THESISES OF THE DOCTORAL (PhD) DISSERTATION

SUSTAINABILITY AND INNOVATION IN EUROPEAN UNIVERSITIES: EXPLORING THE RELATIONSHIP BETWEEN INSTITUTIONAL INDICATORS AND REGIONAL DEVELOPMENT

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1. INTRODUCTION OF THE TOPICS AND OBJECTIVE

The impetus for this dissertation stems from two decades of professional engagement in the field of innovation management and regional economic development. Empirical observations frequently reveals a pervasive tendency to assess innovation performance in silos, divorced from its broader sustainability dimensions and regional economic footprints. Recognizing this critical gap, the overarching scientific objective of this research is to construct and empirically validate a holistic, multi-level framework. Specifically, this study examines the **structural nexus across three distinct levels**: the *academic intrapreneur* as the micro-level catalyst of innovation; the integrated sustainability and innovation performance of European universities at the meso-*institutional level*; and their subsequent macro-economic spillovers onto the surrounding *regions*.

This paradigm shift is deeply intertwined with the 21st-century transformation of higher education. Modern universities are now expected to transcend traditional academic boundaries, functioning not only as "entrepreneurial universities" that actively propel regional economic growth (Clark, 1998; Etzkowitz, 1983; Guerrero & Urbano, 2012b) but also fulfilling a "third mission" anchored in broader societal and community engagement (Etzkowitz & Leydesdorff, 2000; Zomer & Benneworth, 2011). European Union policy frameworks have continuously reimagined this institutional role, evolving from the knowledge-based economy vision of the Lisbon Strategy (European Council, 2000), through the Smart Specialization paradigm (Foray et al., 2009), to the New European Innovation Agenda (European Commission, 2022). Throughout this evolution, higher education institutions are increasingly recognized as "bridging institutions"—vital conduits connecting global knowledge with local markets and serving as cornerstone actors within regional ecosystems (Benneworth & Fitjar, 2019; Benneworth, 2018; McCann & Ortega-Argilés, 2015).

Despite these policy imperatives, the prevailing theoretical landscape remains highly fragmented. Established models frequently fail to assimilate sustainability considerations into the operational framework of entrepreneurial universities. Consequently, there is a critical empirical blind spot regarding how integrated institutional performance translates into regional economic outcomes, particularly when viewed through the lens of the center-

periphery dichotomy (i.e., EU15 versus EU13, and high versus low population density regions). The central thesis of this dissertation posits that the true efficacy of a "Sustainable Entrepreneurial University" can only be deciphered through the symbiotic interplay of micro (individual), meso (institutional), and macro (regional) dimensions.

To operationalize this overarching objective, the research is structured around three specific objectives (Table 1):

- **O1:** To map the conceptual evolution and underlying networks of academic intrapreneurship via systematic bibliometric analysis.
- **O2:** To quantitatively evaluate the integrated innovation and sustainability performance of European universities in conjunction with their global ranking trajectories, utilizing PLS-SEM.
- **O3:** To model the complex structural nexus between institutional characteristics and macro-level regional socio-economic indicators across NUTS 2 regions.

While the regional economic footprint of the traditional entrepreneurial university is extensively documented (Guerrero et al., 2015, 2016), the macro-economic evaluation of the "Sustainable Entrepreneurial University" (Cai & Ahmad, 2023; Guerrero & Lira, 2023) represents a nascent research frontier. This dissertation addresses this lacuna by infusing the classic entrepreneurial paradigm with a rigorous sustainability dimension, directly modeling the pathways through which composite institutional performance dictates regional economic development.

Methodologically, this research breaks new ground through the empirical fusion of distinct analytical levels. By traversing this scalar divide, I first trace the evolving academic discourse surrounding the intrapreneur; subsequently, I evaluate the organizational performance of European universities through a Higher-Order Construct (HOC) model; and finally, I tether institutional metrics directly to NUTS 2 regional datasets. To the best of my knowledge, the deployment of such a comprehensive PLS-SEM architecture is entirely unprecedented at this specific intersection of sustainability, innovation, and regional impact studies.

Table 1: The research objectives, research questions and hypotheses

Objective	Research question	Hypothesis	Indicators and methods used during the research
O1: Bibliometric profiling of the role of academic intrapreneurship	Q1.1: What are the foundational research trajectories and conceptual nodes at the intersection of academic intrapreneurship and entrepreneurial universities?	–	Method: Bibliometric Analysis Metrics: Annual Scientific Production, Trend Topics, Three-field Plot, Authors' Keywords (via Biblioshiny).
	Q1.2: Which key authors, journals, and networks architect the academic discourse?	–	Three-field Plot (Journal-Author-Keyword), Authorship network (Biblioshiny)
	Q1.3: How has the thematic structure of intrapreneurship evolved, and what novel paradigms have emerged?	–	Thematic map (Biblioshiny)
O2: Comparative assessment of the nexus of innovation and sustainability performance of European universities	Q2.1: What is the structural relationship between global rankings, innovation output, and sustainability performance?	H2.1: Global institutional ranking position exerts a significant positive effect on innovation performance.	Method: PLS-SEM. Latent Constructs & Indicators: Rankings: THE/QS overall scores Innovation: Patents, spin-offs. Research: Research Quality/Environment, Industry; International Networks: THE International Outlook Sustainability: SDG alignment, UI GreenMetric, QS Sustainability.
		H2.2: Institutional innovation performance is a significant positive predictor of sustainability outcomes.	Method: PLS-SEM. Innovation: number of patents and spinoffs; Research: Research environment, Research quality, Industry; International Networks: THE International Outlook, H2020 partnerships Sustainability: SDG, UI, QS_Sustain
	Q2.2: To what extent do international research networks and industrial embeddedness drive innovation?	H2.3: High innovation performance is significantly driven by robust participation in international research networks (e.g., H2020) and sustained industrial collaborations.	Method: PLS-SEM. Innovation: number of patents and spinoffs; Research: Research environment, Research quality, Industry; International Networks: THE International Outlook, H2020 partnerships, Sustainability: SDG, UI, QS_Sustain
	Q2.3: Are there structural spatial asymmetries (core-periphery) in the performance of EU15 versus EU13 universities?	H2.4: Core region (EU15) universities exhibit significantly higher baseline innovation and sustainability capacities than peripheral (EU13) institutions.	Method: PLS-SEM & Multi-Group Analysis (MGA) Comparison of THE / QS /H2020 indicators by country groups

Objective	Research question	Hypothesis	Indicators and methods used during the research
		H2.5: Global institutional ranking position exerts a significant positive effect on sustainability performance.	Method: PLS-SEM. Latent Constructs: Ranking indicators → Sustainability outcomes.
O3: Quantitative analysis of the macroeconomic spillover effects of university characteristics	Q3.1: What is the macroeconomic impact of institutional performance on regional economic vitality?	H3.1: Institutional performance (academic excellence) exerts a significant, positive impact on regional macroeconomic indicators.	Method: PLS-SEM. Econ: GDP/capita, income/capita, Youth employment; Uni: THE Research environment, Research quality, Industry, International Outlook, QS Academic Reputation, Employer Reputation, International Faculty, International Research Network, Employment Outcomes
	Q3.2: How does university performance correlate with the broader scientific, educational and innovative absorptive capacity of the region?	H3.2: The quality of universities is positively correlated with the innovation and education indicators of the region. Institutional performance is positively correlated with the regional scientific, educational and innovation absorptive capacity.	Method: PLS-SEM. Regedsci: Student ratio, Graduate ratio, University Researchers, University R&D expenditure (EUR/person), HRST rate Uni: THE Research environment, Research quality, Industry, International Outlook, QS Academic Reputation, Employer Reputation, International Faculty, International Research Network, Employment Outcomes (PLS-SEM)
		H3.3.: High regional population density (hub regions) acts as a positive structural condition for advanced institutional and sustainability performance.	Method: PLS-SEM. & Multi-Group Analysis (MGA) population density (PLS-SEM /MGA)
	Q3.3: Is the sustainability performance of universities related to the economic activity of the region?	H3.4: Institutional sustainability performance generates positive macroeconomic spillover effects for the region.	Method: PLS-SEM. Econ: GDP/capita, income/capita, Youth employment; SDGs, QS_Sustain (PLS-SEM)

Source: Author's own compilation.

2. DESCRIPTION OF THE DATABASE AND APPLIED METHODOLOGY

In pursuit of the dissertation's objectives, a two-phase, mixed-methods research design was operationalized. The investigation is structured along a distinct scalar continuum, transitioning systematically from a micro-level theoretical baseline (O1), through the quantification of meso-level institutional performance (O2), to the empirical modeling of macro-level regional outcomes (O3) (Figure 1).

