

# National Resilience and Smart Specialisation RIS3: Higher Education Institutions as Centres of Excellence in Ireland and the Netherlands

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**Abstract:** Higher Education Institutions (HEIs) play a pivotal role in driving regional innovation, as evidenced by European funding initiatives such as the EIT HEI Initiative. This paper examines and compares the Regional Innovation Smart Specialisation Strategies (RIS3) of Ireland and the Netherlands, exploring how their divergent approaches affect regional development and resilience. Using a systematic review methodology, the study analyses academic literature, government reports, and EU publications related to RIS3 implementation in both countries. Findings reveal that while the Netherlands employs a decentralised model with strong regional autonomy and governance, Ireland implements a centralised national approach with limited regional specificity, contributing to significant regional polarisation. The Netherlands demonstrates superior performance in circular economy initiatives, deep tech innovation, and sustainable development through its regionally specialised strategies. The paper concludes that Ireland's path to economic resilience requires substantial infrastructure investment and a more regionally tailored approach to smart specialisation, with HEIs serving as crucial catalysts within the Triple Helix model. This research contributes to the theoretical understanding of RIS3 implementation and provides practical implications for policy development in peripheral EU regions.

**Keywords:** National Resilience, Regional Innovation, Smart Specialisation, Ireland, The Netherlands, Higher Education

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## 1. Introduction

Regional innovation strategies have become increasingly central to European Union economic and cohesion policies, with Smart Specialisation Strategies (RIS3) emerging as a cornerstone for place-based innovation and development. These strategies aim to identify and develop distinctive competitive advantages within regions by aligning research and innovation investments with regional strengths (Foray, 2015). Within this context, Higher Education Institutions (HEIs) are recognised as key drivers of regional innovation ecosystems, contributing to knowledge creation, human capital development, and technology transfer (Tripl et al., 2020). The Triple Helix model, conceptualised by Leydesdorff and Etzkowitz (1996, 1998), offers a framework for understanding the interdependencies between universities, industry, and government in fostering innovation. HEIs occupy a central position in knowledge flows, generating intellectual capital that drives economic development when effectively connected to industry and supported by appropriate governance. As Leydesdorff and Etzkowitz (1998, p.197) note, universities function as "knowledge-intensive locations where different communication flows can be expected to interact with reference to innovative practices." Despite the theoretical coherence of the Triple Helix model and the EU's promotion of Smart Specialisation, RIS3 implementation has varied significantly across member states (Kroll, 2017). This reflects differing governance traditions, institutional landscapes, and territorial challenges. A particularly relevant comparison emerges between Ireland and the Netherlands, two small, open economies with strong innovation ambitions but contrasting approaches to RIS3.

The Irish approach to Smart Specialisation operates within a centralised governance framework, where a single national strategy guides regional innovation activities through three designated NUTS2 regions (Government of Ireland, 2022). In contrast, the Netherlands employs a decentralised model, with four distinct NUTS1 regions developing and implementing differentiated strategies aligned with their specific territorial assets (Van Dam et al., 2021). These divergent approaches raise critical questions about the relationship between governance structures and innovation outcomes, particularly regarding regional balance and systemic resilience. While extensive research has examined various aspects of RIS3 implementation across Europe (Aranguren et al., 2019; Hassink & Gong, 2019; Tripl et al., 2020), comparative analyses between countries with contrasting governance approaches remain limited. Despite their instructive differences, no comprehensive comparative study has directly examined Ireland's and the Netherlands' approaches to Smart Specialisation and their respective outcomes. This constitutes a significant knowledge gap in understanding how governance frameworks aid RIS3 effectiveness in these nations.

This research addresses this gap by conducting a systematic comparative analysis of Ireland and the Netherlands' RIS3, with particular emphasis on HEIs' roles within these contrasting governance frameworks. The study examines three interrelated dimensions: governance structures and implementation mechanisms, Higher Education Institution integration, and infrastructure development patterns. Through this multidimensional

analysis, the research illuminates how divergent governance approaches influence regional innovation outcomes and system resilience.

The research is guided by three principal questions:

1. How do centralised versus decentralised governance approaches influence the implementation and outcomes of RIS3?
2. In what ways do these divergent governance frameworks condition HEIs' capacity to function as regional innovation catalysts?
3. How do infrastructure development patterns interact with innovation governance to enhance or constrain regional resilience?

