

A Deep Tech Protocol to Strengthen Technology Transfer in Peruvian Public Universities

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ABSTRACT:

Public investment in research, development and innovation (R+D+i) in Peruvian public universities has increased significantly in the last decade, particularly through resources from the canon and royalties associated with extractive activities. However, the absence of systematic instruments to assess technological maturity, commercial readiness and effective knowledge transfer has limited the socio-economic impact of these investments. The objective of this study is to design and analyze a Deep Tech protocol aimed at strengthening the technological transfer of university intellectual production financed with public resources at the Jorge Basadre Grohmann National University (UNJBG). The research was developed through an applied design with a predominant qualitative approach and descriptive analysis of data from Likert scales. The methodological strategy included documentary analysis, the development of three structured protocols (application, dissemination and consolidation) and the realization of six focus groups with 36 researchers belonging to the areas of R+D+i defined by the OECD. The results show a favorable assessment of the implementation of the proposed protocol, with average scores above 6 on a seven-point Likert scale. Likewise, the model allows research projects to be classified according to their level of technological maturity (TRL) and commercial readiness (CRL), facilitating the identification of initiatives with technology transfer potential and avoiding the repeated allocation of resources to projects that remain in early stages of scientific development. It is concluded that the Deep Tech protocol constitutes a governance tool capable of strengthening the management of university intellectual production and directing public funding towards projects with greater potential for innovation and technology transfer. The proposed model can be replicated in other public universities that manage research resources from the canon and royalties..

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Introducción

Peruvian public universities manage important public resources from the canon and royalties associated with extractive industries. Since the enactment of University Law No. 30220 (Ministerio de Educación del Perú, 2014), The Vice-Rectorates for Research are responsible for allocating these resources through competitive calls for research, experimental development and innovation projects, thereby seeking to improve their lines of research (Consejo Nacional de Ciencia, Tecnología e Innovación - CONCYTEC, 2019).

In Peru, public universities located in regions where natural resources are exploited receive transfers from the canon and mining royalties destined for scientific and technological research. According to Law No. 27506 – Canon Law, 20% of the resources received by regional governments for the concept of canon must be transferred to the public universities of their jurisdiction for the development of scientific and technological research. In recent years, these transfers have reached significant amounts; for example, in 2022 public universities received approximately S/ 498 million in canon and mining royalties, accumulating more than S/ 2,000 million in the last decade (Diario El Peruano, 2022).

Despite the magnitude of this public investment, project evaluation processes have focused mainly on administrative compliance and traditional academic products, with little attention paid to technological maturity, market readiness, and effective transfer of results.

In this context, the objective of this study is to design and analyze a Deep Tech protocol that allows improving the processes of evaluation, monitoring and consolidation of university intellectual production financed with canon and royalty resources in Peruvian public universities.

This article is part of the project "Implementation of a Deep Tech Protocol to Consolidate the Transfer of University Intellectual Production Financed with Competitive Funds of Canon and Royalties at the UNJBG", initially located at level TRL 4 (National Aeronautics and Space Administration - NASA, 2023) and CRL 4 (Auerswald & Branscomb, 2003). The central research question addresses how a structured Deep Tech protocol can improve the consolidation and transfer of university intellectual production financed with public resources.

The main contribution of this research lies in the proposal of a methodological protocol aimed at strengthening the technological transfer of university intellectual production financed with public resources. Unlike traditional approaches to evaluating research projects, which are mainly focused on academic products such as scientific publications, the proposed model integrates indicators of technological maturity (TRL), commercial readiness (CRL), alignment with the Sustainable Development Goals (SDGs) and the OECD classification of scientific fields in a single governance system for the management of university R+D+i.

Likewise, the study provides empirical evidence on the perception of researchers regarding the feasibility of implementing a technology evaluation protocol in Peruvian public universities that receive funding from canon and royalties. In this sense, the proposed model contributes to closing the gap between university scientific production and its practical application in innovation and technology transfer processes.

Finally, this research proposes a replicable framework for the management of university intellectual production in contexts where there are significant public resources allocated to research, but there are still no systematic

instruments to assess the technological maturity and transfer potential of the funded projects.

Theoretical Framework

2.1. Deep Tech and University Intellectual Production

Deep Tech refers to innovations based on advanced scientific discoveries or complex engineering developments, characterized by high technological risk, long development cycles, and significant capital requirements. Unlike incremental or purely digital innovations, deep tech initiatives rely on specialized infrastructure, cross-functional teams, and differentiated evaluation frameworks (Auerswald & Branscomb, 2003).

