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Effective model of technological innovation process (EMTIP) for knowledge protection in a university

Abstract

The aim of this research is to propose an effective model for the process of technological innovation and knowledge protection in a university in Peru. To accomplish this, a quantitative applied and descriptive approach was employed within the positivist paradigm. An instrument was utilized to assess 342 publications from the UNU (Universidad Nacional de Ucayali) repository between 2021 and 2022. The research consisted of two specific steps: Step 1: Identification of patentable materials through workshops involving individuals associated with the inventions in their respective technological fields. Step 2: Definition of a process of technological innovation and knowledge protection through the EMTIP model. This model is the outcome of a flexible and adaptive methodology that takes into consideration technological surveillance, demand behavior and needs, and the search for the necessary resources to materialize innovation as a finite fulfillment of its demand. All of this is done under a concurrent feedback system. The EMTIP model represents the seventh generational model for knowledge protection and the process of technological innovation in a university.

Keywords: knowledge management, scientific innovation, intellectual property

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Introduction

Since 1970, the world has been experiencing technological advancements in computing, robotics, and communications, transforming human life and promoting information interoperability, thus facilitating the democratization of information in a rational manner.[1] In other words, the only constant is change.[2] To define organizational processes, it is essential to ensure efficiency and effectiveness in the management of intellectual property.[3] Patents hold significant importance, especially in the context of the Covid-19 pandemic, particularly in the healthcare sector.[4] Patents serve as important evidence to measure utility and represent a real measure of a nation's innovative capacity.[5] Similarly, innovation is the conception and implementation of significant changes in processes, products, marketing, or organization within a company, with the aim of improving results.[6] In 2021, twenty-nine (29) public and private universities submitted patent applications to INDECOPI, with Universidad Privada del Norte having the highest number of inventions (48 applications). Between 1990 and 2021, fifty (50) public and private universities submitted patent applications to INDECOPI, with Universidad Nacional de Ingeniería having submitted 197 applications. Universidad Nacional de Ucayali has submitted two patents during the 1990-2021 periods, one granted and another one pending, ranking 37th in the list of universities with total patent applications submitted during this period.

Small and Medium Enterprises (SMEs) have a significant impact on the economy and the country's development, resulting in job creation, consumption, savings, and investment.[7] However, innovation does not happen on its own; it requires financial resources and the integration of science and technology through the introduction of new products (goods and/or services) into the market.[8] By analyzing the performance of Information and Communication Technologies (ICT) and intellectual property management, it is evident that the knowledge generated in these institutions transforms into innovation as it becomes available to society through alliances between ICT and the business sector.[9] There are several models that establish the sequence of the innovation process for organizations, proposed based on the paradigms of their authors, such as: a) London Business School Model, b) Network Model, c) Integrated Model, d) Interactive or Mixed Models, e) Stage Models, and f) Linear Model. All these models have scientific recognition.[10] Certain common weaknesses can be identified in the identified models: (1) The models focus on obtaining new products in a radical manner, neglecting the incremental nature of the state of the art, which holds greater innovative potential. (2) The models are oriented towards large companies that have R&D or engineering departments. (3) The models prioritize the commercialization of the idea, with commercialization as the main focus. (4) The models do not incorporate the post-innovation stage, failing to consider the product lifecycle, such as the experience curve, and not allowing for adaptation to changing market needs.

Creating, incentivizing, raising awareness, and facilitating access to technology-related information, including patent systems and other intellectual property services, for innovators within the university community is crucial. All creations made by members of the university community should be valued, recognized, and protected. Through this research initiative, we aim to identify these creations, give them the respective recognition, and support their registration. Patents, including both Invention Patents and Utility Model Patents, are recognized as key indicators of progress and development in research and innovation within organizations. In the case of universities, patents offer various benefits, including: (1) Improving institutional rankings, thereby strengthening the university's perception, reputation, and international image. (2) Fostering inventive activity among members of the university community, motivating researchers and students to develop innovative solutions. (3) Generating opportunities to create new sources of income for both the university and inventors through the implementation of a technology transfer system that connects the academic community with the productive or private sector. Thus, patents play a crucial role in advancing research and the impact of educational institutions on society.