This comparative analysis holds significant importance for both theoretical understanding and policy development. Theoretically, it contributes to evolving conceptualisations of the Triple Helix model by examining how different governance contexts shape university-industry-government relationships. From a policy perspective, it provides valuable insights for European regions seeking to enhance their innovation strategies, particularly those struggling with regional polarisation and development disparities.

The paper is structured as follows:

- Section 2 reviews the theoretical foundations of Smart Specialisation and the Triple Helix model, examining current literature on RIS3 implementation and HEIs' roles in regional innovation.
- Section 3 outlines the systematic review methodology employed in this comparative analysis.
- Section 4 presents findings on governance structures, HEI integration, and infrastructure development patterns in both countries.
- Section 5 discusses the implications of these findings for theoretical understanding and policy development.
- Section 6 concludes with policy recommendations, acknowledged limitations, and future research directions.

## 2. Literature Review

This section reviews key academic debates and evidence about Smart Specialisation and the role of Higher Education Institutions (HEIs) in regional innovation. It is structured around four themes: the theoretical basis of Smart Specialisation; governance models for RIS3; HEIs as innovation players; and the role of infrastructure in shaping innovation outcomes.

### 2.1 Theoretical Foundations: Smart Specialisation and the Triple Helix

Smart Specialisation was introduced by Foray and Van Ark (2007) and later developed by Foray et al. (2009) to address Europe's "innovation paradox." It subsequently evolved into a policy framework for guiding regional development through targeted investment in regional strengths (Foray, 2009, 2015). However, its implementation has proven complex, particularly in balancing centralised strategic direction with local entrepreneurial discovery (McCann & Ortega-Argilés, 2015; Hassink & Gong, 2019). The Triple Helix model (Leydesdorff & Etzkowitz, 1996, 1998) offers a complementary framework by emphasising the dynamic interactions between universities, industries, and governments. While influential, it has been critiqued for assuming balanced roles among actors and for insufficiently addressing institutional and regional imbalances (Cai & Etzkowitz, 2020; Cooke, 2019). Later models such as the Quadruple and Quintuple Helix include civil society and the environment (Carayannis et al., 2014, 2018), but these remain mostly theoretical and rarely tested in real-world cases.

Governance of RIS3 varies widely. Some countries, like Ireland and Poland, use a centralised system, while others, such as the Netherlands and Germany, are more decentralised (Kroll, 2017; Trippi et al., 2020). Centralised systems often overlook local needs (Healey, 2018), whereas decentralised systems tend to match strategies with local strengths but can suffer from fragmentation. HEIs are seen as anchors in their regions (Goddard et al., 2016), yet their role is influenced by national policies and incentives (Brown, 2016). In Ireland, the Irish Universities Association plays a key role in shaping national research, development, and innovation (RDI) policy by engaging with the government, while in the Netherlands, universities tend to have stronger formal ties with regional governments and industries, fostering closer regional innovation collaboration (Benneworth & Pablolet, 2021). Infrastructure also shapes innovation by supporting knowledge flow and

collaboration (Rodríguez-Pose & Di Cataldo, 2015). This research addresses gaps in comparing these factors between Ireland and the Netherlands.

## 2.2 Governance Approaches to RIS3 Implementation

There is a wide range of governance models for RIS3, reflecting national traditions and structures. Kroll (2017) outlines a spectrum from highly centralised to decentralised models. Each comes with pros and cons. Trippel et al. (2020) found decentralised approaches allow better local involvement but may lack strategic unity. Centralised systems help with coordination but often struggle to reflect local realities. Studies of countries like Ireland, Poland, and Romania show that centralised models tend to favour national goals over regional priorities. Healey (2018) argues these systems often fail to deliver place-based innovation, especially where regional autonomy is weak. In contrast, decentralised systems such as in the Netherlands, Denmark, and Germany seem more responsive to local needs. Asheim et al. (2017) highlight the need for cross-region coordination to avoid fragmentation. This reflects Foray's (2015) call for place-based innovation that avoids fragmentation.

