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ALÉM DAS MÉTRICAS DE SINERGIA: UMA REVISÃO SISTEMÁTICA DOS RESULTADOS DE INOVAÇÃO NO NÍVEL DA EMPRESA EM ARRANJOS COLABORATIVOS

BEYOND SYNERGY METRICS: A SYSTEMATIC REVIEW OF FIRM-LEVEL INNOVATION OUTCOMES IN COLLABORATIVE ARRANGEMENTS

MÁS ALLÁ DE LAS MÉTRICAS DE SINERGIA: UNA REVISIÓN SISTEMÁTICA DE LOS RESULTADOS DE INNOVACIÓN A NIVEL DE EMPRESA EN ARREGLOS COLABORATIVOS

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ABSTRACT

In the Triple Helix (TH) literature, measurement has advanced through macro and meso-level metrics of interaction and synergy, yet it remains limited in explaining how these relationships connect, at the firm level, to innovation outcomes (post-implementation results) captured during commercialization and diffusion. In response to this gap, this article aims to analyze how to measure innovation outcomes in firms participating in collaborative arrangements, extracting lessons for university-industry-government contexts. To this end, we conducted a systematic review of 5,155 records retrieved from the Web of Science and Scopus databases. The findings indicate a predominance of financial and operational indicators, with reduced attention to adoption/use measures, intangibles, and temporal lags. Methodologically, cross-sectional designs and mediation-based econometric estimations prevail; external agents are generally operationalized as individualized effects, which hinders representing the trilateral

synergy typical of TH. The study contributes by clarifying that systemic synergy is not automatically convertible into firm-level outcomes, by organizing a repertoire of indicators and measurement designs (mediation, comparison, and lag structures), and by outlining a research agenda focused on trilaterality, intangibles, and temporal dynamics. Practical implications include lean dashboards that combine financial metrics, comparative benchmarks, adoption signals, and intangibles to make visible the additionality associated with collaboration.

Keywords: Triple Helix. Innovation measurement. Innovation outcomes. Systematic review.

RESUMO

Na literatura de Tríplice Hélice (TH), a mensuração avançou em métricas de interação e sinergia em níveis macro/meso, mas permanece limitada quanto a explicar como essas relações se conectam, no nível da empresa, a *outcomes* (resultados pós-implementação) de inovação capturados na comercialização e difusão. Diante dessa lacuna, este artigo objetiva analisar como mensurar *outcomes* de inovação em empresas participantes de arranjos colaborativos, extraindo lições para contextos universidade-indústria-governo. Para tanto, realizou-se uma revisão sistemática em 5.155 registros nas bases Web of Science e Scopus. Os achados indicam predominância de indicadores econômico-financeiros e operacionais, com atenção reduzida a medidas de adoção/uso, a intangíveis e a defasagens temporais. Metodologicamente, prevalecem delineamentos transversais e estimações econométricas com mediação; agentes externos são, em geral, operacionalizados como efeitos individualizados, o que dificulta representar a sinergia trilateral típica da TH. O estudo contribui ao explicitar que sinergia sistêmica não é automaticamente convertível em *outcomes* empresariais, ao organizar um repertório de indicadores e desenhos de mensuração (mediação, comparação e defasagens) e ao delinear uma agenda de pesquisa para trilateralidade, intangíveis e dinâmica temporal. Implicações práticas incluem painéis enxutos que combinem métricas financeiras, comparações, sinais de adoção e intangíveis para evidenciar a adicionalidade associada à colaboração.

Palavras-chave: Tríplice Hélice. Mensuração da Inovação. Resultados de Inovação. Revisão Sistemática.

RESUMEN

En la literatura de la Triple Hélice (TH), la medición ha avanzado en métricas de interacción y sinergia en niveles macro/meso, pero sigue siendo limitada para explicar cómo esas relaciones se conectan, en el nivel de la empresa, con los *outcomes* –resultados posteriores a la implementación– de innovación capturados en la comercialización y la difusión. Ante esta brecha, este artículo tiene por objetivo analizar cómo medir los resultados de innovación en empresas participantes en arreglos colaborativos, extrayendo lecciones para contextos universidad-industria-gobierno. Para ello, se llevó a cabo una revisión sistemática de 5.155 registros en las bases Web of Science y Scopus. Los hallazgos indican la predominancia de indicadores económico-financieros y operativos, con atención reducida a medidas de adopción/uso, intangibles y desfases temporales. Metodológicamente, prevalecen los diseños transversales y las estimaciones econométricas con mediación; los agentes externos, por lo general, se operacionalizan como efectos individualizados, lo que dificulta representar la sinergia trilateral típica de la TH. El estudio contribuye al explicitar que la sinergia sistémica no es automáticamente convertible en resultados empresariales, al organizar un repertorio de indicadores y diseños de medición –mediación, comparación y desfases– y al delinear una agenda de investigación orientada a la trilateralidad, los

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intangibles y la dinámica temporal. Las implicaciones prácticas incluyen paneles sintéticos que combinen métricas financieras, comparaciones, señales de adopción e intangibles, a fin de evidenciar la adicionalidad asociada a la colaboración.

Palabras clave: Triple Hélice; medición de la innovación; resultados de innovación; revisión sistemática.

1 INTRODUCTION

The Triple Helix (TH) – university-industry-government (UIG) – is widely used as a framework for understanding innovation as an interactive process in which actors mobilize functions and resources in nonlinear dynamics (Cai & Amaral, 2022; Etzkowitz & Leydesdorff, 2000). Even in recent debates about extensions of the "helix" model, TH remains a key reference for examining collaborative mechanisms in innovation ecosystems (González-Martínez et al., 2025; Linton, 2024).

With respect to measurement in TH, the literature has advanced primarily in metrics designed to capture interactions and synergies at aggregate levels (macro and meso), with recurring applications to regional and national settings (Cai & Amaral, 2022; Leydesdorff, 2003). However, such metrics do not directly address how innovation outcomes are captured at the firm level, where innovation is implemented and managerial decisions are made (OECD/Eurostat, 2018; Stundziene et al., 2024).