This research proposes an efficient model adapted to the specific context of a Peruvian university, aiming to optimize the process of technological innovation and knowledge protection. The goal is to

establish strong and meaningful links between the university, industry, and society through effective initiatives that drive the advancement of a social market economy in the country. This approach promotes respect for free enterprise and freedom of expression while fostering sustainable and equitable growth in Peru. By addressing the relationship between the academic sphere, the business sector, and society as a whole, we seek to generate a positive impact on the national economy, driving innovation and progress in various knowledge domains.

Research Problem: How can an effective model for the technological innovation process and knowledge protection in a university be proposed in 2022? General Objective: To propose an effective model for the technological innovation process and knowledge protection in a university in 2022. Specific Objectives: (1) Identify protectable materials in undergraduate theses, postgraduate theses (Ph.D. and Master's), and research conducted by faculty members at Universidad Nacional de Ucayali through workshops with teachers and/or students according to the technological field. (2) Define a technological innovation process for knowledge protection in the university through a definitive model that promotes the development of adaptable innovations in any university.

To ensure the best productivity and competitiveness of an organization, it is essential to implement technological and innovation processes that address the political, social, and economic aspects that affect its sphere of influence.[28] To achieve this, a technological surveillance system must be designed and incorporated into the organizational structure.[7] University technology parks can have a significant impact on society and are a key component in this process.[11] The creation of strategic alliances between universities and companies is essential to foster organizational development[12] and growth through innovation and transformation.[13] Research is a fundamental tool for developing an effective model of technological innovation that protects knowledge within a university. By establishing this model, technological transfer to businesses and society at large will become possible and efficient.

Methods

The paradigm utilized in this study is positivism, as established by Barrantes Echevarria R.[14] The adopted approach is quantitative, aiming to describe the reality of human and social interactions and functions. In this approach, reality is observed without taking any particular position that could introduce biases, as indicated by Barrantes Echevarria R & Kerlinge FN.[14,15] The research type is applied, which implies seeking practical knowledge and solutions to specific problems, as established by Barrantes Echevarria R.[14] Additionally, the research level is explanatory, aiming to delve into the understanding of phenomena and determine causal relationships between variables, according to the same author.

The reasoning used is deductive, where the scientist deduces the consequences of the hypothesis formulated by themselves, as indicated by Kerlinge FN.[15] Regarding the research design, a descriptive design is employed, corresponding to a pre- experimental design, according to Hernandez Sampieri R.[16] In this design, a sample group (G) is observed (O) in the technological innovation process (X). The target population in this case consists of the total theses or research papers presented and defended in 2021, including both undergraduate and postgraduate works, as well as research conducted by faculty members. This population reaches a total of 342 research works between the years 2021 and 2022.

The population distribution was determined across different strata. 78.95% of the research works correspond to undergraduate theses, while 18.71% are master's theses, 2.05% are doctoral theses, and only 0.29% corresponds to books. In total, these 342-research works comprise the population. Regarding the sample, it is mentioned that a non-probabilistic sampling approach is used, specifically an accidental sampling. This means that a randomized method is not employed to select the samples. This sample selection does not follow the principles of probabilistic sampling, as indicated by Kerlinge FN et al.,[15,16] The specific sample consists of the theses or research papers presented and defended in 2021, including both undergraduate and postgraduate works, as well as research by faculty members. However, an additional inclusion criterion is established for the sample, which is that the works must contain patentable material. As for the data collection techniques and instruments, the checklist technique is used for primary data collection, with a checklist being employed as the instrument. On the other hand, for secondary data collection, the documentary analysis technique is utilized, and textual cards are used as the instrument. The data collection strategy involves the use of a checklist, pens, and electronic boards. The collaboration of an operator or computational assistant is present to manage the information. Data collection is conducted in a single day, and a schedule is established for specialists to complete the forms. As the forms are filled, they are automatically coded to facilitate handling and processing. The researchers cross-reference the publications in the institutional repository of the Universidad Nacional de Ucayali between 2021 and 2022. Regarding the validation of the data collection instrument, it is mentioned that expert judgment was employed. Experts assign scores to each indicator, resulting in a total score and an average score. The results indicate that the quantitative assessment is 19.6, and the qualitative assessment is rated as excellent. It is concluded that the instrument is valid and applicable for use in the research.