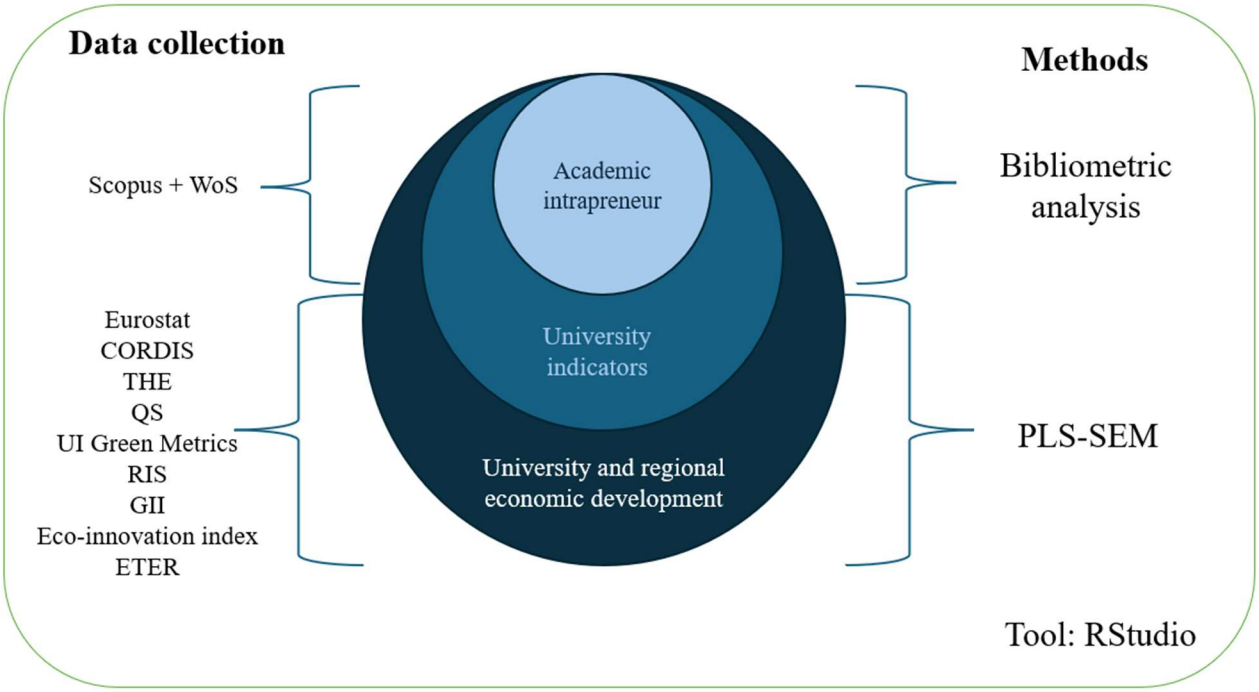

Figure 1: The structure of the research

Source: Author's own compilation.

2.1. Bibliometric Analysis (O1)

To systematically map the intellectual landscape of academic intrapreneurship, a comprehensive literature retrieval was conducted using the foremost multidisciplinary databases, Scopus and Web of Science (Wilder & Walters, 2021). Employing the targeted search string (“intrapreneur*” AND “entrepreneurial universit*”), and following rigorous data curation and deduplication protocols, a final corpus of 408 documents was established, covering the 1990–2024 timeframe. Network visualization and thematic analyses were subsequently performed utilizing the *Bibliometrix* package (via the Biblioshiny interface) within the R environment (Aria & Cuccurullo, 2017).

2.2. The PLS-SEM Database and MICE-CART Imputation

For the empirical construction of the quantitative models (O2, O3), secondary macro- and meso-level data were harvested from universities across the European Economic Area (EEA) and their corresponding geographic regions. This sampling strategy deliberately reflects the contemporary strategic imperatives facing European higher education (Draghi, 2024; Letta, 2024). By isolating the intersection of the 2024 THE and QS global ranking databases, a definitive institutional cohort of 301 universities (N=301) was delineated (Figure 2). This sample size not only substantially surpasses traditional heuristic minimums (such as the 10-times rule) but also—in strict alignment with the latest guidelines by Hair et al. (2022)—guarantees an 80% statistical power, ensuring the robust detection of even the nuanced, small effect sizes inherent to regional economic impacts.

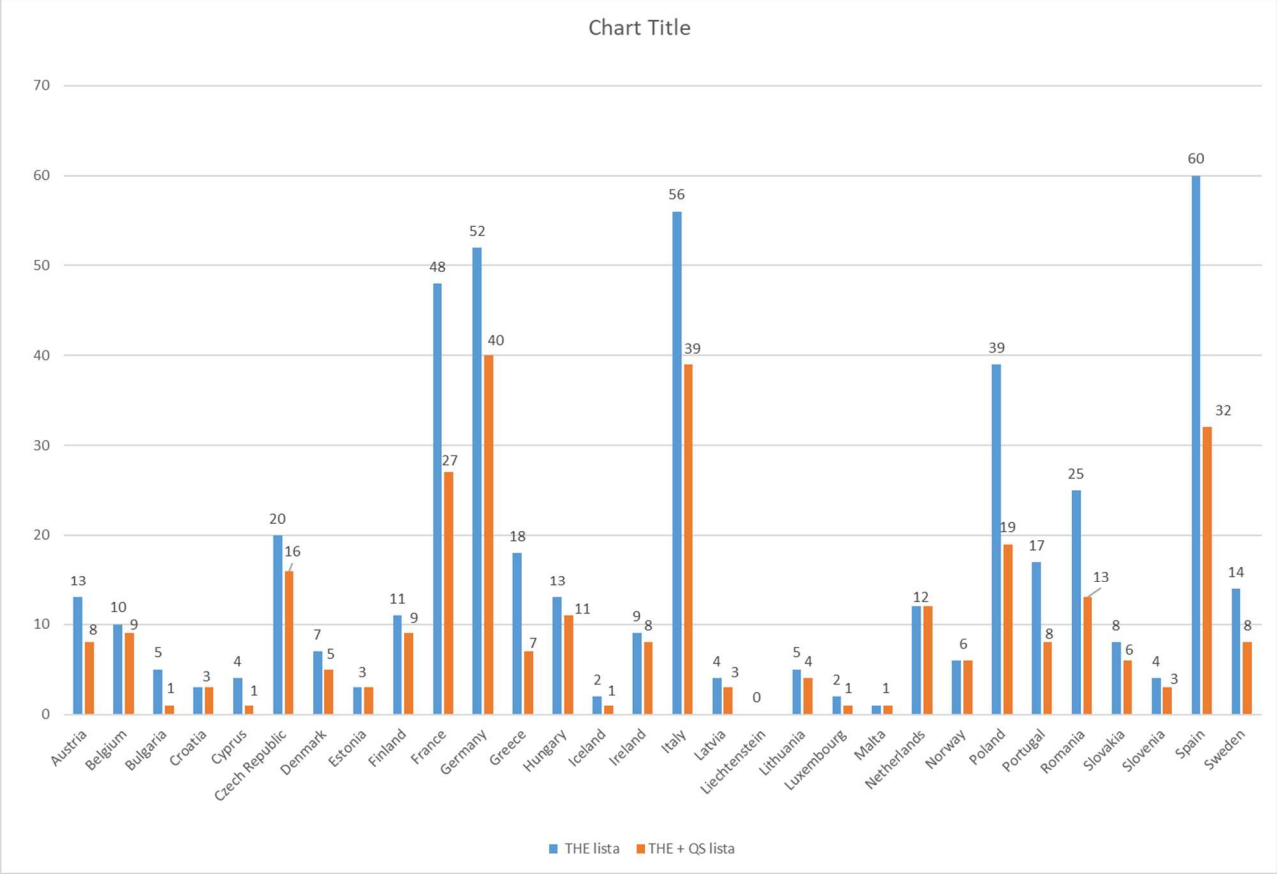

Figure 2: Number of universities in THE and QS lists by country in the European Economic Area (EEA) (2024)

Source: Author's own compilation.

To eliminate Common Method Bias (Podsakoff et al., 2003, 2012), I diversified the data sources (Eurostat, Cordis H2020, RIS, GII, DeepTech) (Table 2).

Table 2: The structure of the database

Database /Source	Category	Collected indicators
University data (THE and QS databases and ETER)	Institutional characteristics	University name Type (public/private) Year of foundation Name of the region and NUTS codes
EUROSTAT	Regional demographic data	Population Area - km² Structure of the population: Median age, Total fertility rate, Median age of women at childbirth
EUROSTAT	Regional economic data	GDP per inhabitant Gross value added - GVA Adjusted disposable income of households
EUROSTAT	Regional educational data	Students enrolled in Higher Education in % of population Early leavers from education, 18-24 Population with tertiary education, 25-64 NEET rate (Not in Education, Employment, or Training), ages 15-34
EUROSTAT	Regional Science and Technology	R&D personnel, researchers in HE GERD by sector HEI, EUR/inhabitant Employment in high-technology sectors HRST - Persons with tertiary education/employed in S&T
Regional Innovation Scoreboard (RIS)	Regional innovation	Performance group Innovation index - NUTS2
THE World University Rankings	Global ranking *(WUR Performance)*	Ranking Number of students, student/staff Partial scores: Teaching, Research env., Research quality Industry, International outlook Overall
THE Impact Rankings	*Sustainability impact / SDGs*	Overall Score & Rank SDG scores 1–17
QS World University Rankings	Global ranking	QS Ranking & Score Academic & Employer Reputation Faculty Student ratio Citations per Faculty Int. Faculty/Students) Int. Research Network) Employment Outcomes Sustainability

Database /Source	Category	Collected indicators
Global Innovation Index (GII)	National innovation performance	GII Total Score Pillars: Institutions, Human capital & research, Infrastructure, Market/Business sophistication, (Knowledge & tech outputs, Creative outputs
UI Green Metrics	Global ranking for universities' sustainability performance	Overall score Setting and Infrastructure Energy and Climate Change Waste Water Transportation Education and Research
Eco-Innovation Index	Eco-innovation	Country level index 2024
CORDIS (EU)	H2020 projects *(Research Funding)*	Number of projects EU funds Total budget Funding intensity Role in the project: Coordinator, Partner / Participant, Third party

Source: Author's own compilation.