At the firm level, measuring innovation results requires distinguishing efforts and activities (inputs), intermediate products (outputs), and post-implementation effects (outcomes), so as not to conflate effort with result (Dziallas & Blind, 2019; Stundziene et al., 2024). Consistent with the definition of innovation as a change implemented and introduced to the market or put into use, outcomes refer to what the firm captures in performance and use (Cirera & Muzi, 2020; Gault, 2018; OECD/Eurostat, 2018). Still, in the empirical literature more broadly, because of greater availability and comparability, inputs and outputs (e.g., R&D expenditures and patents) are often used as indirect measures (proxies) of innovation performance, even though the Oslo Manual recommends that they not be treated as equivalents to firm-captured outcomes (Dziallas & Blind, 2019; OECD/Eurostat, 2018).

Against this backdrop, a mismatch persists in the TH literature: although there are well-established metrics for aggregate levels, empirical frameworks that explicitly connect UIG relationships to firm-captured outcomes remain scarce (Cai & Amaral, 2022; Leydesdorff, 2003). This gap becomes more acute in the commercialization and diffusion phase, when outcomes become observable, but evidence tends to be fragmented and difficult to trace (Ferdinands et al., 2023; Liche & Střelcová, 2023). The core challenge is not only the scarcity of indicators, but also the lack of measurement strategies able to handle the influence of multiple agents and the temporal heterogeneity of outcomes (Dziallas & Blind, 2019; Stundziene et al., 2024).

In light of this mismatch, this study aims to analyze how to measure innovation outcomes at the firm level in collaborative arrangements, in order to extract lessons that can be applied to Triple Helix contexts (Cai & Amaral, 2022; Cai & Etzkowitz, 2020). To that end,

following the Oslo Manual's guidance, this research focuses on outcomes observable after the implementation of innovation (Dziallas & Blind, 2019; OECD/Eurostat, 2018).

To achieve this objective, we conducted a Systematic Literature Review (SLR) in the Web of Science and Scopus databases, starting from an initial set of 5,155 records. The search protocol prioritized empirical studies that link innovation outcomes to the influence of external agents (universities, government, suppliers, etc.), in order to obtain evidence on how collaborative mechanisms can translate into firm-level outcomes in UIG contexts (Etzkowitz & Leydesdorff, 2000; Ranga & Etzkowitz, 2013).

The study's contribution is threefold: first, it critically organizes indicators and techniques for measuring outcomes, offering an operational repertoire for research in UIG environments (Cirera & Muzi, 2020; Dziallas & Blind, 2019); second, it systematizes how external agents are incorporated into empirical models, strengthening the design of investigations that seek to capture effective results without reducing them to innovation effort (Rammer & Es-Sadki, 2023; Stundziene et al., 2024); and third, it consolidates the state of the art's limits and opportunities, supporting an agenda aimed at advancing adoption metrics and intangible dimensions (Björk et al., 2023; Noble et al., 2023). Beyond this introduction, the article presents the theoretical background, method, results, discussion, research agenda, and conclusion.

2 THEORETICAL BACKGROUND

2.1 INNOVATION AND ITS OUTCOMES

For measurement purposes, the concept of innovation must be defined explicitly, given the variety of meanings in the literature (Dziallas & Blind, 2019; Gault, 2018). In this study, we adopt the Oslo Manual definition, according to which an innovation is a new or improved product or business process that differs significantly from the firm's previous products or processes and has been introduced on the market or put into use by the firm (OECD/Eurostat, 2018).

This implementation criterion is central for distinguishing ideas, projects, and innovative activities from innovations that are actually realized (Cirera & Muzi, 2020; Gault, 2018). The same logic supports the distinction among efforts and activities (inputs), intermediate products (outputs), and post-implementation effects (outcomes), preventing effort measures from being treated as results (Dziallas & Blind, 2019; OECD/Eurostat, 2018).

At the firm level, outcomes correspond to what is captured in performance and use, including financial and operational results as well as adoption and capability dimensions (Cirera & Muzi, 2020; Gault, 2018). Because they are more available and standardized, input

and output indicators–such as R&D expenditures, patents, and joint publications–are still often used as proxies, even though they are not equivalent to outcomes (Dziallas & Blind, 2019; OECD/Eurostat, 2018).

From an operationalization standpoint, the Oslo Manual allows both quantitative and qualitative evidence, and recent literature recommends combining numeric indicators with evidence on intangible results and effects distributed over time (Gault, 2018, 2023; OECD/Eurostat, 2018). This combination is particularly relevant in collaborative contexts, where part of the results manifests as learning, reputation, networks, and capabilities that are not fully captured by financial indicators alone (Björk et al., 2023; Noble et al., 2023).

2.2 THE TRIPLE HELIX MODEL

TH describes an innovation system in which university, industry, and government interact and recombine functions in the generation and diffusion of knowledge (Cai & Amaral, 2022; Etzkowitz & Leydesdorff, 2000). In this formulation, universities can assume entrepreneurial roles, firms act as co-producers of knowledge, and governments serve as catalysts for pro-innovation environments (Etzkowitz & Leydesdorff, 2000; Ranga & Etzkowitz, 2013). Functional overlap tends to produce hybrid organizations and coordination spaces that sustain technological trajectories over time (Acuña et al., 2024; Ranga & Etzkowitz, 2013).

In the measurement domain, one established stream developed UIG synergy metrics grounded in information theory, focusing on aggregate levels–regions, countries, and sectors (Leydesdorff, 2003, 2006; Leydesdorff & Park, 2014). These approaches help compare systems and estimate coordination surpluses at macro and meso levels, but they do not, on their own, explain how UIG interactions translate into outcomes captured at the firm level (Cai & Amaral, 2022; Ferdinands et al., 2023).