Results

The identification of patentable material in a university is typically carried out through the technology transfer process. This involves evaluating the research outcomes conducted by university researchers to identify technologies, inventions, or discoveries that may have commercial potential and can be protected through patents. To achieve this, the following activities were undertaken to identify patentable material in a university: (1) Review of research outcomes: The results of research conducted by university researchers were carefully examined. (2) Patentability assessment: The potential patentability of the identified technologies, inventions, or discoveries was evaluated. (3) Commercial potential evaluation: The commercial viability of the patentable material was assessed. (4) Intellectual property protection: Measures were taken to protect the intellectual property rights associated with the identified patentable material. To facilitate this process, a checklist was applied to the total number of theses or research papers presented and defended in 2021, including both undergraduate and postgraduate works, as well as research conducted by faculty members. The population of interest consisted of 342 research works conducted between the years 2021 and 2022 Table 1.

LC1. Is the research outcome novel and has not been previously discovered or patented? Regarding the identification of patentable material, the results indicate that 33% of undergraduate works, 45% of master's works, 14% of doctoral works, and 100% of the published book in the repository of the Universidad Nacional de Ucayali meet the criteria of being novel and not previously discovered or patented. It is worth noting that only a small portion of the undergraduate and doctoral material meets these criteria, whereas a significantly higher

proportion of master's works fulfill the requirements. LC2. Is the research outcome useful and applicable in the real world? Regarding the identification of patentable material, the results show that 78% of undergraduate works, 66% of master's works, 71% of doctoral works, and 100% of the published book in the repository of the Universidad Nacional de Ucayali is considered useful and has practical applications in the real world. While a substantial portion of the undergraduate, master's, and doctoral research outcomes meet these criteria, all the results in the published book satisfy these requirements.

LC3. Is the research outcome inventive and non-obvious to someone working in the field? Regarding the identification of patentable material, the results indicate that 4% of undergraduate works, 8% of master's works, 29% of doctoral works, and none of the results in the published book in the repository of the Universidad Nacional de Ucayali are considered inventive and non- obvious to someone working in the field. This suggests that only a small portion of the undergraduate, master's, and doctoral research outcomes fulfill these criteria, while none of the results in the published book meet these requirements.

LC4. Does the research outcome have commercial potential and could it generate significant income for the university or its researchers? Regarding the identification of patentable material, the results show that 2% of undergraduate works, 3% of master's works, 0% of doctoral works, and none of the results in the published book in the repository of the Universidad Nacional de Ucayali have commercial potential that could generate significant income for the university or its researchers. It appears that only a very small portion of the undergraduate, master's, and doctoral research outcomes possess commercial potential, while none of the results in the published book meet this criterion.

LC5. Is the research outcome original and does it not violate existing intellectual property laws? Regarding the identification of patentable material, the results indicate that 100% of undergraduate works, 100% of master's works, 100% of doctoral works, and 100% of the results in the published book in the repository of the Universidad Nacional de Ucayali are considered original and do not violate existing intellectual property laws. This demonstrates that all the research outcomes produced in the undergraduate, master's, doctoral, and published book categories meet the criteria of originality and legal compliance.