To systematically address the missing data observed across specific indicators within the raw dataset (e.g., granular SDG scores), a multi-staged imputation protocol was implemented. Variables were explicitly excluded from the analysis only if the availability of genuine data fell below the 20% threshold (i.e., a missingness rate exceeding 80%). Beyond this extreme threshold, imputation risks generating purely speculative variance; thus, exclusion was imperative to prevent imputation bias and the artificial distortion of variance (C. K. Enders, 2022; Van Buuren, 2018). For the retained variables, missing values were synthesized utilizing the Multiple Imputation by Chained Equations (MICE) framework within the R environment (Guild, 2021; Van Buuren & Groothuis-Oudshoorn, 2011). Crucially, eschewing traditional mean-based imputation—which artificially compresses data variance—this study deployed the decision tree-based Classification and Regression Trees (CART) algorithm (Bocci et al., 2024; Hayes & McArdle, 2017). This non-parametric approach offers profound robustness: it circumvents the assumption of a normal distribution and remains fundamentally immune to the high multicollinearity inherent among the evaluated indicators (Templ, 2023; Rodgers et al., 2021; Akande et al., 2017). Finally, predictive accuracy was maximized by incorporating external regional covariates—specifically population density, RIS, and the Eco-Innovation Index—the validity of which is corroborated by the results visualized in Figure 3.

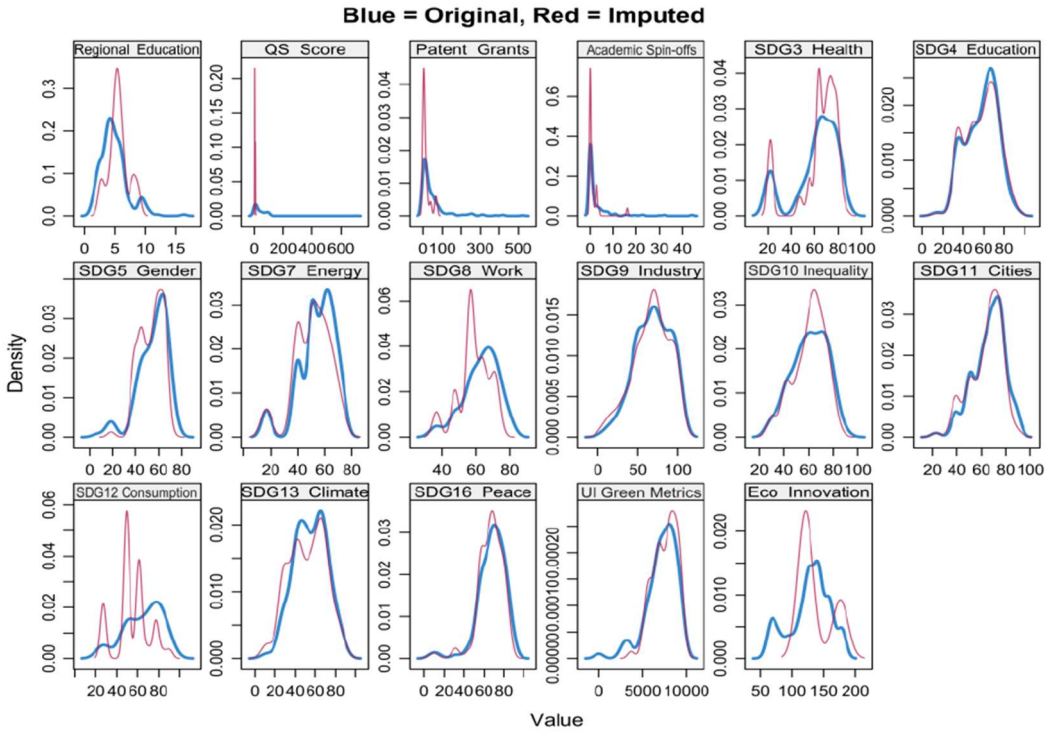

Figure 3: Density distributions of observed (blue) vs. imputed (red) variables using the CART method

Note: The alignment of the curves demonstrates that the non-parametric imputation preserved the variance and distributional characteristics of the original indicators, particularly for skewed variables like patent grants and spin-offs.

Source: RStudio (2026)

2.3. Justification of the PLS-SEM Methodology

For the analysis of the refined data matrix, Structural Equation Modeling (SEM) was employed (Guerrero & Urbano, 2012b), allowing for the concurrent evaluation of both measurement models and structural pathways (J. Hair et al., 2017). Driven by the dual objectives of theory building and the maximization of predictive power, the variance-based Partial Least Squares (PLS-SEM) algorithm (Wold, 1975, 1982) was deliberately selected over the traditional covariance-based (CB-SEM) paradigm. As a non-parametric, distribution-free methodology, PLS-SEM is exceptionally equipped for the stable estimation of complex, highly dimensional architectures that incorporate formative indicators (J. F. Hair, Black, et al., 2019; Dijkstra & Henseler, 2015).

2.4. The O2 Model: Rankings, Innovation, and Sustainability

The initial iteration of the O2 model was built on five theoretically distinct, reflective (Mode A) constructs (Figure 4).

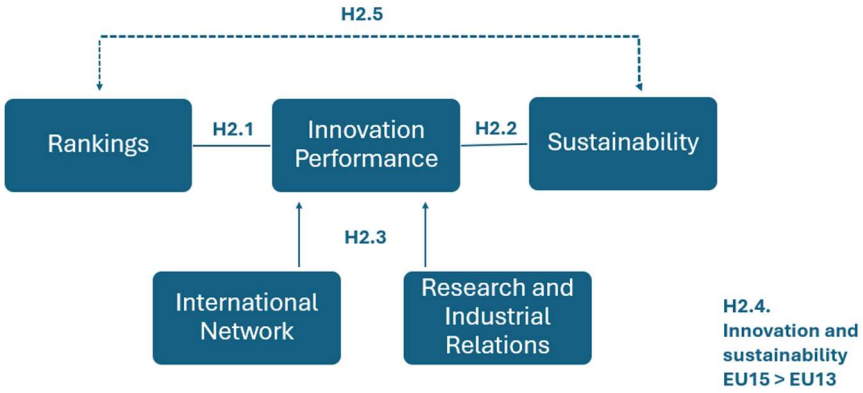

Figure 4: The Initial Hypotheses of the Structural Nexus between University Innovation and Sustainability

Source: Author's own compilation.

However, preliminary diagnostic assessments revealed that the Heterotrait-Monotrait (HTMT) ratio (Henseler et al., 2015) breached critical thresholds across multiple relational pathways. This empirically corroborated a fundamental lack of discriminant validity, demonstrating that within the European higher education landscape, research excellence, international embeddedness, and innovation output are organically intertwined, which is a structural manifestation of the "Matthew effect" (Merton, 1968). To resolve this structural multicollinearity, the PLS-SEM "Two-Stage Approach" was implemented, synthesizing these overlapping variables into a cohesive, formative (Mode B) Higher-Order Construct (HOC: *Uni_Performance*) (J. F. Hair, Risher, et al., 2019; Sarstedt et al., 2019). Furthermore, structural disparities between geopolitical cohorts (EU13 versus EU15) were systematically mapped utilizing Multi-Group Analysis (MGA) alongside exact permutation tests. The resulting integrated model architecture is depicted in Figure 5.