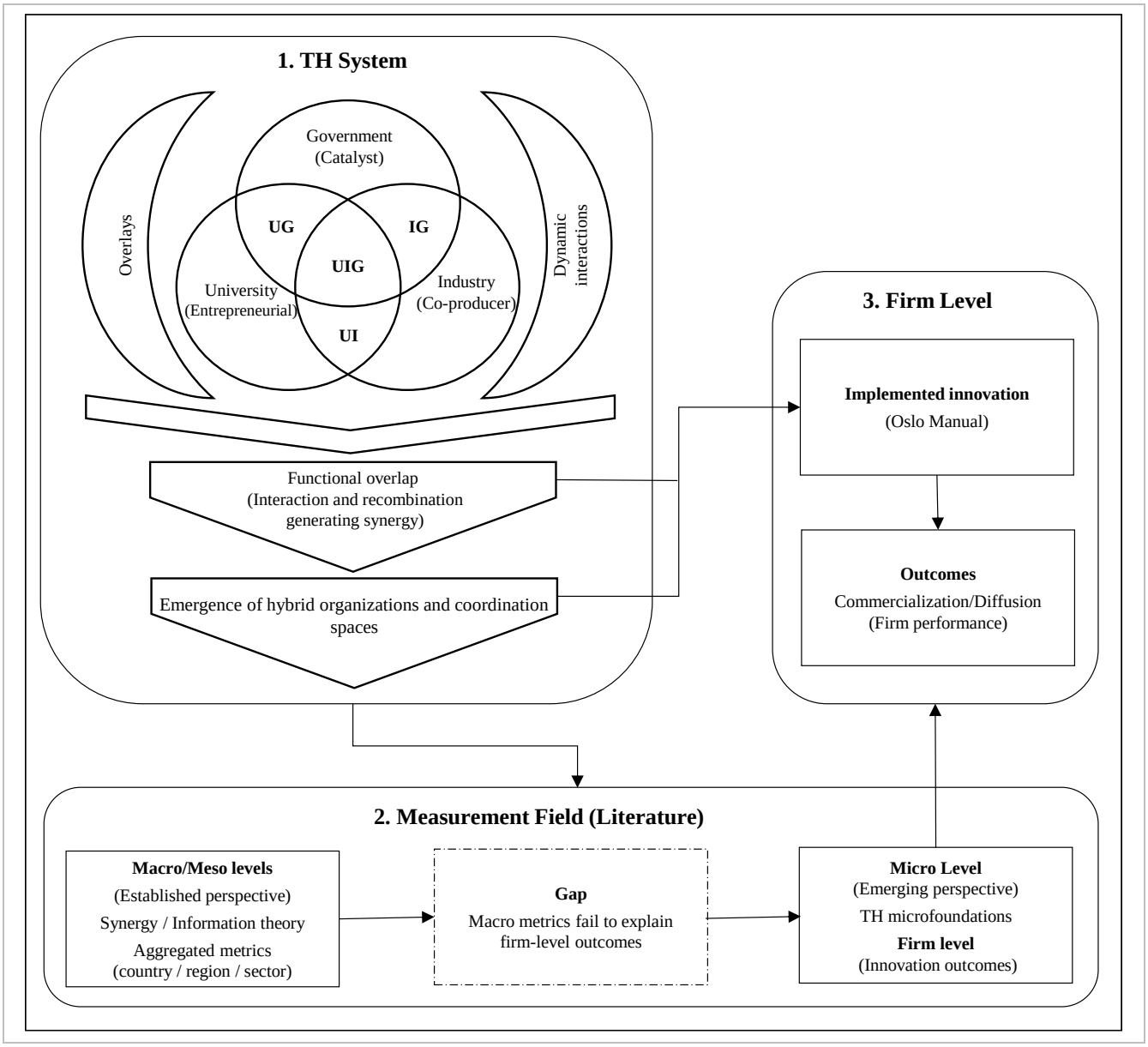
For this reason, recent literature has called attention to TH microfoundations and to the need to connect collaborative mechanisms to outcomes observable after innovation implementation, especially in the commercialization and diffusion phase (Ferdinands et al., 2023; Liche & Střelcová, 2023). In parallel, the diffusion of open innovation strategies reinforces the importance of understanding how external agents enter explanatory models of firms' innovation performance (Cai & Etzkowitz, 2020; Rammer & Es-Sadki, 2023). Figure 1 synthesizes this chain, linking UIG interactions, implemented innovation, and firm-level outcomes (Cai & Amaral, 2022; OECD/Eurostat, 2018).

This is where this article's SLR fits in: rather than proposing an additional synergy metric, the review systematizes empirical evidence on how studies in collaborative

arrangements incorporate external agents (universities, government, suppliers, customers, etc.) and operationalize firm-level outcomes (Templier & Paré, 2015; Tranfield et al., 2003). The premise is to extract methodological and operational lessons for research in TH contexts, while preserving the implementation criterion and the distinction among inputs, outputs, and outcomes (Dziallas & Blind, 2019; OECD/Eurostat, 2018).

Figure 1

Analytical framing of the Triple Helix (UIG) measurement mismatch: macro/meso-level synergy metrics versus firm-level innovation outcomes



Source: Prepared by the authors.
Note. The figure links (1) Triple Helix (UIG) mechanisms, (2) the measurement field – where macro- and meso-level synergy metrics predominate – and (3) the firm level, where implemented innovation translates into observable outcomes during commercialization and diffusion. This framing highlights the mismatch discussed in the article between aggregate metrics and micro-level measurement of innovation outcomes.

3 METHOD

This study is characterized as an SLR of an exploratory and descriptive nature, with synthesis guided by content analysis (Bardin, 2015). Methodological rigor follows the guidelines of Templier & Paré (2015) and best practices for systematic reviews in management systematized by Tranfield et al. (2003). The protocol was operationalized in seven phases, described below.

Phase 1 – *Search term formulation*. A comprehensive search string was used, organized into two sets of keywords: (1) terms related to measurement; and (2) terms associated with innovation results and synonymous expressions. This resulted in the following string: ((apprais *OR assess* OR evaluat *OR gaug* OR measur *OR indicator* OR estimate *OR calculate*) AND ("innovat *outcom*" OR "outcom *innovat*" OR "outcom *of innovat*" OR "innovat *result*" OR "result *innovat*" OR "result *of innovat*" OR "innovat *output*" OR "output *innovat*" OR "output *of innovat*" OR "innovat *return*" OR "innovat *of return*" OR "return *innovat*" OR "return *of innovat*" OR "innovat *performanc*" OR "innovat *of performanc*" OR "performanc *innovat*" OR "performanc *of innovat*" OR "innovat *impact*" OR "impact *innovat*" OR "impact *of innovat*" OR "innovat *effect*" OR "innovat *of effect*" OR "effect *innovat*" OR "effect *of innovat*")).

Phase 2 – *Database search*. The Web of Science and Scopus databases were used due to their scientific relevance and breadth in business and management (Pranckutė, 2021). The search was refined by topic (title, abstract, and keywords), document type (article), source (journals), and language (English), with no restrictions by field, journal, or time period. The queries returned 5,520 articles in Scopus and 4,277 in Web of Science, totaling 9,797 records.