LC6. Does the research outcome have scope and application that can justify the cost and time of obtaining a patent? Regarding the identification of patentable material, the results show that 100% of undergraduate works, 100% of master's works, 100% of doctoral works, and 100% of the results in the published book in the repository of the Universidad Nacional de Ucayali have scope and application that justify the cost and time of obtaining a patent. This indicates that all the research outcomes in the undergraduate, master's, doctoral, and published book categories possess the necessary scope and application to warrant the investment required for patent acquisition.

LC7. Are there sufficient financial resources available to protect and commercialize the research outcome? Regarding the identification of patentable material, the results indicate that none of the undergraduate works, master's works, doctoral works, or the results in the published book in the repository of the Universidad Nacional de Ucayali have sufficient financial resources to protect and commercialize the research outcome. It appears that there is a lack of financial resources to support the protection and commercialization of the research outcomes in all categories.

LC8. Is there sufficient protection for the research outcome to ensure that the university's intellectual property is not violated? Regarding the identification of patentable material, the results show that 100% of undergraduate works, 100% of master's works, 100% of doctoral works, and 100% of the results in the published book in the repository of the Universidad Nacional de Ucayali have sufficient protection to ensure that the university's intellectual property is not violated, at least in terms of copyright protection. This indicates that all the research outcomes in the undergraduate, master's, doctoral, and published book categories have adequate measures in place to safeguard the university's intellectual property.

LC9. Can the research outcome be effectively commercially exploited? Regarding the identification of patentable material, the results indicate that none of the undergraduate works, master's works, doctoral works, or the results in the published book in the repository of the Universidad Nacional de Ucayali can be effectively commercially exploited. It seems that there is a lack of potential for commercial exploitation in all categories.

LC10. Does the research outcome have any benefit for society? Regarding the identification of patentable material, the results indicate that 100% of undergraduate works, 100% of master's works, 100% of doctoral works, and 100% of the results in the published book in the repository of the Universidad Nacional de Ucayali have some benefit for society. This implies that all the research outcomes in the undergraduate, master's, doctoral, and published book categories contribute positively to society in various ways.

As a result of these findings, we propose the Model for Effective Technological Innovation Process (METIP), which can be adapted for use in any university. The model encompasses the following steps: Step 1: Technological surveillance, which involves collecting, monitoring, and analyzing data and communications from patent databases, scientific article databases, and other knowledge databases to establish and identify the state of the art in a defined technological field. Step 2: Technological demand, which refers to the need or desire for innovative and advanced products or services by consumers and businesses. This demand can be driven by factors such as increased efficiency, improved user experience, enhanced safety, cost reduction, and greater accessibility. Step 3: Research, Development, and Innovation (RDI), an integral process involving scientific research, technological development, and innovation of products, services, or processes. RDI is crucial for the growth and competitiveness of companies and economies as it enables organizations to create new products and services that meet the needs and desires of customers and improve internal processes for greater efficiency and profitability. Additionally, RDI contributes to advancing knowledge and solving problems in various fields. Step 4: Factors of production, which include the tangible and intangible resources necessary for innovative materialization. This encompasses human effort, skills, technical knowledge, risk-taking ability, and decision-making to organize and coordinate other factors of production. Step 5: Knowledge protection, which involves preserving and protecting intellectual property and confidential information, such as patents, trademarks, trade secrets, etc. This may include implementing security measures, signing confidentiality agreements, and applying for patents and trademarks. To achieve this, it is necessary to have policies, technological tools, strategic alliances, instruction and knowledge of intellectual property, and an investigative organizational culture. Step 6: Verification of the resources required to develop the innovative activity. Step 7: Production, which is the stage where the innovative idea is materialized into a technical document. This document specifies the problem, the technical solution and its feasibility, the technological

level components or procedures, technical parameters, optimization, claims, and corresponding diagrams. Step 8: Communication with the demand side to validate the expected outcome. This interaction allows for continuous and ongoing improvement. Step 9: The entire system undergoes constant monitoring through a feedback mechanism driven by technological advancements and updates to quality indicators or standards.