## 2.3 Higher Education Institutions in Regional Innovation Ecosystems

Universities are now seen as key players in regional innovation, beyond just transferring technology. Goddard et al. (2016) outline how HEIs contribute through research, education, and civic engagement. Yet their effectiveness varies. Vallance et al. (2017) show that both internal structures and external conditions shape how HEIs engage in innovation, with major differences between leading and lagging regions. Kempton (2019) notes that universities often face a clash between international research priorities and local roles. This tension is made worse by national performance metrics that don't always reward regional activity (Brown, 2016). Benneworth and Pablolet (2021) studied how universities take part in entrepreneurial discovery across Europe. They found good results when universities are formally linked to regional innovation plans something often missing in centralised systems. Dutch HEIs are better integrated. In regions like the Northern Netherlands, formal partnerships help universities support regional specialisation (Benneworth & Pablolet, 2021). Still, few studies directly compare how national governance affects university roles a gap this study will help to address.

## 2.4 Infrastructure Development and Regional Innovation Capacity

Infrastructure is increasingly seen as vital to regional innovation. Rodríguez-Pose and Di Cataldo (2015) found strong links between infrastructure and innovation results across Europe, especially for spreading knowledge and turning it into products. Crescenzi and Rodríguez-Pose (2020) show digital infrastructure is especially important in remote regions. Balland et al. (2019) add that transport networks affect how often businesses and universities work together. Still, it remains challenging to prove direct cause-and-effect, and other factors like education and local institutions matter too (Iammarino et al., 2018). In Ireland, infrastructure gaps hold back less-developed areas. The Netherlands shows a more even spread. Moghadam-Saman et al., (2020) highlight the role of green infrastructure in supporting competitiveness. This research adds to the literature by comparing how different governance models shape the link between infrastructure and innovation.

## 2.5 Synthesis and Research Gaps

This review points to four main gaps in current knowledge:

1. While Smart Specialisation and the Triple Helix are well-developed in theory, there is little empirical work comparing how governance systems affect how these ideas are put into practice.
2. We know HEIs matter for regional innovation, but don't fully understand how national policies help or hinder their involvement.
3. Infrastructure clearly affects innovation, but the role of governance in shaping this link is under-explored.
4. Despite clear differences between Ireland and the Netherlands, no major studies have directly compared their RIS3 strategies.

This research fills these gaps by comparing the two countries across governance models, university engagement, and infrastructure, helping both theory and policy development.

### 3. Methodology

This section outlines the systematic approach used to analyse and compare Smart Specialisation Strategies (RIS3) in Ireland and the Netherlands. Positioned within an interpretive paradigm, the research recognises the complexity of innovation ecosystems while ensuring rigour through structured data collection and a systematic comparative framework.

#### 3.1 Research Design

A qualitative comparative case study design, based on Yin's (2018) principles, was chosen to explore "how" and "why" questions concerning RIS3 implementation in real policy contexts. This approach suits complex policy phenomena where social and institutional settings are key to understanding processes. Comparing Ireland and the Netherlands, which differ in governance models but share characteristics as small, open European economies, provides a "most similar systems design" (Gerring, 2017) that links RIS3 outcomes primarily to governance differences rather than broader contextual factors. Ireland employs a centralised RIS3 governance, while the Netherlands follows a decentralised, multi-level system. This contrast offers rich insights into how governance affects innovation strategies.

#### 3.2 Data Collection

A structured data collection strategy gathered comprehensive evidence from diverse sources to enable robust triangulation and reduce bias.

- **Academic Literature:** A broad systematic review was conducted across major databases (Scopus, ScienceDirect, Google Scholar) using terms such as "Smart Specialisation," "RIS3," "Triple Helix," and "Higher Education Institutions AND innovation," focusing on peer-reviewed publications. Over 120 studies were initially screened, with approximately 40 key journal articles selected and cited for detailed thematic analysis.
- **Policy Documents:** Official policy documents were collected from European Commission portals (DG Regio, DG Research & Innovation), national and regional government websites in both countries, and EU Structural Funds and EIT resources. Approximately 40 policy reports, evaluations, and strategy documents were reviewed, with key documents from Ireland and the Netherlands cited in this study.
- **Statistical Data:** Quantitative indicators on innovation and infrastructure were sourced from Eurostat, the European Innovation Scoreboard, and national statistical offices. These data supported empirical triangulation and comparison of innovation capacity and infrastructure at NUTS2 regional levels.