Phase 3 – *Initial screening and quality assessment*. Metadata were exported to Rayyan, which automatically identified 4,356 duplicate records. After manual verification, these records were excluded. The remaining 5,441 articles were classified based on indicators available in Journal Citation Reports (JCR) and CiteScore (Pranckutė, 2021). Journals without an indicator, not evaluated, or with a value of zero or N/A in both indexes were excluded, resulting in the removal of 286 articles and retention of 5,155 for the next stage.

Phase 4 – *Primary selection (inclusion criteria)*. Still in Rayyan, titles and abstracts of the 5,155 articles were read. Articles were included if they (a) reported empirical research; (b) measured innovation outcomes in accordance with the Oslo Manual definitions (OECD/Eurostat, 2018); (c) presented data and results at the firm level; and (d) captured the influence of agents external to the firm on innovation outcomes. Each record was evaluated by at least two authors in a blinded process; in cases of disagreement, a third author served as an arbiter. This stage excluded 4,782 articles, leaving 373 for full-text review.

Phase 5 – *Download and eligibility screening*. The 373 articles were downloaded and read in full, following the same inclusion criteria. The main reasons for exclusion at this stage were: (a) use of "innovation outcome" variables inconsistent with the Oslo Manual (OECD/Eurostat, 2018); (b) absence of explicit measurement of innovation outcomes; (c) failure to specify the variables used to measure outcomes; and (d) focus on levels of analysis

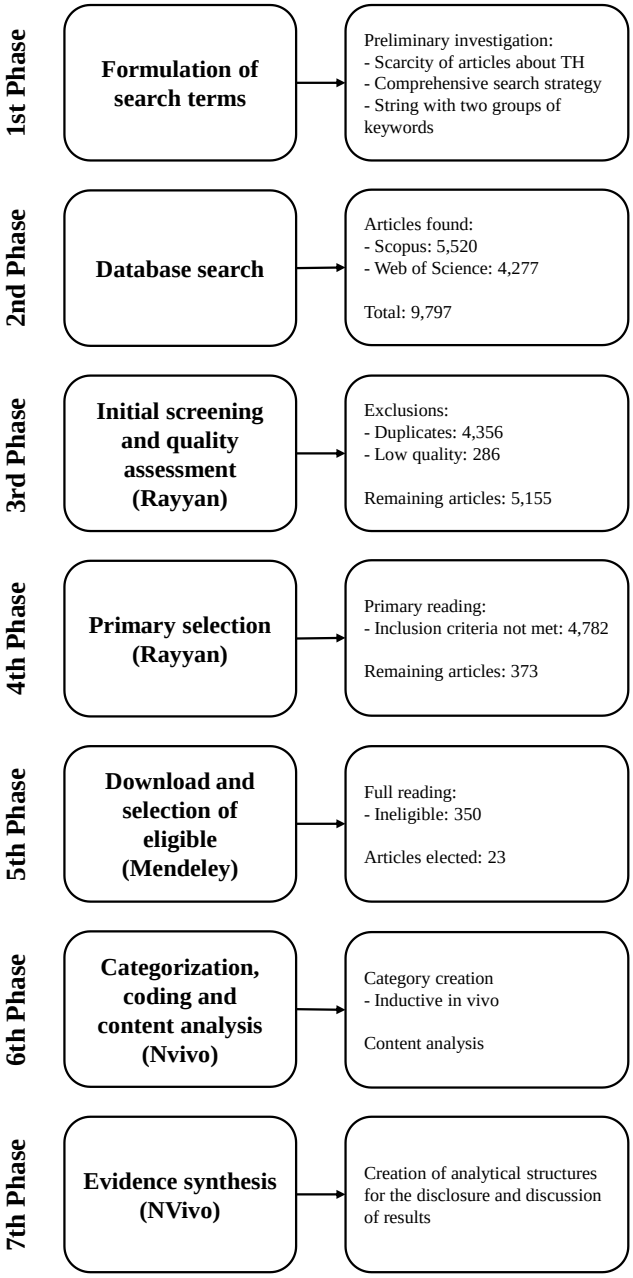
other than the firm. Doubts and disagreements were discussed in a meeting with all authors. In the end, 23 articles were deemed eligible for content analysis.

Phase 6 – *Categorization, coding, and content analysis*. PDFs of the 23 articles were organized in Mendeley to verify metadata and then imported into NVivo for categorization and coding. The categories and subcategories emerged inductively from the empirical material. Content analysis followed the procedures of Bardin (2015).

Phase 7 – *Evidence synthesis*. Coded excerpts in NVivo were exported into tables and organized into an analytical framework for synthesis and evidence comparison, which made it possible to consolidate and compare the identified measurement modeling approaches. Figure 2 summarizes all methodological stages of the study.

Figure 2

Summary of methodological procedures



Source: Prepared by the authors.

4 RESULTS

The 23 studies included in the SLR measure firm-level innovation outcomes predominantly through financial and operational indicators, notably sales/revenues, productivity, market share, and profitability measures (Joueid & Coenders, 2018; Mansury & Love, 2008; Thi et al., 2023). Although operationalization varies in specific instances, the main difference across studies lies in how the influence of external agents is incorporated into empirical models (Cieślik et al., 2018; Gaglio et al., 2022; Kahn et al., 2022).