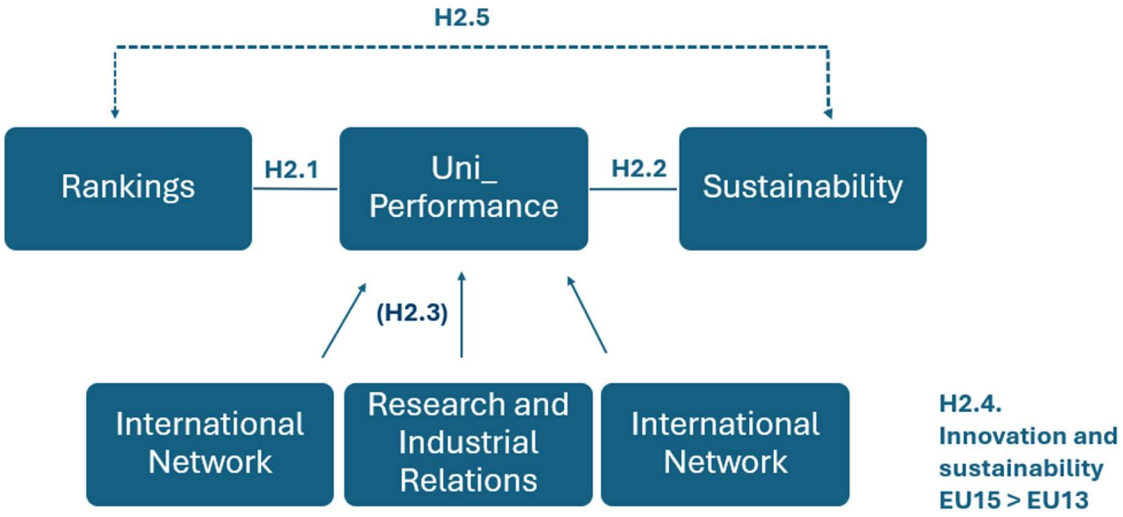

Figure 5: The Validated Structural Nexus Between University Innovation and Sustainability

Source: Author's own compilation.

2.5. The O3 Model: Universities and Regional Development

The final phase of the research design (O3) focused on modeling the structural nexus between the institutional-level metrics of European universities (encompassing rankings, innovation, and sustainability) and the macroeconomic vitality of their respective NUTS 2 regions (captured via GDP per capita, R&D expenditure, and regional educational statistics). The empirical evaluation of these macroeconomic spillover effects is of critical importance, given that the regional embeddedness of universities fundamentally conditions the ultimate efficacy of broader European policy frameworks, including EU cohesion initiatives and the targeted interventions of the European Green Deal (European Commission, 2019). A comprehensive operationalization of the latent constructs formulated within the O3 model is provided in Table 3.

Table 3: Indicators used for the analysis of O3 model

Construct	Measurement Type	Description and Component Indicators	Data Source
Econ ***(Endogenous)***	Reflective	**Regional Economic Development** A latent variable measuring regional prosperity and productivity. • **econ1:** GDP at current market prices (EUR/capita, 2022) • **econ3:** Adjusted gross disposable income (EUR/capita, 2021) • **reged4:** NEET rate (ages 15-34, inverted)	Eurostat (NUTS 2)
Uni	Reflective	**Aggregate Institutional Performance** A synthesis of ranking-based reputational and performance metrics.	THE, QS World Univ. Rankings

		• **THE:** the3, the4, the5, the6 • **QS:** qs1, qs2, qs5, qs7, qs8	
Regedsci	Reflective	**Regional Knowledge Capacity** The educational and R&D human capital potential of the region. • **reged1, reged3:** Proportion of population with tertiary education • **regsci1, regsci2, regsci4:** R&D personnel and expenditures	Eurostat
H2020_innov	Reflective	**Innovation Intensity** Institutional activity in international R&D&I projects and industrial output. • **H2020:** Number of projects (h2, h4, h5) • **Output:** Number of patents granted (patgrant), Number of spin-off companies	Cordis, Deep Tech
SDG_soc	Formative	**Social Sustainability** SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 16 (Peace, Justice and Strong Institutions)	THE Impact Rankings
SDG_env	Formative	**Environmental Sustainability** SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action)	THE Impact Rankings
SDG_econ	Formative	**Economic Sustainability** SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities)	THE Impact Rankings

Source: Author's own compilation

Given the multidimensionality of the regional indicators (e.g., economic vitality, educational attainment), model stability was safeguarded through a hybrid—reflective and formative—measurement specification. The PLS-SEM algorithm provides a highly specialized methodological framework explicitly designed to accommodate such complex operationalizations (J. F. Hair, Risher, et al., 2019). Furthermore, hypothesis testing and the exploration of structural heterogeneity were executed via Multi-Group Analysis (MGA), stratifying the sample by population density. This analytical approach facilitated the precise identification of divergent path magnitudes and significance levels across the different spatial cohorts. The comparative evaluation was structured across a dual-tier framework: (1) descriptively, by contrasting the central tendencies and dispersions (means and standard deviations) of the latent constructs, and (2) inferentially, by deploying the PLS-MGA permutation test to statistically validate significant divergences between the structural path coefficients.

3. MAIN FINDINGS OF THE DISSERTATION

3.1. Intrapreneurship at universities

To systematically delineate the evolving role of the academic intrapreneur, this investigation addressed three fundamental inquiries. Drawing upon the curated corpus, the bibliometric mapping examined: (1) the temporal evolution of research trajectories via keyword co-occurrence, (2) authorial impact and collaborative clustering dynamics, and (3) the prospective frontiers of the field as delineated by thematic mapping.

The bibliometric corpus comprised 408 documents with a remarkably low mean age of 4.34 years, underscoring the acute contemporary relevance and novelty of the domain. Publication volume over the preceding five-year period has demonstrated an exponential proliferation, surpassing the historic scientific growth rates (i.e., doubling every 10–15 years) postulated by Price's general model of scientific growth (Bornmann et al., 2021; Fortunato et al., 2018; Price, 1963). The temporal distribution traces a classic exponential growth trajectory, highly characteristic of rapid innovation diffusion.

A longitudinal evaluation of the literature reveals three distinct evolutionary phases:

1. **Incubation Phase (1990–2008)**: This foundational era was characterized by highly fragmented, exploratory research initiatives. The genesis of the discourse is widely attributed to Ralston (1990), whose case-based examination of the "academic entrepreneur" acted as a critical catalyst for conceptualizing the entrepreneurial university. This development emerged against the backdrop of Etzkowitz's (1983) foundational entrepreneurial paradigm and preceded Clark's (1998) seminal framework, which posited an integrated entrepreneurial culture as a core institutional pillar. Consequently, this era was dominated by the pedagogical dimensions of entrepreneurship (Heinonen et al., 2007; Pittaway & Cope, 2007), ultimately leading to Kirby's (2006) pioneering University of Surrey case study, which formally introduced the modern concept of academic intrapreneurship.
2. **Consolidation Phase (2009–2014)**: Coinciding with the aftermath of the 2008 global economic crisis, this secondary phase witnessed a strategic pivot. Moving beyond purely pedagogical confines, academic focus expanded into the rigorous mechanisms of technology and knowledge transfer (Bicknell et al., 2010; Guerrero & Urbano,

2012a). This period was defined by a concerted scholarly effort to establish unified definitions (Cantaragiu, 2013) and robust conceptual models (Nayyar & Naqvi, 2013; Kirby et al., 2011; Woollard, 2010), while simultaneously introducing social entrepreneurship as a nascent area of academic inquiry (Kacperczyk, 2013).

3. **Expansion and Diversification Phase (2015–present):** Over the past decade, intrapreneurship within the university context has solidified into a highly dominant research trajectory. While absolute definitional consensus remains elusive, the most profound conceptual shift of this contemporary era is the systemic integration of sustainability. Notably, 14.9% of the recent corpus explicitly anchors intrapreneurial activity to sustainability frameworks. Modern scholars increasingly couple this intersection with advanced innovation capabilities (Muñoz & Cohen, 2018; Nair & Bhattacharyya, 2022; Ndubuka & Rey-Marmonier, 2019; Terán-Yépez et al., 2020) or embed it directly into the operational architecture of the Business Model Canvas (Pepin et al., 2024).

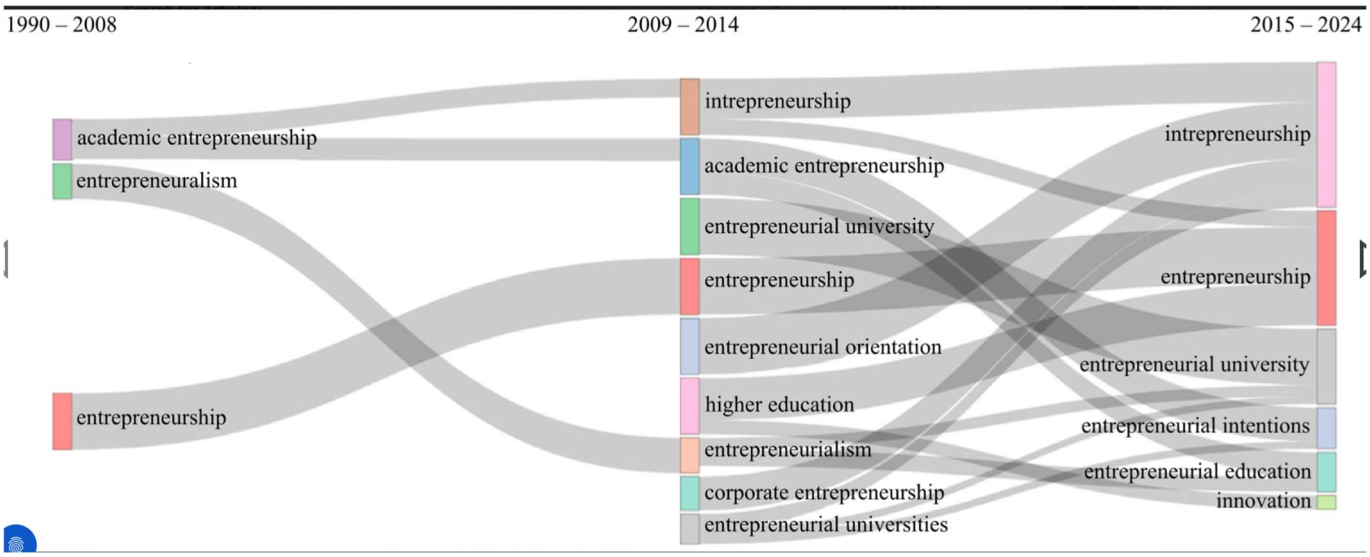

Figure 6: Evolution of research keywords in the three stages

Source: Biblioshiny (2024)

