innovation and ensuring competitive advantages. To provide a balanced perspective, additional sub-chapters detail specific aspects of IP management.

All HEIs are concerned with the creation and dissemination of knowledge. The challenge for university IP managers, policy makers and heads of academic departments is to discern the value of such knowledge and develop policies that best realise its value. Once an institution has determined its overall business model, it must structure an IP policy that complements that model and delivers maximum benefits, then implement it appropriately across its disciplinary portfolio.

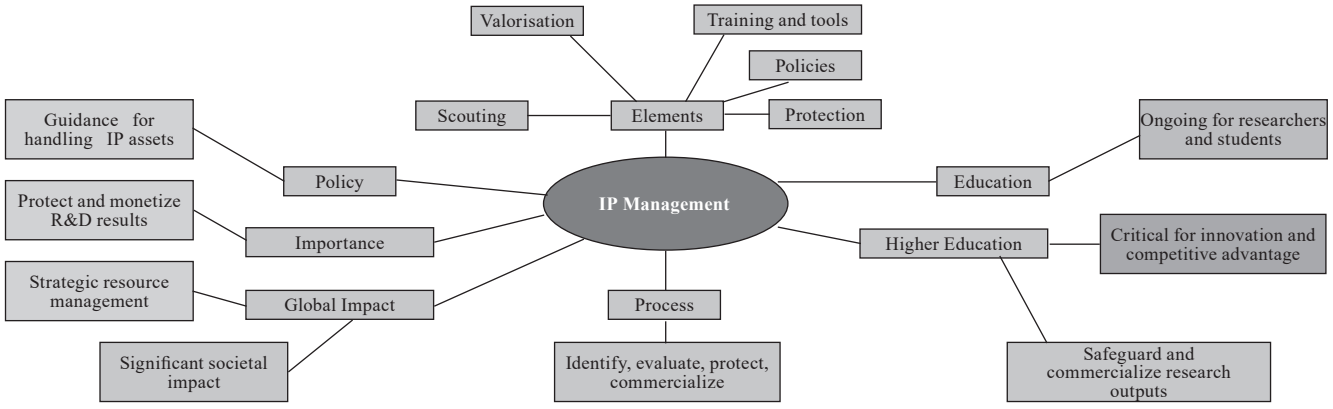
IP management in HEIs is a nuanced process which ensures the protection and optimal utilisation of research outputs. Prior researches (Siegel & Wright, 2015; Perkmann et al., 2021, Mohamed Hashim et al., 2022) emphasised a series of interconnected stages which HEIs undertake for effective IP management. First, the institution identifies potential IP from research outputs. Once identified, the IP undergoes a thorough evaluation for its commercial or societal potential. If deemed viable, the institution then proceeds to protect the IP, typically through patents, copyrights or trademarks. With protection in place, the HEI can then strategies on commercialisation or licensing opportunities, often in partnership with industry or through TTOs. Throughout this process, ongoing IP education for researchers and students is crucial to ensure the sustained creation and protection of valuable IP. This process is illustrated in Figure 10.

Policies

Technology-driven innovation dominates all areas of society, especially human life, and creates a business economy based on ‘knowledge generation’. IP is an intangible

Figure 10

Research and Development Model – IP Management



Source: own compilation

asset of HEIs and is often more valuable than any tangible asset. Additionally, IP policies are high-level principles, guidelines and rules associated with the mentioned fields. Trommetter (2008) mentioned that universities should be aware of the identification, protection, management, use and benefits associated with IP rights and formulate corresponding policies to guide operational behaviour. The core purpose of an IP policy is to provide a framework to declare and protect the rights of universities and university staff (Rooksby, 2020). Another goal to provide guidelines for industry, government and other communities to make use of universities' IP for national and global interests (Holgersson & Santen, 2018). Therefore, promoting the transfer of technology produced by universities fosters university innovation and creativity, as well as local and national economic growth. Based on the continuous development of technological explosions, 'knowledge assets', various institutions and stakeholders have become the triggers of IP policy formulation (Busch, 2023).