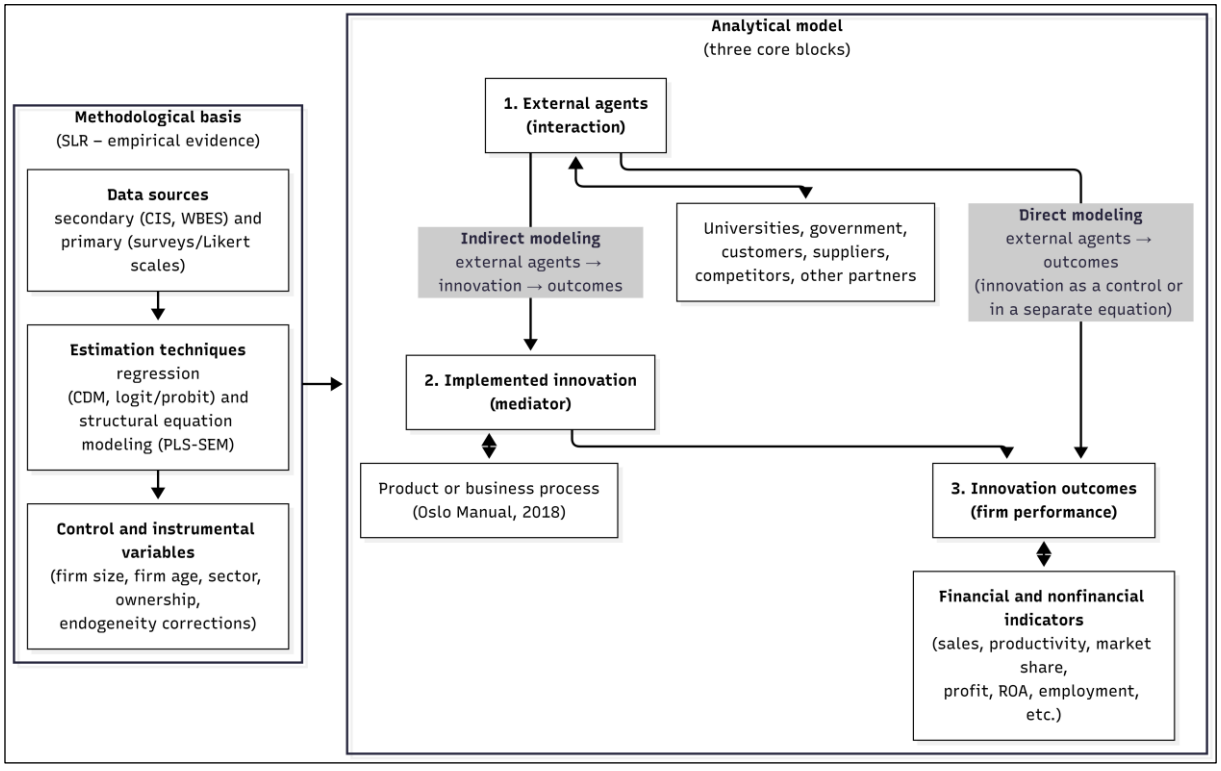
In part of the corpus, this influence is estimated as a direct effect on outcomes (external agents → outcomes) (Cieślik et al., 2018; Thi et al., 2023; Wang et al., 2021). In another part,

the influence is estimated as an indirect effect mediated by innovation variables (external agents → innovation → outcomes), with innovation operating as an explicit mediator between external collaboration and performance (Gaglio et al., 2022; Kahn et al., 2022; Peters et al., 2018). In direct models, innovation typically enters as a control variable or is estimated in separate equations, while external agents affect outcomes directly (Cieślik et al., 2018; Mansury & Love, 2008; Thi et al., 2023). Only Hungund et al. (2023) estimate direct and indirect effects within the same model.

To operationalize these relationships, firm survey data (especially CIS and WBES) and structured questionnaires predominate, often using Likert-type scales to measure collaboration intensity and open innovation practices (Doan et al., 2023; Paily, 2018; Spithoven et al., 2010). Estimation approaches concentrate on regressions (including logit/probit), CDM-type models, and PLS-SEM, incorporating control variables and, in some cases, strategies to address endogeneity, such as instrumental variables (Crépon et al., 1998; Doran & Ryan, 2016; Fabrizi et al., 2020). Figure 3 schematically summarizes the elements involved in this measurement process – external agents, innovation, and firm outcomes.

Figure 3

Schematic of measuring the influence of external agents on firm-level innovation outcomes



Source: Prepared by the authors.
Note. CIS (*Community Innovation Survey*); WBES (*World Bank Enterprise Surveys*); CDM (*Crépon–Duguet–Mairesse*); and PLS-SEM (*Partial Least Squares Structural Equation Modeling*).

The SLR also indicates that the same external agent can be modeled either through a

direct path or an indirect path, depending on the analytical design, and that most studies assess multiple external actors simultaneously (Hungund et al., 2023; Kahn et al., 2022; Spithoven et al., 2010). Table 1 summarizes the external agents identified in the corpus and indicates, for each case, whether the influence was modeled as direct, indirect, or both (Hungund et al., 2023).

Table 1

Ways of measuring the influence of external agents on firm-level innovation outcomes

External Agents	Modeling		References (a)
	Direct	Indirect	
Suppliers	X		01, 08, 09, 18, 19, 20, 22
		X	03, 07, 08, 11, 13, 14, 16, 23
Universities	X		01, 08, 09, 18, 19
		X	03, 07, 10, 11, 12, 14, 16
R&D Institutes	X		01, 08, 09, 18, 19, 22
		X	10, 14, 16, 21
Competitors	X		09, 18, 19, 22
		X	03, 07, 12, 13, 14, 16
Customers	X		08, 09, 18, 19, 20
		X	07, 11, 14, 16, 23
Government	X		19, 22
		X	02, 07, 10, 11, 12, 14
Companies	X		01, 04
		X	05, 10, 14, 16, 21
Consultants	X		01, 09, 18
		X	07, 13, 16
Consumers	X		22
		X	03, 12, 13
Conferences	X		19
		X	14
External Partners	X		20
		X	06
Spinoffs	X	X	08
Laboratories	X		09, 18, 19
Technology Intermediary Organizations	X		22
Intellectual Property Organizations	X		22
Venture Capital Investment Corporations	X		22
Distributors	X		22
Fairs	X		19
Exhibitions	X		19
Unrelated Companies	X		22
Subsidiaries		X	13
Joint Ventures		X	13
Non-Commercial Institutions		X	14
Employees		X	17
Others		X	11, 15

Source: Prepared by the authors.
Note. (a) To mitigate subjectivity, the types of agents are presented according to the nomenclature adopted in the respective articles.