#### 3.3 Analytical Framework

The analysis was guided by a three-dimensional framework informed by qualitative methods (Miles, Huberman, & Saldaña, 2014), focusing on:

- **Governance Structures:** Examining policy formulation, stakeholder engagement, decision-making, and coordination between national and regional actors. Key questions included how RIS3 priorities are set, the authority of regional bodies, stakeholder integration, and implementation mechanisms.
- **HEI Integration:** Investigating Higher Education Institutions' roles within RIS3 governance, including collaboration with industry, knowledge transfer, commercialisation, and alignment with regional priorities. Questions addressed how universities connect formally and informally with RIS3 governance, incentives, and boundary-spanning structures.
- **Infrastructure Patterns:** Analysing the spatial distribution and quality of physical, digital, and environmental infrastructure relative to RIS3 priorities. Key considerations involved digital infrastructure coverage, support for sustainable innovation, and disparities between core and peripheral regions affecting resilience.

### 3.4 Analytical Process

The analysis followed an iterative abductive reasoning logic:

1. Document Review: All documents were reviewed against the framework's three dimensions.
2. Within-Case Analysis: Each country's data were analysed to identify governance, HEI, and infrastructure characteristics and their interrelations.
3. Cross-Case Comparison: Comparative analysis identified similarities, differences, and causal links, focusing on governance influence over HEI engagement and infrastructure.
4. Theoretical Synthesis: Empirical results were compared with existing theory on RIS3 implementation.

### 3.5 Validation

To ensure rigour:

- Data Triangulation: Combined academic, policy, and statistical sources to corroborate findings.
- Chronological Analysis: Distinguished early policy aims from later implementation realities.
- Cross-Referencing: Compared academic and policy evaluations for consistency.
- Alternative Explanations: Explored other causal factors beyond governance to avoid bias.

### 3.6 Limitations

- Dependence on published documents limits insight into informal dynamics and tacit knowledge.
- Government evaluations may exhibit reporting bias favouring positive outcomes.
- Institutional differences and reporting standards challenge full comparability.
- The snapshot covers a transitional policy phase, which may evolve.

These limitations were mitigated through rigorous source selection, triangulation, and transparency, enabling balanced interpretation.

## 4. Results

This section presents a comparative analysis of Smart Specialisation Strategy (RIS3) implementation in Ireland and the Netherlands, focusing on governance structures, higher education institution (HEI) integration, and infrastructure. The findings reveal significant differences with implications for regional innovation.

### 4.1 Governance Structures and Policy Frameworks

Ireland uses a centralised RIS3 governance model, with the national government leading strategy and regional assemblies implementing decisions. The three NUTS2 regions lack real policy-making power, leading to similar strategies across regions despite different economic profiles. Stakeholder engagement is limited, and regional innovation performance is uneven. Eastern and Midland outperform while the Northern and Western region lags. The Netherlands employs a decentralised model, where four NUTS1 regions independently develop RIS3 strategies. Regional development agencies and thematic clusters lead strategy creation, supported by broad stakeholder input. For instance, in the Eastern Netherlands, over 80 individuals representing key east Netherlands organisations contributed to the RIS3 process (Technopolis, 2020). Each region has unique strengths, e.g., circular economy in the North, high-tech in the South. Innovation outcomes are more balanced across regions.

### 4.2 Higher Education Institution Integration

Ireland acknowledges HEIs as innovation anchors, but implementation lags. Initiatives like the TU RISE programme aim to boost regional engagement, yet technology transfer remains below EU averages. In contrast, Dutch HEIs are deeply embedded in regional ecosystems. Universities of applied sciences serve as innovation bridges, with campuses like Water Campus Leeuwarden and High Tech Campus Eindhoven aligning academic work with regional priorities. National and regional funding, such as through the Top Sectors policy, supports this alignment.

### 4.3 Infrastructure and Regional Innovation

Ireland faces significant infrastructure gaps. Fixed broadband access is uneven, 78% in the Northern and Western region versus 90% in Dublin (CSO, 2024). Storm Éowyn exposed resilience issues: it took two weeks to restore services in the West, compared to 48 hours in Dublin. Green transition infrastructure also falls short; Ireland is set to meet only 29% of its emissions targets (EPA, 2024). The Netherlands shows more balanced infrastructure development. Broadband exceeds 90% nationally, and regions integrate infrastructure with RIS3 goals, for example, the hydrogen valley in the North. Spatial planning at the provincial level ensures alignment with regional innovation needs. The Netherlands leads Europe in circular material use (30.9%) compared to Ireland (1.8%) as seen in the table below.