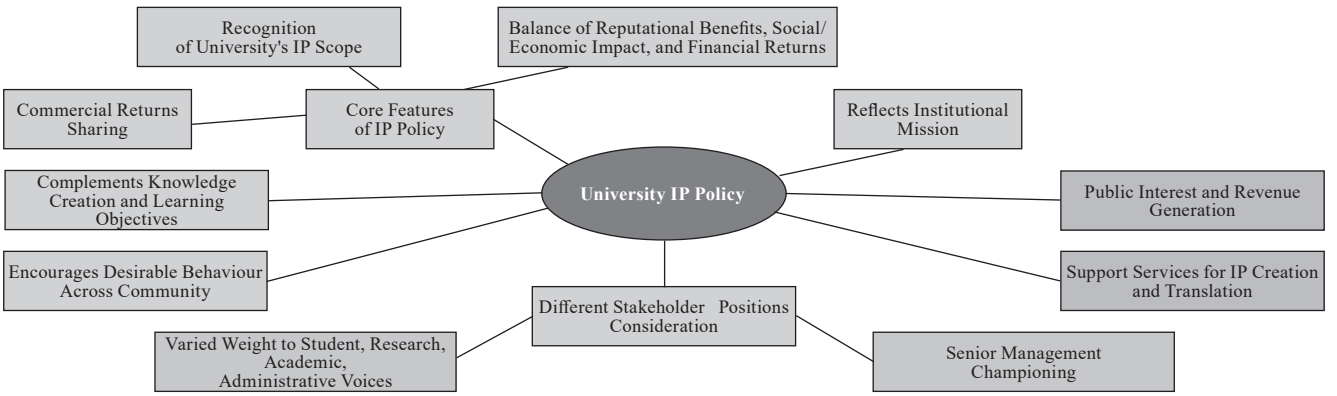
important for senior management to champion a policy to give it the respect it warrants, different institutions may give varying weights to the voices of the student, research, academic or administrative communities in their policies, again suggesting a 'one size fits all' method does not apply. When developing a set of policies, the agency must ensure that it encourages desirable behaviour in every part of its community (Figure 11).

Patenting

Many universities' research results remain a long way from the market. This is often the case with university-patented technologies. Universities must assess how close any IP is to the market and develop appropriate strategies. For example, cold selling a research opportunity to a business can be challenging. However, the benefit of patented technologies is that they effectively express research results in the form of products which can be commercial-

Figure 11

Research and Development Model – IP policies



Source: own compilation

A university IP policy should reflect the mission of the institution. IP policies must complement the core objectives of knowledge creation, scholarship and learning. It is the institution's responsibility to develop policies and support services which create the best possible environment for the creation of IP and its transformation into practical use, but in a manner which is in the public interest and that generates revenue for the originating institution, students and researchers. The core features of an IP policy should be:

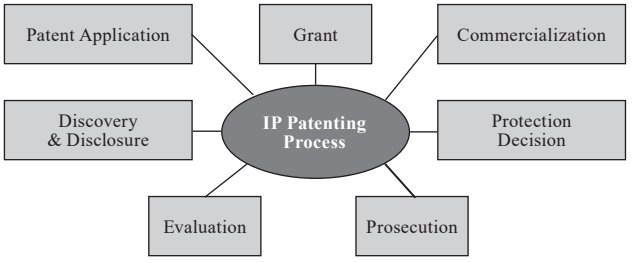
- Arrangements to share any commercial returns from the commercialisation of IP, thereby providing appropriate benefits to the IP originator.
- Recognition of the scope of the university's IP activities; and
- Balancing reputational benefits, positive social and economic impacts, and financial returns from IP-related work.

Those drafting IP policies should ensure it reflects the positions of various stakeholders in academia. While it is

ised. Alternatively, they can enable universities to express complex scientific activities in a language which companies can understand. This then creates an avenue to open a dialogue with companies, which could lead to companies investing in research relationships through licensing deals as part of an overall deal. However, universities should view their IP strategy as part of their research strategy rather than as a revenue strategy.