I hope this provides a more comprehensive response to your request. If you have any further questions, please feel free to ask. Figure 1 Taking into account the Linear Model (Technology Push and Demand Pull Model), Stage Models, Interactive or Mixed Models, Integrated Models, and Network Models,[17]as well as the London Business School Model,[10] and adding the Model of Innovation Management in Manufacturing SMEs, which enables the development of new products,[12] and the presented models: Linear Model, Marquis Model, London Business School Model, and Kline Model.[18] Additionally, the Linear Innovation Model, Chain-Link Model or Interactive Innovation Model (Kline Model), Marquis Model, Technology-Based Innovation Management Model, and Hamel's Solution to Innovation Model,[19] as categorized by López O [20]as generational models of innovation management, we propose the inclusion of EMTIP as the seventh generation, as shown in Table 2.

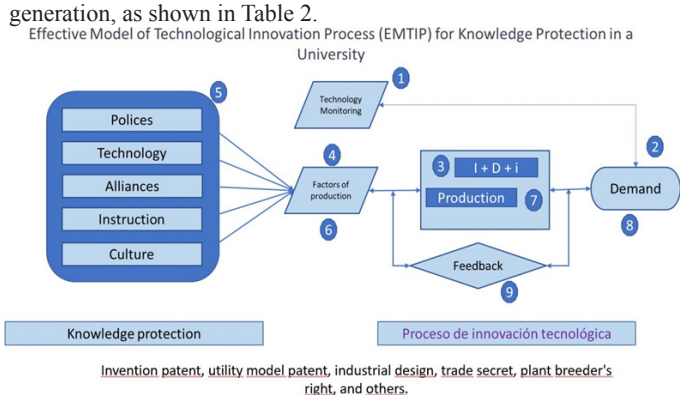

Figure 1 Effective Model of Technological Innovation Process (EMTIP) for Knowledge Protection in a University.

Table 1 Global results of the application of the checklist to identify patentable material

Items	Undergraduate		Master's		Doctorate		Book	
	NC	C	NC	C	NC	C	NC	C
LC1	67%	33%	55%	45%	86%	14%	0%	100%
LC2	22%	78%	34%	66%	29%	71%	0%	100%
LC3	96%	4%	92%	8%	71%	29%	100%	0%
LC4	98%	2%	97%	3%	100%	0%	100%	0%
LC5	0%	100%	0%	100%	0%	100%	0%	100%
LC6	0%	100%	0%	100%	0%	100%	0%	100%
LC7	100%	0%	100%	0%	100%	0%	100%	0%
LC8	0%	100%	0%	100%	0%	100%	0%	100%
LC9	100%	0%	100%	0%	100%	0%	100%	0%
LC10	0%	100%	0%	100%	0%	100%	0%	100%
TOTAL	270		64		7		1	

NC: Do not comply; C: Comply

Table 2 New categorization of generational models of innovation management, 2022

Generation	1st	2nd	3rd	4th	5th	6th	7th
Major sectors or main sectors	Linear Models	Stage or Department Models	Interactive or Mixed Models	Integrative Models	Network Models	Innovation Model for SMEs	EMTIP
1) Market orientation		X	X	X	X	X	X
2) Creativity						X	X
3) Research and Development	X	X	X	X	X	X	X
4) Product Design	X	X	X	X	X	X	X
5) Operational Efficiency	X	X	X	X	X	X	X
6) Commercial Efficiency	X	X	X	X	X	X	X
7) Finance							X
8) Suppliers					X		X
9) Customers, Strategic Alliances, Competitors					X		X
10) Universities, Society, Public Knowledge					X		X
11) Technological Monitoring							X
12) Feedback or control							X

Source: (López et al., 2009), and own elaboration.