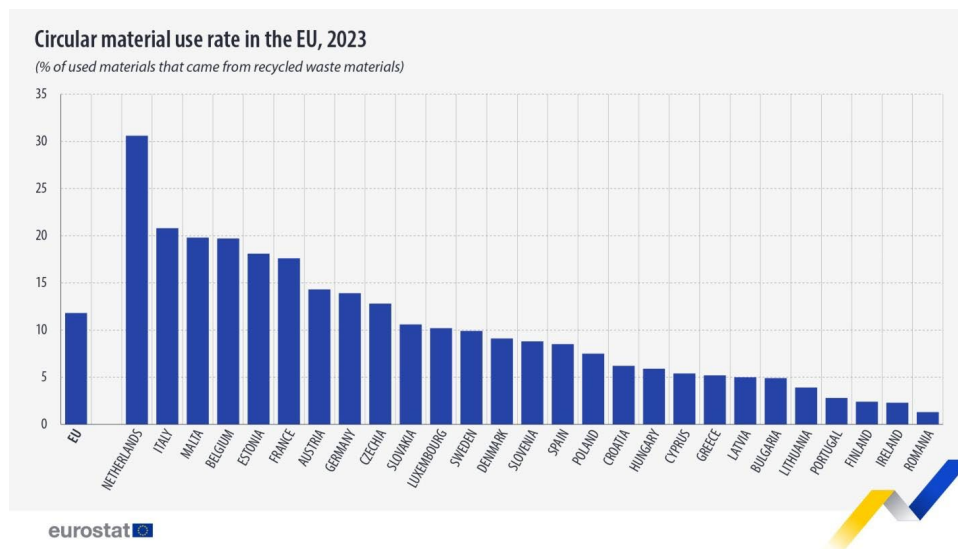


Figure 1: EU Circular material use (Eurostat, 2023)

### 4.4 Summary of Findings

Ireland’s centralised RIS3 model limits regional differentiation and HEI involvement, with uneven infrastructure compounding disparities. The Netherlands’ decentralised approach enables place-based specialisation, robust HEI integration, and equitable infrastructure investment. Effective RIS3 implementation requires regional autonomy, engaged HEIs, and balanced infrastructure to foster resilient innovation ecosystems.

## 5. Discussion of Results

This section discusses comparative findings on Smart Specialisation (S3) implementation and the role of Higher Education Institutions (HEIs) in regional innovation in Ireland and the Netherlands. It highlights how governance structures shape outcomes, offering implications for theory and policy.

### 5.1 Governance and RIS3 Effectiveness

Ireland and the Netherlands illustrate how governance affects RIS3. The Netherlands’ decentralised approach supports regional specialisations tailored to strengths, aligning with Kroll’s (2017) and Foray’s (2015) arguments on the importance of place-based governance. Ireland’s centralised model results in limited regional differentiation, hindering local innovation. However, decentralisation alone does not ensure success. The Netherlands benefits from specific institutional mechanisms that foster stakeholder coordination and knowledge flows, confirming Aranguren et al.’s (2019) view that governance quality matters. Dutch “public-private innovation escalators” (Van Dam et al., 2021) exemplify this. The Triple Helix model is more effectively realised in the Netherlands, where university-industry-government collaboration thrives. In Ireland, fragile regional governance limits Triple Helix implementation, supporting critiques by Cooke (2019) on the model’s practical constraints. While economic structure differences (FDI vs. balanced industry) may play a role, the evidence suggests governance frameworks help shape these patterns, aligning with Iammarino et al. (2018).

## 5.2 HEIs and Regional Innovation

HEIs’ regional roles reflect governance structures. Dutch institutions are enabled by established policies and incentives. In contrast, Irish HEIs face performance metrics misaligned with regional engagement, echoing Kempton’s (2019) concerns. Universities like Twente demonstrate how tailored governance can balance global and regional missions, countering Brown’s (2016) scepticism. Differentiated university roles in the Netherlands complement regional specialisations; Ireland’s uniform approach limits responsiveness. Though cultural factors, such as the strong industrial ties of Dutch universities of applied sciences, contribute significantly, policy frameworks remain a key driver of HEI engagement differences. Irish HEIs outside Dublin show minimal involvement due to structural constraints.

## 5.3 Infrastructure and Innovation

Infrastructure investment reveals another governance difference. The Netherlands ensures balanced digital and physical infrastructure aligned with regional needs, enhancing knowledge flows and innovation capacity (Crescenzi & Rodríguez-Pose, 2020). Ireland is investing €396 million in funding for regional projects under the national RIS3 policy (O’Driscoll, 2025). However concentrated investment limits peripheral regions. Storm Éowyn highlighted infrastructure’s role in resilience. The Netherlands planning supports equitable access, reinforcing Balland et al.’s (2019) view on policy agency. The table below, provides an overview of current Irish and Dutch RIS3.