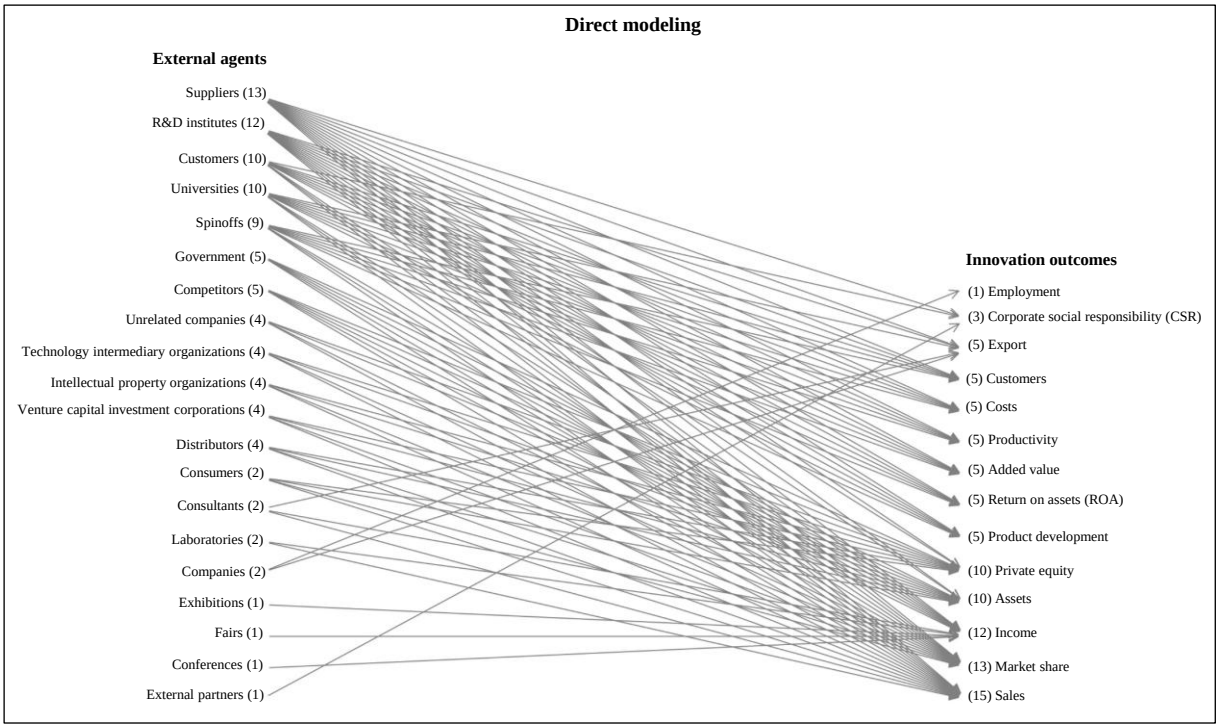
(b) 01 - (Cieślik et al., 2018); 02 - (Doan et al., 2023); 03 - (Doran & Ryan, 2016); 04 - (Fabrizi et al., 2020); 05 - (Gaglio et al., 2022); 06 - (Hassen & Talbi, 2022); 07 - (Hochleitner et al., 2017); 08 - (Hungund et al., 2023); 09 - (Joueid & Coenders, 2018); 10 - (Kahn et al., 2022); 11 - (Kurniawati et al., 2022); 12 - (Lin et al., 2016); 13 - (Mansury & Love, 2008); 14 - (Musolesi & Huiban, 2010); 15 - (Paily, 2018); 16 - (Peters et al., 2018); 17 - (Rangus & Slavec, 2017); 18 - (Santoro, 2017); 19 - (Spithoven et al., 2010); 20 - (Thi et al., 2023); 21 - (Vincenzi & Cunha, 2021); 22 - (Wang et al., 2021); and 23 - (Yunus, 2018).

Table 1 shows that universities, R&D institutes, and government–core TH actors–are among the most recurrent external agents in the models, alongside suppliers, customers, and competitors (Cieślik et al., 2018; Santoro, 2017; Wang et al., 2021). This pattern reinforces that, at the firm level, innovation outcomes are explained by a broad portfolio of external relationships, combining knowledge partnerships and market ties in innovation dynamics (Mansury & Love, 2008; Spithoven et al., 2010; Thi et al., 2023).

In direct models (Figure 4), market outcomes predominate, especially sales/revenues and market share, suggesting that the ability to convert innovation into commercial acceptance is the main indicator of success in the analyzed corpus (Joueid & Coenders, 2018; Thi et al., 2023). Profitability and economic performance measures also appear, albeit less frequently, as a way to capture financial gains associated with external collaborations (Thi et al., 2023; Vincenzi & Cunha, 2021; Wang et al., 2021).

Figure 4

Direct modeling of the influence of external agents on firm-level innovation outcomes



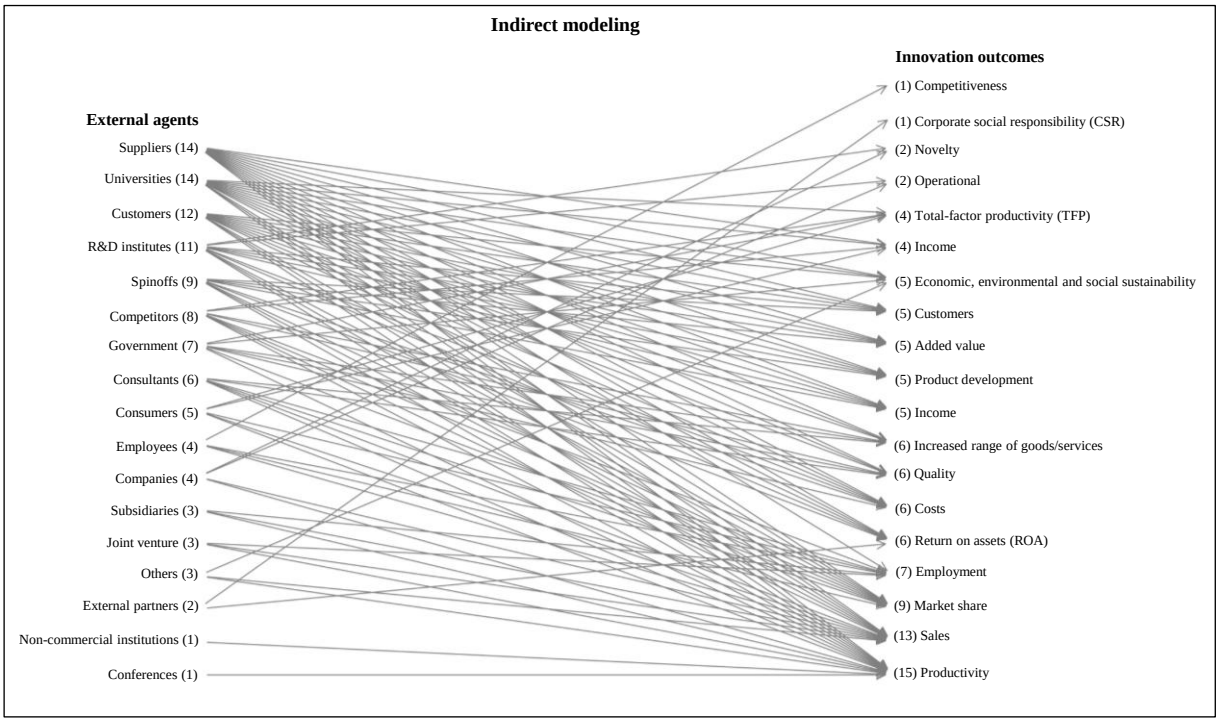
Source: Prepared by the authors.