Figure 12

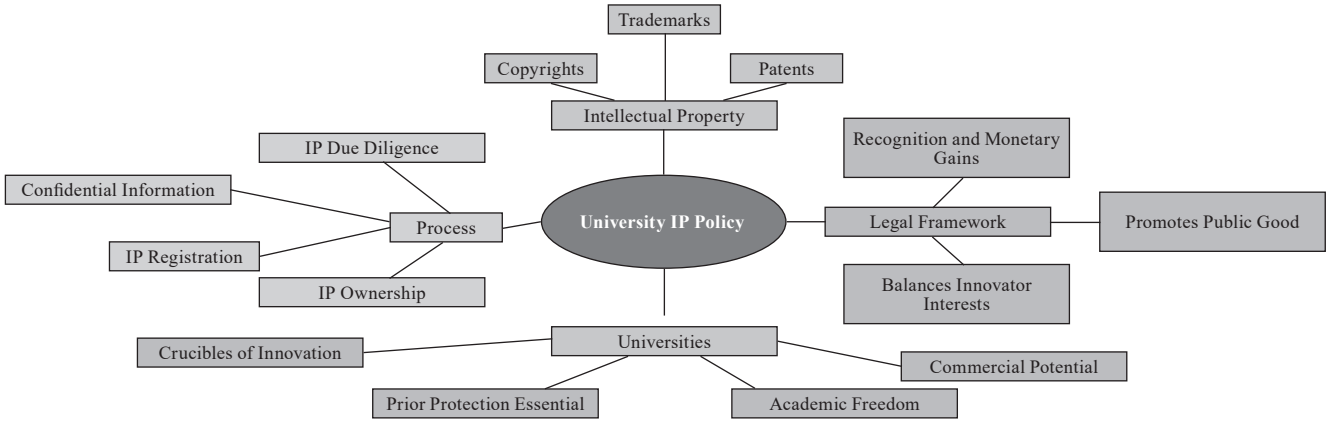
Research and Development Model – Patenting



Source: own compilation

Figure 13

Research and Development Model – IP Protection



Source: own compilation

The patenting process for university research results generally involves a sequence of actions, beginning with the discovery of potentially patentable research results and eventual reaching the protection of its IP. Drawing from literatures, the process can be summarised as follows:

- *Discovery & Disclosure:* Researchers realise they have potentially patentable results and disclose these to the university's TTO or equivalent body (Conti et al., 2013).
- *Evaluation:* The TTO assesses the patentability of the discovery and its potential commercial value (Soranzo et al., 2017).
- *Protection Decision*: If the invention is deemed patentable and has potential value, a decision to proceed with the patenting process is made (Siegel et al., 2015).
- *Patent Application*: The TTO, often with the help of external patent attorneys, drafts and submits a patent application to the patent office (Grimaldi et al., 2015).
- *Prosecution*: This step involves correspondence with the patent office to clarify, adjust or defend the patent claims (Knight, 2013).
- *Grant:* If successful, the patent application results in a granted patent, giving the university rights to the invention for a set period, usually 20 years (Tahmooresnejad & Beaudry, 2018).
- *Commercialisation:* The university, often through the TTO, seeks to commercialise the patent, either through licensing agreements, creating spin-off companies, or other avenues (Perkmann et al., 2013) (Figure 12).

Protection

IP, an amalgamation of patents, copyrights and trademarks, provides creators and inventors with legal avenues to earn recognition or income. This legal framework balances the innovator's interests against the larger public good, creating a conducive environment for creativity and innovation to thrive. Given the intangible nature of these assets, it is imperative they receive protection akin to tangible assets (Lemley, 2015).

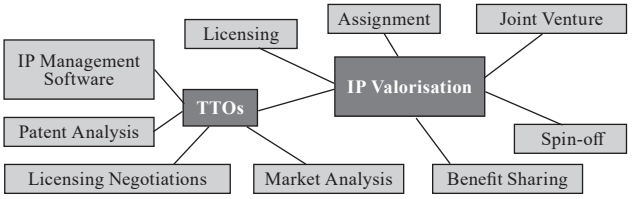
Universities, as crucibles of innovation, recognise the value of IP protection. While academic freedom to publish remains paramount, there is an understanding that prior protection of IP related to research is essential before any publication, especially if there is potential commercial utility (Conti et al., 2013)

The process of IP protection is multifaceted and can be delineated into the following processes: IP due diligence, IP ownership, confidential information, IP registration (Figure 13).

Valorisation

IP valorisation refers to the process of converting the results of R&D into commercial assets or societal value. The goal of IP valorisation is to ensure that the results of the research are not just published in academic journals, but also put to practical use for the benefit of society (Siegel et al., 2003). There are several ways to valorise IP, including licensing, assignments, spin-offs, joint ventures, etc. Licensing involves when a third party uses IP in exchange for a fee. Assignment is the giving of the IP to another entity. A spin-off is a new company based on the IP. A joint venture is a partnership to develop and sell the IP. IP ownership and incentives vary by country. Some countries let universities own the IP created by their researchers. In others, the researchers retain ownership. Some countries offer tax incentives or other financial incentives to companies which invest in R&D. The term 'benefit sharing' refers to the distribution of advantages derived from IP. There are three principal models for the distribution of benefits: profit sharing, royalty-based models and equity-based models. The principles of benefit sharing are fairness, transparency and inclusiveness.