Stratifying the keyword clusters across the three previously delineated evolutionary phases (Figure 6) reveals a distinct trajectory of conceptual maturation. During the initial Incubation Phase, scientific discourse was predominantly anchored in broad, foundational constructs. Transitioning into the Consolidation Phase (2009–2014), the literature underwent pronounced structural differentiation, characterized by the crystallization of

specialized terminology. Ultimately, the Expansion and Diversification Phase (2015–2024) is defined by. As visually corroborated by the network diagrams, “intrapreneurship”.

Stratifying the keyword clusters across the three previously delineated evolutionary phases (Figure 6) reveals a distinct conceptual maturation. During the Incubation Phase, the scientific discourse was predominantly anchored in broad, foundational constructs. Transitioning into the Consolidation Phase (2009–2014), the literature underwent pronounced differentiation, characterized by the crystallization and specialization of terminology. Ultimately, the Expansion and Diversification Phase (2015–2024) is defined by consolidation around key thematic hubs. Visually corroborated by the network diagrams, “intrapreneurship” exhibits high network centrality, evolving into the primary hub of the conceptual architecture and establishing intrapreneurial behavior as the foundational pillar of contemporary entrepreneurial university research.

The bibliometric landscape also demonstrates acute publication and authorial concentration (Figure 7) Aligning with Bradford’s Law of Scattering, the analysis identified a highly concentrated core of only three journals that account for the highest-frequency publications (>8 manuscripts) by the field’s most prolific scholars. This clustering phenomenon is predominantly driven by the robust co-authorship network between Guerrero and Urbano. Furthermore, despite significant variance in the absolute volume of keywords deployed by individual authors, overarching conceptual cohesion is robust. This is evidenced by a shared scholarly lexicon, wherein prominent researchers consistently anchor their empirical work to a core set of four primary keywords.

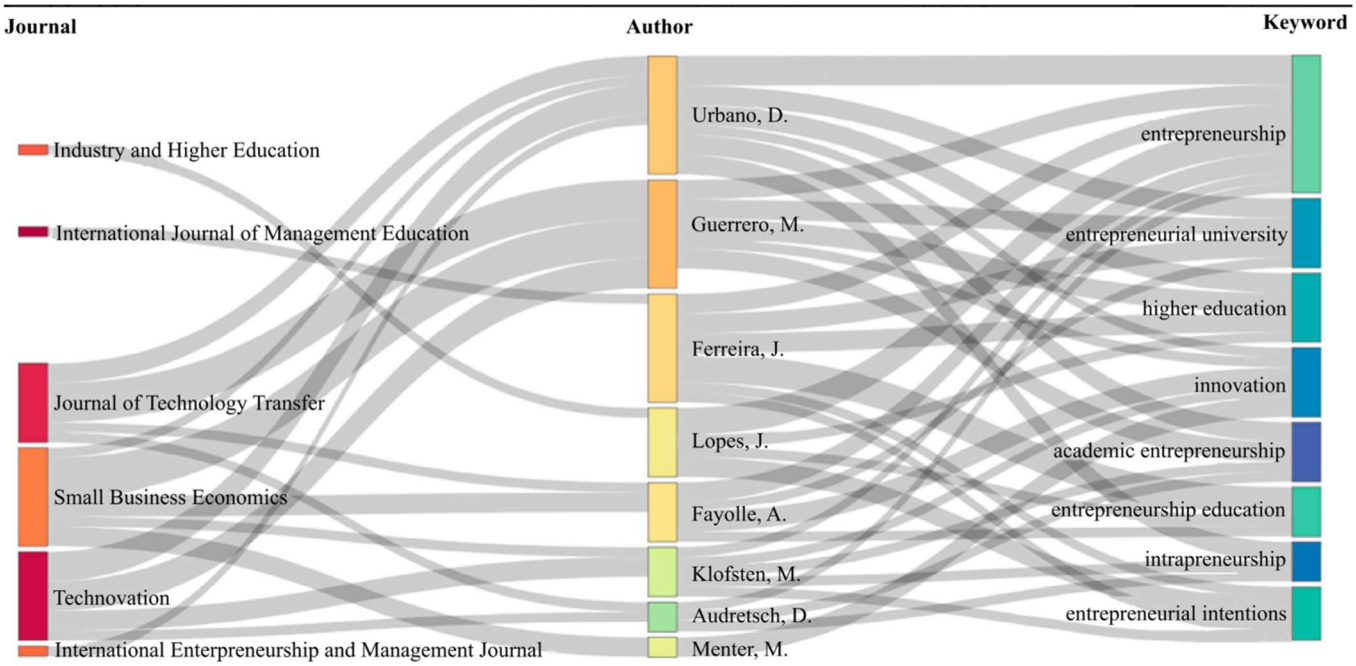

Figure 7: Sankey diagram of journals, authors and keywords

Source: Biblioshiny (2024)

Looking forward, strategic thematic mapping (Figure 8) prognosticates that the future trajectory of this research domain hinges upon convergence. Specifically, the field is poised to integrate the robust, classical theoretical foundations of knowledge transfer and academic entrepreneurship models with the emergent, transformative, novel paradigms of sustainability and digitalization.

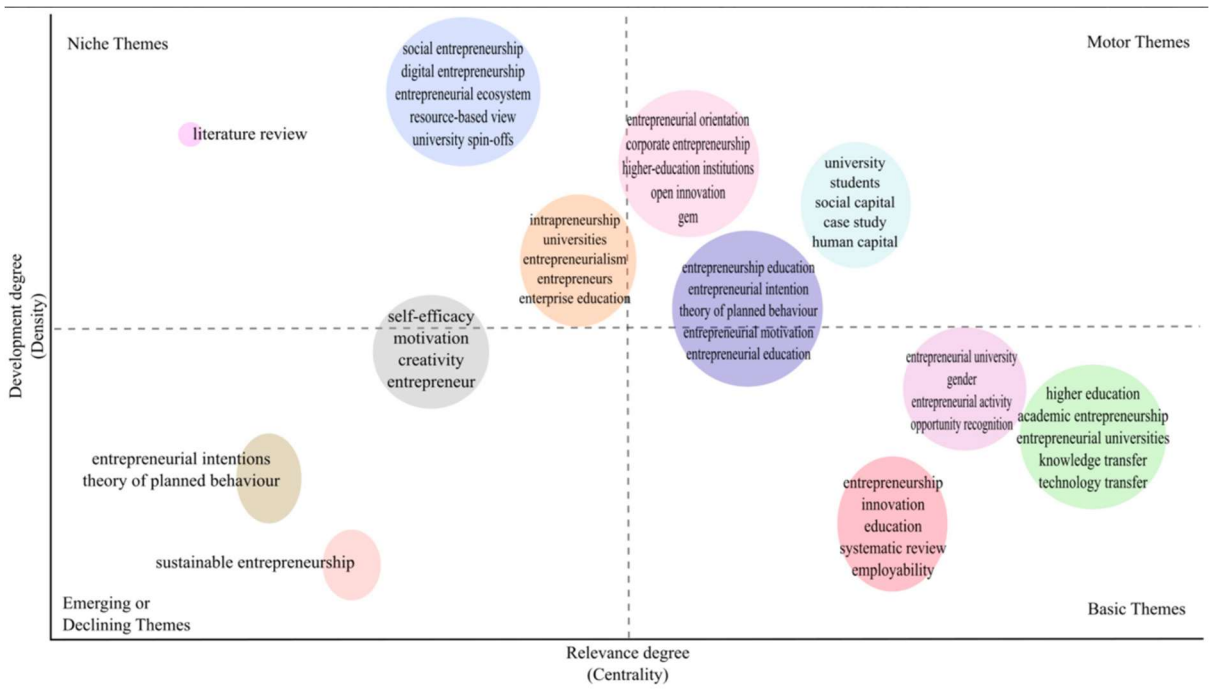

Figure 8: Thematic map

Source: Biblioshiny (2024)

3.2. Ranking, innovation and sustainability

Preliminary diagnostic evaluation of the baseline model exposed structural limitations, necessitating the implementation of a Higher-Order Construct (HOC) architecture. Within this finalized framework, the *Uni_Performance* HOC successfully synthesizes three conceptually overlapping Lower-Order Constructs (LOCs): *Research*, *Internat*, and *Uni_innov (*Figure 9*)*.