University Intellectual Production (PIU) comprises both tangible and intangible results generated through academic activity, including scientific publications, patents, software, prototypes, and funded research projects. Effective management of the PIU is essential to ensure knowledge transfer, technological commercialisation and territorial impact (Manrique Tejada, 2022).

2.2. TRL, CRL, ODS y Clasificación OCDE

Technology Maturity Levels (TRLs) and Business Readiness Levels (CRLs) provide structured metrics to assess the progression of technologies from basic research to market deployment. By integrating with the United Nations Sustainable Development Goals (SDGs) and the OECD classification of Science and Technology Fields, these indicators offer a comprehensive framework for strategic decision-making in R+D+i governance.

2.3. University Technology Transfer

University technology transfer comprises the set of processes by which the knowledge generated in universities is transformed into practical applications that can be used by society, companies or the public sector. This process includes various activities, such as the protection of intellectual property, the licensing of technologies, the creation of spin-offs, as well as

the development of collaborative projects with industry.

In recent decades, universities have taken on an increasingly active role in knowledge transfer, moving from being institutions mainly dedicated to teaching and basic research to becoming relevant actors within innovation ecosystems. Various studies indicate that the interaction between academia and industry can take multiple forms, such as collaborative research, scientific consultancy or the mobility of researchers between both sectors. These interactions contribute to accelerating the practical application of scientific knowledge and strengthening the innovative capacity of knowledge-based economies.

Likewise, the specialized literature highlights the importance of Technology Transfer Offices (TTO), which play a central role in the management of intellectual property and in the articulation between researchers and companies. The effectiveness of these offices depends, among other factors, on the experience of the staff, the institutional incentives for researchers and the existence of clear mechanisms for the commercialization of research results (Perkmann, et al., 2013).

2.4. University Innovation Systems and the Triple Helix Model

Contemporary scientific and technological development is characterized by the interaction between multiple institutional actors. In this context, the triple helix model emerges, which states that innovation occurs from the collaboration between university, industry and government. This approach proposes that each of these actors plays complementary roles within innovation systems, generating an environment conducive to the creation and application of knowledge.

According to this model, universities not only produce scientific knowledge, but also actively participate in processes of innovation, entrepreneurship and technological development. This evolution has given rise to the

concept of entrepreneurial university, characterized by its ability to generate technology-based companies, promote knowledge transfer and establish strategic links with the productive sector.

The interaction between university, business and the State generates spaces for cooperation where new forms of applied research, technological innovation and regional economic development are developed. In this sense, the triple helix has become one of the most widely used theoretical frameworks for analysing innovation ecosystems in knowledge-based economies (Etzkowitz y Leydesdorff, 2000).

2.5. Innovation systems and science policies

Innovation systems refer to the set of institutions, policies and actors involved in the generation, dissemination and application of scientific and technological knowledge within an economy. This approach recognizes that innovation does not arise solely from scientific research, but also from interactions between universities, businesses, governments, and other social actors.

The Organisation for Economic Co-operation and Development (OECD) has identified innovation as one of the main drivers of sustainable economic growth and social welfare. Consequently, public policies on science, technology and innovation have sought to strengthen the links between scientific research and productive development, promoting cooperation between academia, the business sector and government agencies.

In a context characterized by rapid technological changes and the increasing complexity of social problems, innovation systems require interdisciplinary approaches and governance mechanisms that allow scientific production to be articulated with the needs of economic and social development (Organisation for Economic Co-operation and Development - OECD, 2018).

2.6. Mission-Driven Innovation

In recent years, a science policy approach known as mission-oriented innovation has emerged,

which proposes to direct research and innovation efforts towards solving large-scale social and economic problems. This approach suggests that public investments in science and technology can play a strategic role in generating new industries, technologies and solutions to global challenges.

From this perspective, the State does not only act as a regulator or financier of research, but also as an active agent that promotes innovation processes through the definition of strategic priorities and the mobilization of public and private resources. This approach has been widely discussed in the context of innovation policies aimed at addressing complex problems such as climate change, public health or energy sustainability.

Mission-oriented innovation also involves the articulation between universities, research centers, companies and governments, with the aim of generating technological solutions that respond to specific challenges of society (European Commission: Directorate-General for Research and Innovation, 2018).

Methodology

Design of applied research with a predominant qualitative approach and descriptive analysis of data from Likert scales. The methodological strategy included:

Documentary analysis: Review of the Deep Tech institutional project and the three structured protocols developed.

Focus groups: Six sessions held, one for each area of R+D+i of the OECD (Natural Sciences; Engineering and Technology; Medical and Health Sciences; Agricultural Sciences; Social Sciences; Humanities), making a total of 36 researchers.