In indirect models (Figure 5), productivity appears recurrently as an outcome

associated with chains in which external collaboration translates into implemented innovation and, subsequently, into efficiency and performance (Kahn et al., 2022; Musolesi & Huiban, 2010; Peters et al., 2018). In addition to sales and market share, some studies use employment and ROA to capture organizational expansion and asset-use efficiency, respectively, in contexts of innovative success (Hassen & Talbi, 2022; Mansury & Love, 2008).

Figure 5

Indirect modeling of the influence of external agents on firm-level innovation outcomes



Source: Prepared by the authors.

Taken together, these findings describe which outcomes predominate in firm-level measurement, which external agents are most frequently incorporated into models, and which modeling strategies are used to connect external collaboration, innovation, and performance (Cieślik et al., 2018; Kahn et al., 2022; Thi et al., 2023). This descriptive synthesis sets the stage for a discussion of the state-of-the-art limits and the lessons for measurement in Triple Helix contexts, presented in Section 5.

5 DISCUSSION

Within the scope of this SLR, universities, R&D institutes, and government – core actors in TH – are among the external agents most frequently associated with firm-level outcomes (Cieślik et al., 2018; Santoro, 2017; Wang et al., 2021). This pattern is consistent with the literature on innovation systems and ecosystems, in which relationships with

knowledge institutions and government instruments sustain learning processes, knowledge recombination, and innovative trajectories (Granstrand & Holgersson, 2020; OECD/Eurostat, 2018).

However, the way these agents are incorporated into empirical models is predominantly additive and/or bilateral; that is, partners enter as individual explanatory variables, as dimensions of latent constructs of open innovation, or as control variables (Cai & Etzkowitz, 2020; Santoro, 2017; Wang et al., 2021). In this operationalization, functional overlap and the trilateral coupling that the TH literature associates with the notion of synergy are not explicitly modeled at the micro level (Etzkowitz & Leydesdorff, 2000; Ranga & Etzkowitz, 2013). Three-way configurational metrics and game-theory extensions were designed to estimate this coordination surplus at aggregate levels, but this logic is not transferred, in the analyzed sample, to the firm as the unit of analysis (Ivanova & Leydesdorff, 2014; Leydesdorff, 2006, 2021; Mêgnigbêto, 2018). Thus, available evidence advances more in estimating the effect of partners than in measuring the “extra gain” associated with UIG coordination at the micro level (Cai & Amaral, 2022; Leydesdorff, 2006, 2021).

Regarding outcomes, firm-level measurement is operationalized mainly through financial and operational indicators: sales of innovative products, productivity, market share, employment, and profitability/return measures (Cieślik et al., 2018; Kahn et al., 2022; Thi et al., 2023; Wang et al., 2021). In regressions (including CDM), these outcomes generally appear as individual dependent variables; in PLS-SEM, they are often aggregated into latent constructs of organizational or competitive performance (Crépon et al., 1998; Hungund et al., 2023; Kurniawati et al., 2022).

This focus on observable performance is consistent with the recommendation to measure results after implementation, avoiding treating inputs and outputs as equivalents to outcomes (Cirera & Muzi, 2020; OECD/Eurostat, 2018). Still, three limitations recur in the reviewed literature: (i) the distinction between outputs and outcomes is not always made explicit; (ii) intangible dimensions associated with collaboration (learning, networks, capabilities, and reputation) are seldom operationalized; and (iii) cross-sectional designs and short time windows prevail, with limited attention to lags between implementation and effects (Artz et al., 2010; Noble et al., 2023; OECD/Eurostat, 2018; Stundziene et al., 2024).

For research and evaluation in TH contexts, the findings suggest an incremental strategy: start with a lean core set of widely used outcomes (sales, productivity, market share, employment, profitability), but make explicit the status of each measure (output vs. outcome) and incorporate, when feasible, adoption/use indicators and intangible dimensions (Björk et al., 2023; Gault, 2018, 2023; OECD/Eurostat, 2018). This complement is particularly relevant

in collaborative arrangements, where part of the effects manifests as learning, networks, and capabilities that are not fully captured by economic metrics alone (Noble et al., 2023; Smit et al., 2024).

From the standpoint of quantitative strategies, regression and CDM models applied to surveys (CIS, WBES, and similar instruments) are suitable for estimating associations among external collaboration, innovation, and outcomes, but they were not designed to measure trilateral synergy at the micro level (Crépon et al., 1998; Doan et al., 2023; Spithoven et al., 2010). PLS-SEM approaches allow testing indirect relationships and mediation chains (external agents → innovation → outcomes); however, even in these cases, university and government tend to be treated as dimensions of openness/cooperation rather than as a measurable coordination surplus as in configurational metrics (Hungund et al., 2023; Ivanova & Leydesdorff, 2014; Yunus, 2018). Practically, these approaches are valuable for research and ex post evaluation, but translating them into managerial routines requires lighter, interpretable instruments aligned with firms' own decision records (Cirera & Muzi, 2020; Gault, 2018, 2023).

Operationally, the lessons can be summarized along three axes: (i) preserve the distinction among outputs, outcomes, and impacts, focusing on what is effectively captured by the firm after implementation; (ii) adopt lean dashboards that combine financial and non-financial results, avoiding reliance on a single synthetic indicator of "innovation success"; and (iii) transparently record how managers perceive and attribute results to interactions with universities, government, and other partners (Björk et al., 2023; Cai & Amaral, 2022; Dziallas & Blind, 2019; OECD/Eurostat, 2018).

In addition, when the goal is to interpret outcomes as potential effects associated with participation in collaborative Triple Helix (UIG) arrangements, they tend to be more informative when analyzed using comparative designs: compare firms in TH arrangements with similar firms outside such arrangements; compare, within the same ecosystem, different levels of engagement with universities and government; and contrast innovations supported by UIG collaborations with similar innovations developed outside these networks (Doan et al., 2023; Gaglio et al., 2022; Granstrand & Holgersson, 2020).