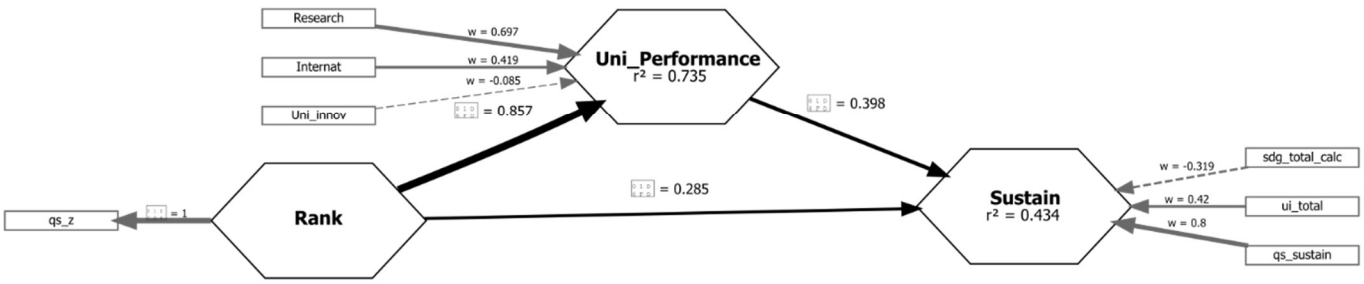

Figure 9: The Structural Nexus of Ranking Performance, Innovativeness, and Sustainability across European Universities

Source: RStudio (2026)

Table 4 summarizes the results of the hypothesis testing for the O2 model.

Table 4: Empirical Evaluation of the Hypotheses for the O2 Model

Hypothesis	Path / Relationship	Result (β) (T-stat)	Decision	Interpretation / Conclusion
H2.1	Rank → Uni_Perf	β = 0.857* (T = 61.870)	Supported	**Matthew Effect:** Global ranking position and institutional performance are intrinsically linked. There is a robust overlap between ranking methodologies and substantive academic excellence (research and innovation).
H2.2	Uni_Perf → Sustain	β = 0.398* (T = 4.544)	Supported	**Synergy:** Contradicting the decoupling assumptions prevalent in the literature, the full sample data demonstrate that universities with high *Uni_Performance* effectively leverage their capacities (Resource-Based View) to achieve sustainability targets. "Green" performance is deeply embedded in core operations.

H2.3	Research / Internat → Uni_Innov	HTMT = 0.947 *(Based on diagnostics)*	Supported#	**Conceptual Unity:** Diagnostic tests reveal that research and innovation do not function as isolated processes. The statistical association is so profound that synthesizing them into a unified performance construct (*Uni_Performance*) was justified (validated via HOC implementation).
H2.4	EU15 vs. EU13 (MGA)	Structural divergence	Supported	**"Two-Speed Europe":** A clear manifestation of disparate operational logics between the two cohorts. While external ranking pressure still dominates in the EU13 region (decoupling), internal professional performance serves as the primary catalyst for sustainability in EU15 universities (organic development).
H2.5	Rank → Sustain *(Total Effect)*	β = 0.626* (T = 8.272)	Supported	**Reputational (Halo) Effect:** While higher-ranked universities are systemically evaluated as more sustainable—partly due to enhanced visibility and institutional prestige—sustainability outcomes are increasingly driven by substantive actual performance rather than mere perception.

*Notes: *p < 0.001*

#The evaluation of Hypothesis H2.3 was conducted via discriminant validity diagnostics (HTMT criterion) within the measurement model, rather than through structural path coefficients (Henseler et al., 2015).

Source: Author's own compilation.

The outcomes of the Multi-Group Analysis (MGA) (Table 5, Figures 8 and 9) reveal that while core-region (EU15) institutions exhibit systemically higher median values, there is significant regional heterogeneity in the structural logic driving sustainability performance. The model empirically substantiates the asymmetrical relationship between institutional reputation and sustainability: whereas in advanced regions sustainability is driven by substantive institutional performance (core competencies), the periphery is dominated by mere ranking-driven prestige (the halo effect).

Table 5: Multi-Group Analysis (MGA) Results: Structural Disparities Between EU13 and EU15 Cohorts

Structural Path	EU13β (T-value)	EU15β (T-value)	Structural Diagnostics & Interpretation
Rank → Uni_Performance	0.815	0.825	**No significant divergence.** The relationship between global ranking position and actual institutional performance is deterministic in both

	(26.901)	(36.243)	macro-regions. The structural validity of performance measurement exhibits no spatial asymmetry.
Rank → Sustain	0.533 (2.364)	0.142 (0.802)*	**Significant divergence.** In the EU13 cohort sustainability metrics are heavily distorted by compensatory legitimacy-seeking and a reputational *halo effect*. Conversely, in the EU15, mere prestige exerts no statistically significant impact on sustainability scores (the halo effect is neutralized).
Uni_Performance → Sustain	0.174 (0.629)*	0.447 (1.823)	**Significant divergence.** In the EU15, actual institutional performance is organically integrated into sustainability outcomes (Resource-Based View). In the EU13, this causal nexus is non-significant, providing unequivocal empirical evidence for institutional decoupling (symbolic compliance).

*Note: * T-values fail to reach the critical threshold of 1.96, indicating a non-significant path [p > 0.05].*

Source: Author's own compilation and computation via RStudio.

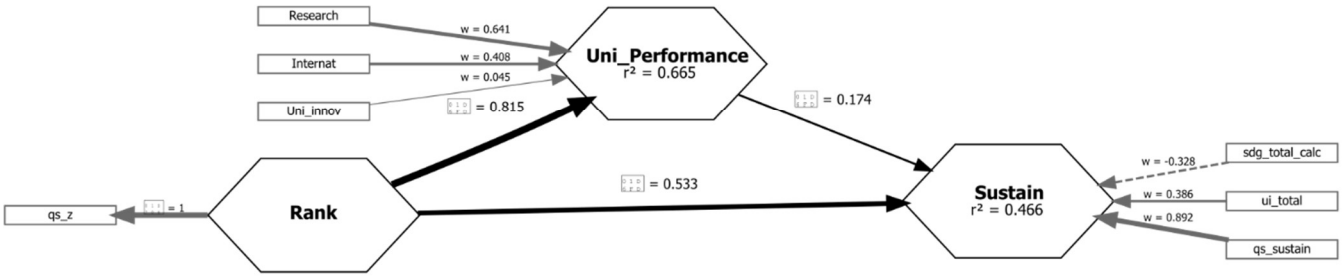

Figure 10: The Structural Nexus of Ranking Performance, Innovativeness, and Sustainability of EU13 Universities

Source: RStudio (2026)

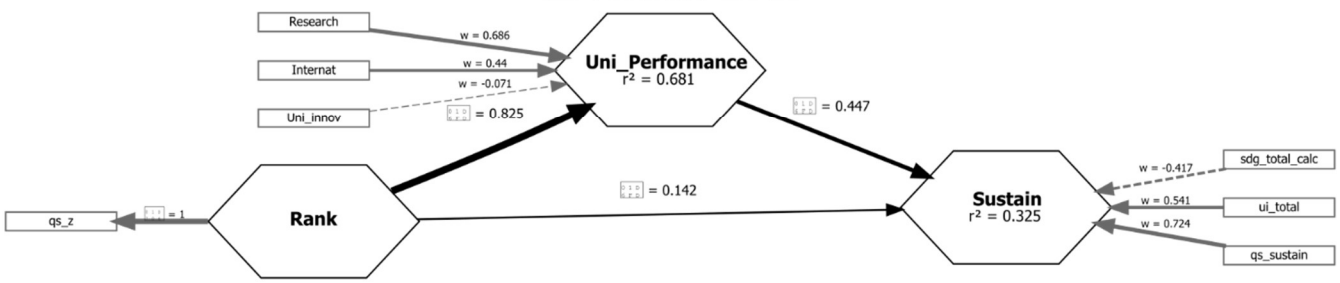

Figure 11: The Structural Nexus of Ranking Performance, Innovativeness, and Sustainability of EU15 Universities

Forrás: RStudio (2026)

Ultimately, the deployment of the Two-Stage HOC approach proved indispensable in safeguarding the empirical validity of the O2-level model. The findings robustly validate the complex, multi-stage nexus interlinking higher education reputation with sustainability outcomes. Most notably, the analysis demonstrates that substantive institutional performance exerts a significantly more profound impact on sustainability than the mere manifestation of a reputational "halo effect".