Instruments: Three structured self-assessment questionnaires with a seven-point Likert scale, corresponding to the stages of application, dissemination and consolidation, integrating TRL, CRL, SDGS and impact indicators.

The qualitative data were systematized through thematic analysis, which allowed the

identification of shared perceptions about technology transfer and the consolidation of university research results.

Limitations of the study: The present study has some limitations that should be considered when interpreting the results. First, the research was developed in a single university institution, which implies that the results obtained mainly reflect the institutional context of the Jorge Basadre Grohmann National University. Consequently, the generalization of the results to other public universities in Peru or the region should be carried out with caution.

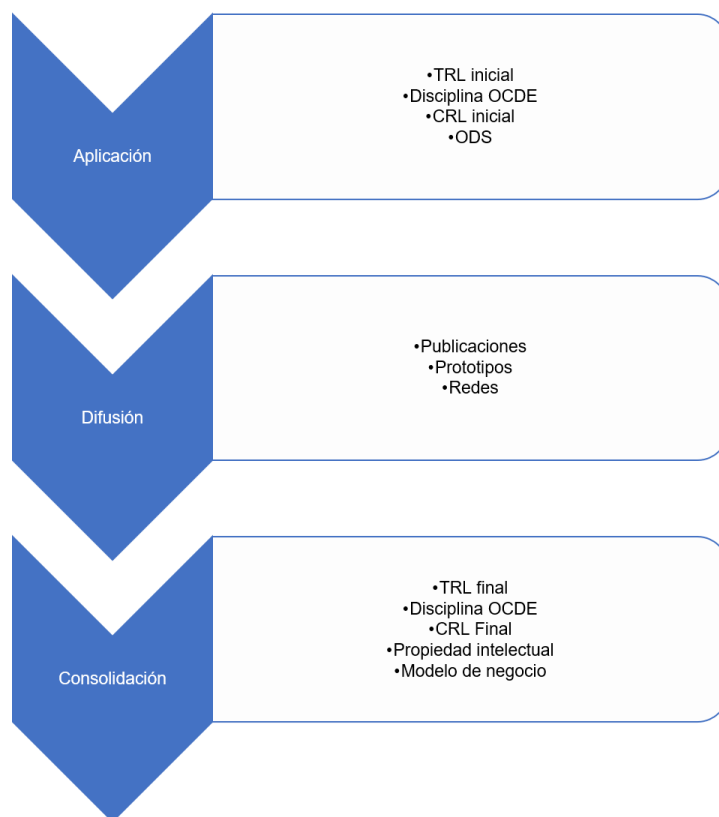
Secondly, the analysis was based on the perception of researchers participating in focus groups and on the application of self-assessment instruments, which could incorporate biases associated with the participants' previous

experience in the management of research projects.

Finally, the proposed Deep Tech protocol is currently in an initial phase of implementation, so future research could evaluate its longitudinal application in different institutional contexts, as well as analyze its impact on the generation of patents, technological prototypes and effective technology transfer processes. This line of research is particularly relevant in the Peruvian context, where there is still no standardized institutional protocol to assess the technological maturity and commercial readiness of projects financed with public resources. This situation becomes even more important if one considers that public universities manage resources from the canon and royalties that, together, can exceed one billion dollars allocated to research, development and innovation.

Results

Figure 1 *Deep Tech Protocol for the Management of Intellectual Production*



The projects analyzed identified the following from 36 researchers:

Table 1 *Classification of projects by TRL*

TRL	Number of projects
1-2	12
3-4	18
5-6	9

There were researchers who have already executed more than one project, that is why there are 39 projects identified, and they continue to give results at a TRL level 1.

The application of the evaluation rubric made it possible to analyze the researchers' perception regarding the relevance and feasibility of the proposed Deep Tech protocol. A total of 36

researchers participated, distributed in the six research areas defined by the OECD classification. The results showed a mostly favorable assessment of the implementation of the protocol, highlighting its potential to strengthen the processes of monitoring, evaluation and consolidation of university intellectual production.

Table 2 *Results of the evaluation of the Deep Tech protocol by researchers (n = 36)*

Dimension evaluated	Indicator	Media (Likert 1-7)	Desv. East.	Favorable evaluation (%)
Application	Clarity of protocol criteria	6.1	0.72	91.7
Application	Pertinencia del protocolo para evaluar proyectos	6.3	0.65	94.4
Application	Utilidad para identificar niveles TRL	6	0.81	88.9
Dissemination	Capacity of the protocol to make research results visible	6.2	0.69	91.7
Dissemination	Usefulness to promote collaboration with other actors	6	0.76	88.9
Consolidation	Contribution of the protocol to technology transfer	6.4	0.61	94.4
Consolidation	Utility for project-to-market orientation (CRL)	6.2	0.7	91.7
Consolidation	Potential to strengthen the management of the PIU	6.5	0.58	95.8

The application of the evaluation rubric made it possible to analyze the researchers' perception regarding the relevance and feasibility of the proposed Deep Tech protocol. 36 researchers from the six research areas defined by the OECD classification of scientific fields participated in the process. The results show a favorable assessment of the implementation of the protocol, with average scores above 6 on the seven-point Likert scale.