Discussion

It is possible to identify the material that can be protected in undergraduate theses, postgraduate theses, and research conducted by professors at the Universidad Nacional de Ucayali through a workshop designed to train teachers and students in the corresponding technological field. This workshop provides the basic concepts of intellectual property and copyright, including the different types of

protection available for different types of works, such as patents, industrial designs, copyrights, and trademarks.[21]In the case of undergraduate theses, the scope of copyright protection is discussed, and information is provided on how to properly cite and reference the work of other authors. For postgraduate theses, emphasis is placed on the importance of originality and novelty in research work, and information is provided on how to protect it through patent applications or copyrights. For research conducted by professors, the discussion revolves around how to protect research results, either through patent applications or copyright registration. Additionally, the importance of technology transfer is highlighted, along with how research findings can be commercialized to generate income and foster innovation.[22]

It is possible to define a process of technological innovation for knowledge protection within the university through a definitive model that promotes the development of innovations adaptable to any university.[23] The following steps can be included in this process: (1) Identification of the innovation: The first step is to identify research projects and innovations developed by the university that can be protected through patent registration or Zother means of intellectual property.[24] This may involve reviewing ongoing research projects and identifying areas where innovation is taking place. (2) Patentability evaluation: Once the innovations are identified, a patentability evaluation must be conducted to determine if they meet the criteria for patentability.[25] This may involve reviewing technical literature and patents to identify existing similar inventions and assessing whether the university's innovations are novel and non-obvious. (3) Formulation of the patent application: If it is determined that the innovation is patentable, the patent application must be formulated, which includes the scientific-legal technical document and other documents required by the corresponding Patent Office. This process can be carried out by intellectual property experts within the university or specialized lawyers hired by the university. (4) Filing the patent application: Once the patent application has been formulated, it must be filed with the corresponding Patent Office along with the payment of the corresponding fees. (5) Monitoring and maintenance of the patent: Once the patent is granted, it must be monitored and maintained to ensure that all necessary obligations for its protection are being fulfilled. This may include the payment of maintenance fees and monitoring possible patent infringements. (6) Commercialization of the innovation: Finally, the university should consider the commercialization of the innovation protected by the patent, which may include licensing to third parties for their use and commercial exploitation. This process can be adapted and customized according to the needs and capabilities of each university.[26] However, it is important to highlight that knowledge and innovation protection require specialized knowledge in intellectual property, and it is recommended to seek advice from experts in the field to ensure the proper protection of the university's intellectual property rights.[27,29–46]

Conclusion

Regarding whether it is possible to identify protectable material in undergraduate theses, postgraduate theses, and faculty research at a Peruvian university through a workshop with teachers and/or students in the technological field. In this workshop, basic concepts of intellectual property and copyright can be addressed, including the different types of protection available for various kinds of works. In the case of undergraduate theses, the scope of copyright protection can be discussed and how to properly cite and reference the work of other authors. For postgraduate theses, the importance of originality and novelty in the research work can be discussed and how it can be protected by filing patent applications or copyright claims. In the case of faculty research, how to protect the research findings can be discussed, either by filing patent applications or by registering copyrights. The importance of technology transfer and how research findings can be commercialized to generate income and foster innovation can also be addressed.

Regarding whether it is possible to define a technological innovation process for protecting the university's knowledge, through a definitive model that promotes the development of innovations adaptable to any university. This process includes the identification of innovation, evaluation of patentability, formulation of the patent application, submission of the patent application, monitoring and maintenance of the patent, and the commercialization of the innovation. This process can be adapted and customized according to the needs and capabilities of each university, but it is important to highlight that the protection of knowledge and innovation requires specialized knowledge in intellectual property and it is recommended to seek advice from experts in the field to ensure adequate protection of the university's intellectual property rights. The implementation of a technological innovation process can be key in the development of research and in the generation of income for the university.

Authors contribution

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Conflicts of interest

The authors declare there is no conflict of interest.

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