3.3. Universities and Regional Economic Development

The O3 macro-model (Figure 10, Table 6) corroborates the central thesis of this dissertation with substantial explanatory power. By accounting for 65.0% of the variance in regional economic development (Econ) ($R^2 = 0.650$), the model provides robust empirical evidence that the university ecosystem constitutes a fundamental pillar of regional competitiveness. Analysis of the internal causal mechanisms further demonstrates that institutional reputation and quality (Uni) account for 25.3% of the variance in the regional knowledge base (Regedsci), while dictating nearly half ($R^2 = 0.499$) of the aggregate innovation outputs (H2020_innov).

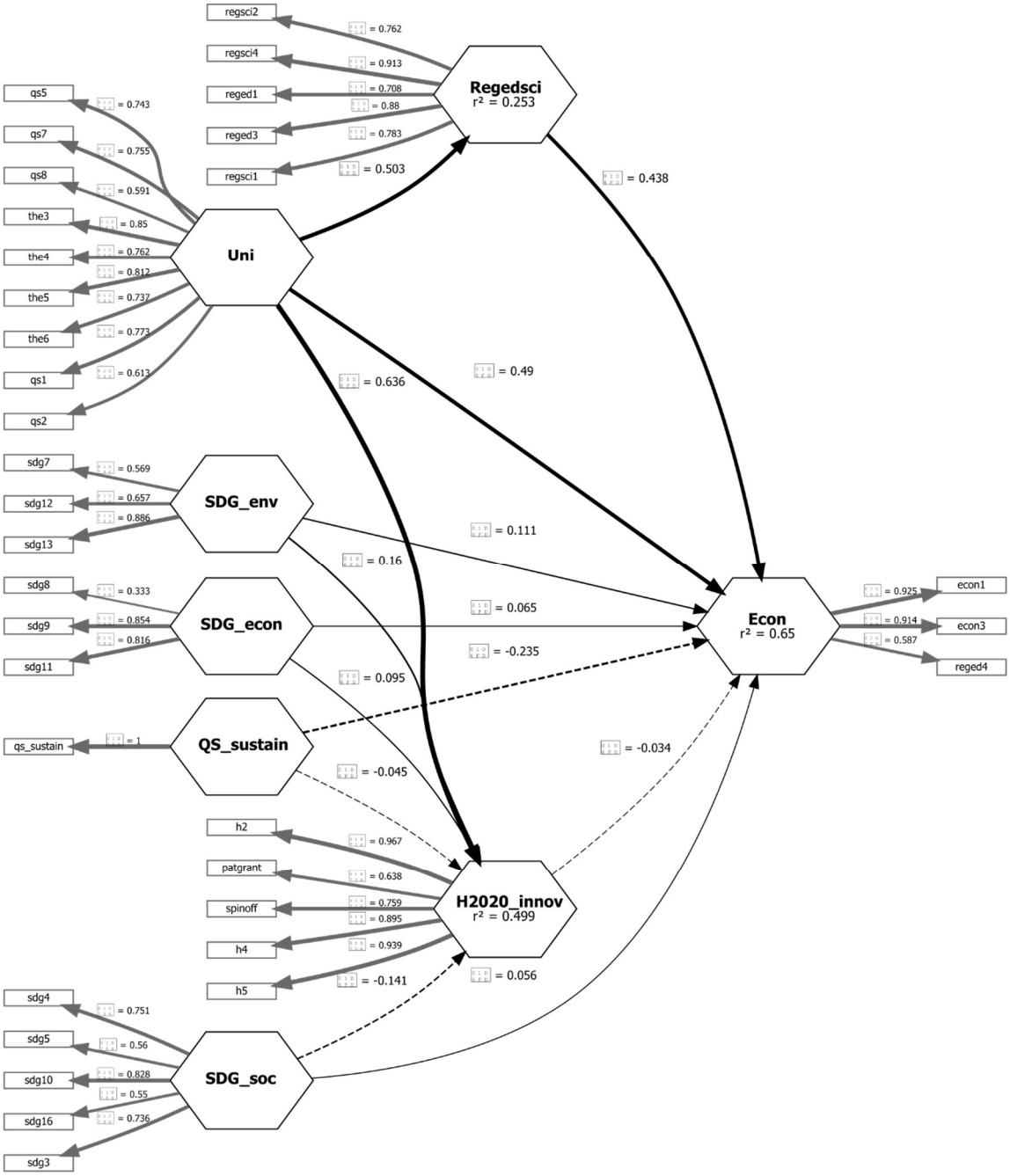

Figure 12: : Structural Drivers of Regional Economic Development: Assessing the Impact of European University Ecosystems and Sustainability Metrics

Source: Author's own compilation and computation via RStudio (2026)..

Table 6: Structural Path Coefficients and Multi-Group Analysis (MGA) for the O3 Model

Hypothesis	Structural Path	Full Sample (β)	Low Density (Periphery)	High Density (Hub)	Difference (Δβ)	Decision & Interpretation
H3.1	Uni → Econ	0.490*	0.610*	0.376*	+0.234	**Supported** *(Strong direct effect)*
H3.2	Uni → Regedsci	0.503*	0.684*	0.541*	+0.143	**Supported** *(Knowledge base capacity building occurs primarily in the periphery)*
H3.3	MGA (Uni → Econ)	0.506	0.598 *(Strong)*	0.441 *(Moderate)*	+0.157	**Supported** *(The 'anchor institution' effect is substantially more pronounced in the periphery)*
H3.4 Sustainability → Econ						
	SDG_env → Econ	0.111*	0.117*	0.037	+0.080	**Partially Supported** *(Only environmental sustainability exerts a significant positive impact)*
	SDG_soc → Econ	0.056	0.052	0.106	-0.054	**Rejected** *(No direct macroeconomic/GDP impact)*
	SDG_econ → Econ	0.065	-0.004	0.018	-0.022	**Rejected** *(Clear evidence of institutional decoupling)*
	QS_sustain → Econ	-0.235*	-0.252*	-0.026	-0.226	**Rejected** *(Legitimacy paradox / Crowding-out effect)*
Additional Structural Paths						
	Regedsci → Econ	0.438*	0.381*	0.494*	-0.113	**Fundamental structural nexus** *(Regional knowledge is more effectively absorbed and leveraged in hub regions)*
	Uni → H2020_innov	0.636*	0.768*	0.680*	+0.088	**Substantiates the critical role of innovation transfer**
	H2020_innov → Econ	-0.034	-0.088	-0.067	-0.021	**Not significant** *(A temporal lag effect is strongly presumed)*

Notes: *Path coefficients are statistically significant $|T| > 1.96$, $p < 0.05$.*

A positive value in the Difference (Δβ) column indicates that the structural effect is stronger in Low Density (Periphery) regions.

Source: Author's own compilation and computation via RStudio (2026).

The PLS-MGA (Table 6) uncovered a pronounced structural asymmetry between core (hub) and peripheral regions. In the low-density periphery, the university acts as the primary custodian of knowledge reproduction, exerting an intense localized economic impact. Conversely, high-density hubs demonstrate significantly greater efficiency in absorbing and utilizing existing knowledge capital.

Visualizing Structural Asymmetry: Corroborating Evidence from the CART Algorithm

The structural pathways delineated by the PLS-SEM are robustly corroborated by the data-driven Classification and Regression Trees (CART) algorithm, which autonomously isolated the critical systemic predictors:

- **Variable Importance:** The algorithmic decision logic relied heavily on regional economic vitality and innovation capacity. Furthermore, the pronounced weight of internationalization metrics (e.g., qs5, the6) validates that sustainability necessitates deep embeddedness within global knowledge networks.
- **The Legitimacy Paradox and the "Anchor Trap":** To predict regional GDP variance, CART isolated H2020 funding and population density as pivotal nodes, whereas prestige-driven ranking metrics lacked substantive explanatory power. Crucially, the tree's trajectory visually maps the "anchor trap", showing that under conditions of low density and deficient innovation funding, regional absorptive capacity collapses. Consequently, mere institutional presence in the periphery is inherently insufficient to catalyze a regional economic breakout.

Synthesizing these data-driven insights with the foundational frameworks of anchor institution theory and the "talent magnet" effect provides a compelling empirical baseline. Ultimately, these findings—offering a distinct methodological validation of the PLS-SEM outputs—serve as critical strategic leverage for the design and implementation of future, spatially targeted European Union convergence policies.

4. NEW AND NOVEL RESULTS OF THE DISSERTATION

This research addresses a critical lacuna in the extant literature by deploying a complex, quantitative methodological framework—integrating PLS-SEM with advanced bibliometric tools. It systematically evaluates the structural nexus between the innovation and sustainability metrics of European universities and regional macroeconomic development at the NUTS 2 level. Particular emphasis is placed on mapping the spatial asymmetries inherent to the European core-periphery dichotomy (stratified by the EU15/EU13 divide and regional population density).

Based on these comprehensive empirical investigations, I articulate the following novel scientific contributions:

Thesis 1. Validating academic intrapreneurship as the central, integrating paradigm of entrepreneurial university research. Through advanced bibliometric mapping (thematic analysis), I demonstrated that academic intrapreneurship—once considered a peripheral concept—has evolved into the field's dominant, high-centrality driving force. During the Expansion Phase (2015–2024) "intrapreneurship" transcended mere presence, establishing itself as one of the most robust structural nodes and the definitive thematic core of the discipline.