Figure 14
Research and Development Model – IP Valorisation



Source: own compilation

IP can be valued in publicly and privately funded research projects. In cases of publicly funded research, a funding agency retains ownership of the IP and seeks to generate revenue from it. In cases of privately funded research, the company providing the funding will own the IP. TTOs provide researchers with assistance in the commercialisation of their innovations. They also facilitate connections between researchers and industry partners, licensing partners and investors. TTOs assist in the creation and negotiation of agreements pertaining to the protection and utilisation of IP. The IP valorisation process involves numerous individuals, including researchers, TTOs, industry partners, licensing partners, investors and legal advisors. Tools employed in IP valorisation include market analysis, patent analysis, licensing negotiations and software for managing IP. These tools assist in determining the optimal means of generating revenue from IP (Figure 14).

Discussion

This research demonstrates how technology transfer operates within the context of higher education and how it facilitates the development of novel ideas and societal advancement. This discussion focuses on how university research, innovation policies and IP management contribute to technology transfer.

It is essential that the missions of universities and the goals of technology transfer are aligned. HEIs must demonstrate their commitment to technology transfer, as this informs the decision-making process regarding research focuses. A university's innovation strategy must support the discovery, protection and commercialisation of its IP.

TTOs provide invaluable assistance in navigating the intricate landscape of IP management. TTOs facilitate the commercialisation of innovations by researchers and play a pivotal role in facilitating technology transfer. Currently, the role of these entities is undergoing a transformation. Their role extends beyond the mere protection of IP, as they facilitate the development of entrepreneurial initiatives and the formation of industry partnerships.

The processes of commercialisation and IP management present significant challenges. The process of commercialising research findings is fraught with difficulty. It is incumbent upon HEIs to develop more efficacious IP management methods which are tailored to the specific needs of diverse individuals. To optimise the commercial potential of research findings, it is also essential to consider various IP valorisation strategies, including licensing, spin-offs and joint ventures. Yet, academic freedom and commercial interests must be balanced. Thus, the traditional way of sharing knowledge must be balanced with the need to generate income from technology. This balance ensures that HEIs can continue doing their primary work of teaching and research. IP protection must be managed to protect academic freedom and make research results available for commercial use.

While IP is a way to sell and apply research, it does not cover all possible results. If we focus solely on traditional commercial outputs like patents and licensing, other ways to use research might be missed. For example, new companies or startups could be created from basic research.

Basic research is the foundation of practical applications. Neglecting this type of research is a big mistake. The Pfizer SARS-CoV-2 vaccine is an example of this. It was developed from research into mRNA technology, which is basic research which only became useful during the COVID-19 pandemic. Therefore, it is essential to advocate for an integrated approach within academic discourse—one which recognises the continuum from basic to applied research. This approach helps different research activities work together, potentially leading to new ideas which can be used in the real world. If universities encourage both basic and applied research, they can commercialise research more easily and demonstrate the value of various types of research. This strategy helps academic institutions contribute to society and economies, and aligns with their broader missions and objectives. By embracing this perspective in our models and planning, this study examines research commercialisation in a broader way and fosters a more vibrant and impactful innovation ecosystem.

Technology transfer should be fair and inclusive. There is a growing focus on inclusivity, including gender and socio-economic factors, so any technology transfer strategy must also be inclusive. This ensures that innovation benefits everyone and helps society as a whole.

Further research should examine how working across different subjects helps technology transfer and the effect of technology transfer on local development and innovation. Additionally, studies examining how well different IP strategies work could help improve the models discussed. Furthermore, the present analysis and review demonstrate that technology transfer is not a simple process; it is a strategic, integrated endeavour. Its success depends on matching university goals with innovation plans, giving TTOs more power and treating all staff fairly when managing IP.

Conclusion

This paper has suggested a way to improve R&D in higher education. The map describes five areas: university mission, research strategy, innovation strategy, research management and IP management. This map also demonstrates how these areas help HEIs achieve their goals.

Technology transfer is important for society and innovation. TTOs manage IP and commercialise academic research. However, it is difficult to balance commercial and academic values. Therefore, HEIs must adapt their strategies to address new technologies and varying interests.

This study demonstrates that we must test these models using real data. Future research should assess how well these frameworks work in different institutions. Comparative studies of these models in different educational systems would help adapt R&D strategies to suit different institutions and make them more widely applicable. This approach will make R&D management in HEIs more relevant, ensuring that they continue to use academic research to benefit society.

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