Taken together, the discussion reinforces the identified gap: despite synergy metrics at aggregate levels and established instruments for firm-level outcomes, there is still a lack of a framework that explicitly connects UIG collaborations, implemented innovation, and outcomes captured by firms (Cai & Amaral, 2022; Dziallas & Blind, 2019; Gault, 2018, 2023; Stundziene et al., 2024). By synthesizing limits and lessons, this SLR offers clues to move in that direction, without extrapolating to a micro-level measurement of synergy that the

literature has not yet consolidated (Cai & Etzkowitz, 2020; Leydesdorff, 2021).

6 RESEARCH AGENDA

Based on the gaps identified in the SLR, Table 2 summarizes nine research suggestions to advance the measurement of firm-level outcomes in collaborative contexts associated with the TH.

Table 2

Research Agenda

Suggestions for future research	Rationale
1. Outcome indicators sensitive to UIG collaboration.	Firm-level outcomes have been operationalized mainly through financial and operational metrics, with lower sensitivity to the specific contribution of UIG collaborations (Cirera & Muzi, 2020; Dziallas & Blind, 2019). Dashboards combining performance, adoption/use, and intangible signals tend to be more informative for TH contexts (Björk et al., 2023; Gault, 2023).
2. Quantitative–qualitative integration for intangible outcomes.	Intangible results and effects distributed over time are poorly captured by isolated metrics (Björk et al., 2023). Combining quantitative indicators with qualitative evidence can strengthen interpretation of learning, reputation, networks, and capabilities (Gault, 2023; Noble et al., 2023).
3. TH microfoundations at the firm level.	Advances in TH have concentrated on macro/meso measurements of interaction and synergy, and their translation into firm-level outcomes is less clear (Cai & Amaral, 2022; Leydesdorff, 2003). Micro-level studies can detail how forms of engagement with university and government relate to post-implementation performance (Cai & Amaral, 2022; Etzkowitz et al., 2023).
4. Consistent operationalization of inputs–outputs–outcomes (Oslo Manual).	Mixing effort (inputs), intermediate outputs, and results (outcomes) hinders comparison and interpretation across studies; consistently applying this distinction is recommended (Dziallas & Blind, 2019; OECD/Eurostat, 2018). Future studies can make trade-offs in the use of proxies explicit and report observable outcomes–sales, productivity, adoption/use, etc. (Cirera & Muzi, 2020; Stundziene et al., 2024).
5. Mediation models: external agents → implemented innovation → outcomes.	Mediation makes it possible to separate direct and indirect effects in the collaborative chain and is consistent with modeling widely used in surveys (Crépon et al., 1998; Hungund et al., 2023). In TH contexts, the agenda is to test how university and government enter the chain and how interaction combinations relate to outcomes (Cai & Amaral, 2022; Cai & Etzkowitz, 2020).
6. Primary data and indicators designed for TH.	Standardized surveys are useful, but may not capture nuances of UIG interaction and managerial attribution of results (Cirera & Muzi, 2020). Primary instruments designed for TH can refine collaboration scales and complement quantitative outcomes with qualitative evidence (Dziallas & Blind, 2019; Gault, 2023).
7. Sensitivity studies: compare operationalizations and techniques.	Different techniques (regression/CDM, PLS-SEM, and related approaches) may yield different results regarding the role of external agents on outcomes; sensitivity studies support more robust choices (Crépon et al., 1998; Yunus, 2018). Systematic comparisons by sector and institutional context can reduce

	interpretive uncertainty (Cai & Amaral, 2022; Stundziene et al., 2024).
8. Comparative designs in TH environments.	To interpret outcomes as potential effects associated with participation in collaborative arrangements, comparative designs (participants vs. non-participants; higher vs. lower engagement) tend to be especially informative (Doan et al., 2023; Gaglio et al., 2022). Such designs make the collaboration-related "increment" more visible without requiring strong causal inference (Granstrand & Holgersson, 2020; Stundziene et al., 2024).
9. Macro–micro bridge: systemic synergy and firm-level outcomes.	Configurational synergy metrics characterize UIG interaction at aggregate levels; one agenda is to investigate how these conditions relate (or not) to firm-level outcomes (Leydesdorff, 2003, 2021). This requires designs that combine aggregate data and microdata while preserving the implemented-innovation criterion (Cai & Amaral, 2022; OECD/Eurostat, 2018).

Source: Prepared by the authors.

7 CONCLUSION

This study analyzed how to measure firm-level innovation outcomes in collaborative arrangements, aiming to extract lessons applicable to Triple Helix contexts. In doing so, it addressed a recurring mismatch in the literature: while there are well-established metrics for synergies at aggregate levels, empirical guidance remains limited on how to connect, at the micro level, UIG interactions to outcomes effectively captured by the firm, especially in the commercialization and diffusion phase.

Within the limits of the analyzed corpus, the influence of external agents (universities, government, and partners) is widely incorporated into explanatory models, but it tends to be operationalized as separate effects, without fully capturing the trilateral and recursive logic that characterizes the TH. In measurement terms, financial and operational indicators predominate, whereas adoption/use dimensions and intangible effects (learning, networks, and reputation) appear unsystematically, constraining understanding of how collaboration translates into firm-level performance.

Theoretically, the article contributes by bringing the TH literature closer to the innovation measurement literature, clarifying that "measuring systemic synergy" and "measuring firm-level outcomes" are distinct yet complementary tasks. Methodologically, the study structures an analytical framework that systematizes collaborative mechanisms and makes explicit analysis strategies consistent with the distinction among effort, implemented innovation, and outcomes, including mediation, comparisons, and attention to time lags.

From a practical standpoint, the findings suggest that the managerial usefulness of measurement can be enhanced through lean dashboards that combine financial metrics with adoption signals and intangible dimensions. For managers in UIG arrangements, the central implication is to strengthen record-keeping discipline and use comparisons that make visible the increment associated with collaboration, reducing reliance on inferences based solely on

inputs and outputs.

As limitations, we highlight the restriction to the Web of Science and Scopus databases and the conceptual heterogeneity of primary studies, which requires caution in generalization. Nonetheless, by systematizing limits, opportunities, and a research agenda detailed in a dedicated section, the article provides concrete inputs for advancing micro-level measurement in Triple Helix contexts, indicating realistic paths to connect collaboration, implementation, and performance.

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