Thesis 2. Statistical corroboration of the "Matthew Effect" in European institutional performance. Based on discriminant validity diagnostics (HTMT > 0.90), I provided empirical evidence that within the European higher education landscape, research excellence, international networking (e.g., Horizon 2020), and innovation output (patents) do not function as isolated endeavors. This was methodologically validated through the conceptualization of a novel, formative Higher-Order Construct (HOC: *Uni_Performance*), substantiating the deeply synergistic and mutually reinforcing nature of these dimensions.

Thesis 3. Methodological innovation in the scalar integration of micro-level institutional and macro-level regional data. Deploying a novel, multi-level measurement architecture coupled with Multi-Group Analysis (MGA), I demonstrated that knowledge-driven regional development is fundamentally non-linear. The empirical results confirm that institutional innovation performance is converted into regional economic prosperity with

radically different degrees of efficiency when comparing high-density knowledge hubs to peripheral (spoke) regions.

Thesis 4. Statistical substantiation of the institutional decoupling phenomenon. I empirically refuted the prevailing assumption that highly innovative European universities are inherently more sustainable. The analysis rigorously proved the existence of institutional decoupling: in operational practice, "hard" innovation outputs and "soft" sustainability targets function in isolated silos. This finding exposes the critical infrastructural limitations currently hindering the realization of the integrated "Sustainable Entrepreneurial University" model.

Thesis 5. Validating the meritocratic transition and the decline of the reputational "halo effect" in global sustainability rankings. Grounded in the Resource-Based View (RBV) framework, I demonstrated that institutional visibility in global sustainability rankings is no longer dictated solely by reputational capital (the halo effect). The competitive landscape has transitioned into a strictly meritocratic phase: achieving elite prestige now requires substantive innovation and research capacities (core competencies), actively counteracting the superficial dominance of "green labels."

Thesis 6. Identifying the spatial dichotomy of the European higher education landscape: Supply dependency in the periphery versus demand efficiency in the core. Through density-stratified MGA, I uncovered a sharp functional division of labor within the European knowledge space. I proved that peripheral regions are characterized by "supply dependency"—where the university acts as an anchor institution with a monopolistic, yet highly inefficient, mode of knowledge creation. Conversely, core regions are driven by "demand efficiency," where dense agglomeration networks and robust corporate absorptive capacities convert academic knowledge into economic value with significantly greater efficacy.

Thesis 7. Uncovering the legitimacy paradox and the crowding-out effect in peripheral regions. I provided empirical evidence ($\beta = -0.252$) that in less-developed peripheral regions, the institutional pressure to comply with global sustainability rankings exerts a strictly negative impact on regional economic development. I contextualize this through the theory of compensatory legitimacy-seeking: the aggressive pursuit of "soft" green labels

actively drains resources from substantive, localized technology transfer. Consequently, this strategic misalignment generates a severe short-term “crowding-out effect,” effectively neutralizing the university's foundational mandate to stimulate regional economic growth.

5. PRACTICAL APPLICABILITY OF THE RESULTS

The findings of this dissertation advance the economic discourse on sustainable innovation by providing empirical substantiation that the Third and Fourth Missions of universities yield not only socio-environmental benefits but also direct regional macroeconomic spillover effects. To operationalize these impacts, the following strategic recommendations are proposed across macro-level policy and meso-level institutional management frameworks:

1.1. Policy and European Funding Recommendations (Macro Level)

Differentiated Funding Mechanisms: To mitigate the Matthew Effect, EU R&D policy must transcend purely excellence-driven, uniform resource allocation paradigms. While competitive funding (e.g., ERC) remains vital for advanced hubs, the periphery (EU13) necessitates robustly reinforced capacity-building (Widening) instruments. Cohesion funds should explicitly incentivize the "anchor role" and demographic retention capabilities of universities to effectively counteract systemic brain drain.

Relieving Absorptive Bottlenecks: In the allocation of European Regional Development Funds (ERDF), policymakers must recognize that the primary impediment to knowledge transfer in the periphery is rarely the university itself, but rather the deficient absorptive capacity of local SMEs. Funding must be strategically redirected toward enhancing the local market's innovation-reception capacity, thereby fostering demand-driven developmental outcomes.

Integrated Policy Frameworks: Innovation and mobility programs require structural synchronization. Demonstrated commitment to the green transition and integration into validated international consortia should serve as prerequisites for innovation funding, reinforcing the paradigm that robust science policy fundamentally constitutes the most effective sustainability policy.

1.2. University Strategy and Management (Meso Level)

Dismantling Institutional Silos and Synchronizing Mobility: Recognizing that research, internationalization, and innovation are statistically inextricable dimensions, universitiesl universities must consider the functional fusion of Technology Transfer Offices (TTOs) and

International Directorates to bolster competitiveness. At the EU level, this requires dissolving the rigid boundaries between mobility (Erasmus) and innovation support, repositioning international networking as a central catalyst for "born global" industrial partnerships.

Transcending the Legitimacy Paradox (Decoupling): Peripheral universities must move beyond compensatory legitimacy-seeking to escape the "ranking trap". Replacing symbolic compliance (which generates crowding-out effect), sustainability should be reconceptualized through the lens of the Resource-Based View (RBV), prioritizing genuine regional embeddedness and internal absorptive development.

SDG targets must be integrated into faculty performance appraisals, transforming sustainability from an administrative burden into a substantive business and innovation opportunity.

Cross-Subsidization Models: While the expansion of R&D&I capacity is the most potent driver of sustainability-related spillover effects, leadership must employ cross-subsidization to manage the temporal asynchronicity of sustainability dimensions. Revenues derived from rapid-return industrial technology transfers should be strategically reallocated to support social sustainability goals with delayed macroeconomic impacts.

The "Oasis Effect" and Complex Campus Ecosystems: Strengthening the university's role as an anchor institution is the definitive solution to mitigating brain drain in the periphery. Pedagogical development alone is insufficient; institutions must engineer holistic "Campus Environments" that—through English-language ecosystems and high-quality infrastructure (culture, housing)—can retain international human capital and drive demographic stabilization.

Returning to Substantive Regional Impact: In strict alignment with Goodhart's Law—"*when a measure* (e.g., ranking position) *becomes a target, it ceases to be a good measure*"—visibility-driven metrics have forfeited their diagnostic utility. Institutional grant funding should be decisively pivoted away from prestige investments and toward substantive regional embeddedness (the "Third Mission"), explicitly synchronizing university competencies with the innovation-absorptive capacities of local SMEs.

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Subject: PhD Publication List

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Doctoral School: Doctoral School of Management and Business
MTMT ID: 10080644

List of publications related to the dissertation

Articles, studies (5)

1. **Gregán, O.**, Kovács, S., Szűcs, E., Gabnai, Z.: Eco-innovation in the context of sustainable development between 2000 and 2024.
   International Review of Applied Sciences and Engineering. 17 (1), 110-127, 2025. ISSN: 2062-0810.
   DOI: http://dx.doi.org/10.1556/1848.2025.01050

2. **Gregán, O.**, Kovács, S., Gabnai, Z.: The Role of Intrapreneurs in Driving Entrepreneurial Transformation in Universities: A Bibliographic Analysis Between 1990 and 2024.
   Administrative Sciences. 14 (12), 327-347, 2024. ISSN: 2076-3387.
   DOI: https://doi.org/10.3390/admsci14120327
   IF: 3.1

3. **Gregán, O.**: Analysis of the possible impact of romanian and Hungarian Universities to economic development.
   Studies and Scientific Researches. Economics edition. 37, 18-34, 2023. ISSN: 2066-561X.
   DOI: http://dx.doi.org/http://dx.doi.org/10.29358/sceco.v0i37.542

4. **Gregán, O.**: Correlation of innovativeness and impact on sustainability (SDG) at the universities of Europe.
   In: No Question: Sustainability is Everyone's Business : V. BBS International Sustainability Student Conference Proceedings. Ed.: Szegedi Krisztina, Budapest Business School, Budapest, 144-165, 2022. ISBN: 9786156342386

5. **Gregán, O.**: Milyen kihívásokkal szembesül a vállalkozó egyetemen dolgozó intrapreneur? = What challenges do intrapreneurs working at entrepreneurial univerisities face?
   Economica. 13 (3-4), 57-66, 2022. ISSN: 1585-6216.
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List of other publications

Conference presentations (1)

6. **Gregán, O.**, Gabnai, Z., Szűcs, E.: 25 Years of Eco-Innovation Research: Evolution, Key Trends, and Future.
In: "New Trends and Challenges in Management - Management of Global Business Processes" ABSTRACT BOOKLET. Szerk.: Judit T. Kiss, University of Debrecen Faculty of Engineering Department of Engineering Management and Enterprise, Debrecen, 58-59, 2025. ISBN: 9789634907268

Total IF of journals (all publications): 3,1
Total IF of journals (publications related to the dissertation): 3,1

The Candidate's publication data submitted to the Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

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