In particular, the indicators associated with the consolidation dimension obtained the highest scores, highlighting the contribution of the protocol to technology transfer (mean = 6.4) and its potential to strengthen the management of university intellectual production (mean = 6.5). These results suggest that researchers perceive the protocol as a useful tool to structure the monitoring of research projects and guide their evolution towards higher levels of technological maturity (TRL) and commercial readiness (CRL).

Likewise, the application and dissemination dimensions obtained high levels of acceptance, which indicates that the protocol not only facilitates the evaluation of projects in early stages, but also the visibility of research results and the generation of opportunities for collaboration with external actors.

The findings show that the Deep Tech protocol works as a phased self-assessment system capable of organizing the portfolio of university projects according to their technological and commercial maturity.

In the application stage, the initial levels of TRL and CRL function as a baseline, allowing projects with authentic Deep Tech potential to be identified early before the allocation of funding.

In the dissemination stage, the results highlight the importance of differentiated strategies of scientific and technological communication to generate visibility, strategic alliances and new funding opportunities.

In the consolidation stage, the protocol assesses whether the technologies developed are substantively novel, technically validated, adequately protected, and supported by an incipient business model. This mechanism avoids repeated funding of projects stuck at proof-of-concept levels and promotes effective progress towards transferable Deep Tech solutions.

Discussion

The results obtained in this study suggest that the implementation of a Deep Tech protocol can contribute significantly to improving the management of university intellectual production financed with public resources. The favourable assessment obtained by the participating researchers indicates that the incorporation of indicators of technological maturity (TRL) and commercial readiness (CRL) allows for a clearer structuring of the monitoring and evolution of research projects.

These findings are consistent with the international literature that highlights the importance of technology assessment

frameworks to guide the transition from scientific research to applied innovation. In various European innovation systems, for example, TRL levels have been incorporated as fundamental tools for evaluating projects funded through programmes such as Horizon 2020 and Horizon Europe, allowing technologies to be classified according to their degree of development and to direct funding towards stages of validation and technological demonstration.

Likewise, the results of this study are related to scientific policy experiences developed in the United States, particularly through the Small Business Innovation Research (SBIR) program, which seeks to facilitate the transition of technologies developed in academic environments to commercial applications. This program has shown that the combination of public funding, technology assessment, and support for scientific entrepreneurship can reduce the so-called "innovation gap" or valley of death, which often hinders the transfer of research results to the market.

Similarly, the Deep Tech ecosystems developed in countries such as Israel and South Korea show that the articulation between universities, the productive sector and innovation-oriented public policies can generate highly dynamic environments for technological development. In these cases, universities not only act as centers for knowledge generation, but also as platforms for the incubation of technology companies, the development of patents and the creation of solutions based on advanced science.

In the context of Peruvian public universities, the results of this research suggest that the implementation of structured technology assessment protocols can contribute to overcoming some of the existing limitations in the management of research funds from canon and royalties. The absence of systematic instruments to assess the technological maturity of projects has led, in many cases, to the repetition of research that remains in the early stages of scientific development without

advancing towards processes of technological validation or transfer.

In this sense, the proposed Deep Tech protocol constitutes a governance tool that allows the integration of international technology assessment indicators with national research policies. The articulation of TRL, CRL, SDGS and the OECD classification of scientific fields allows for a more transparent structuring of the allocation of resources, facilitating the identification of projects with potential for technology transfer and generation of territorial impact.

Finally, the incorporation of this type of protocol can strengthen regional innovation ecosystems by promoting greater interaction between universities, companies, governments and civil society, in line with the quadruple helix approach. In this way, university intellectual production financed with public resources could be progressively oriented towards the generation of technological solutions capable of contributing to the economic and social development of the regions.

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Conclusion

The results of this research suggest that the implementation of a Deep Tech protocol constitutes a relevant methodological innovation for the management of public funding of R+D+i in public universities.

The results suggest that the protocol is scalable and replicable in other public universities in Peru and in comparable higher education systems, contributing to maximizing the social, economic and scientific returns of public investment in research and innovation.

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