Region / Country	Key Focus Areas	Governance Structure	Key Institutions & Actors	Notable Strengths
Northern Netherlands	Circular economy, energy transition, sustainable agriculture	Strong regional governance via Samenwerkingsverband Noord-Nederland (SNN)	University of Groningen, Universities of Applied Sciences, NOM	Leading in sustainable innovation, EU funding, low-carbon development
Eastern Netherlands	Deep tech (AI, robotics, photonics), precision agriculture	Provincial governance in Gelderland and Overijssel	University of Twente, Fraunhofer Project Centre	Strong applied science base, collaboration in advanced materials
Southern Netherlands	High-Tech Systems & Materials (HTSM), life sciences, biobased economy	Regional innovation clusters, flexible RIS3 implementation	Brainport Eindhoven, ASML, Philips, VDL, regional government	International competitiveness, strong industrial-university collaboration
Western Netherlands	Smart cities, circular economy, smart mobility, creative industries	Metropolitan governance, cross-border cooperation	AMS Institute, TU Delft, Rotterdam’s Port	Urban innovation, circular economy projects, diversity and scale
Ireland	Green technology, sustainable solutions, agri-tech	Centralised governance with regional steering groups	Government of Ireland, Enterprise Ireland, Regional Development Agencies	Focus on green tech, EU funding opportunities, potential for growth
Reference	Sources: Van Dam et al. (2018), Benneworth & Pabollet (2021), Interreg Europe (2024), European Commission (2025), OECD (2024)	Table created by author using Excel		

Figure 2: Overview table of S3 in Ireland and the Netherlands created by the author.

## 5.4 Implications for S3 Theory and Practice

Governance is a critical enabler of S3. The Netherlands demonstrates that effective implementation depends on multi-level coordination, not just decentralisation. Infrastructure is also key but often overlooked in theory. For centralised systems like Ireland’s, symbolic regional recognition is insufficient. Real authority and tailored strategies are needed. Operationalising the Triple Helix requires tangible institutions like the Netherlands’ innovation escalators.

## 5.5 Limitations

Findings may not generalise beyond the two countries or account for transition phases between EU programmes. While economic and cultural differences exist, governance emerges as a primary driver of observed patterns. Despite limitations, the consistency across governance, HEI roles, and infrastructure suggests strong links deserving further study.

## 6. Conclusion

This study compared Smart Specialisation (S3) implementation in Ireland and the Netherlands, focusing on how governance shapes regional innovation and resilience. While both countries formally adopted RIS3 strategies, management approaches significantly influence outcomes related to regional development, university engagement, and infrastructure.

### 6.1 Synthesis of Key Findings

Three main points emerged.

First, governance strongly impacts RIS3 effectiveness. The Netherlands employs a decentralised system where regions independently design innovation strategies with strong local involvement, fostering unique regional

strengths such as circular economy in the North and deep tech in the East. Ireland's more centralised system features national-level strategy decisions, with local agencies mainly executing plans rather than shaping them.

Second, universities play distinct roles. Dutch HEIs are deeply embedded in regional innovation, supported by policies and evaluation frameworks valuing local impact. Irish universities are developing regional ties but face constraints from performance metrics and funding prioritising academic research over local benefits.

Third, infrastructure influences innovation capacity. The Netherlands has a balanced infrastructure spread supporting innovation across regions, while Ireland shows notable gaps, especially in digital access and environmental infrastructure. For instance, during Storm Éowyn, electricity restoration took two weeks in parts of the Northern and Western region versus 48 hours in Dublin.

## **6.2 Theoretical Implications**

Findings support the premise that successful university-industry-government cooperation depends on clear governance structures rather than symbolic recognition alone. The Dutch model exemplifies effective multi-level coordination and regional ownership, while Ireland illustrates risks when regions lack real authority. Furthermore, infrastructure emerges as a foundational element underpinning both innovation and system resilience.

## **6.3 Policy Implications**

Centralised systems like Ireland's should devolve greater authority and funding to regional bodies, empower them to set context-specific priorities, foster university-regional collaboration, and address infrastructure gaps. For EU policymakers, this study highlights that robust local governance capacity is as critical as financial resources. All Universities need clear mandates for regional engagement, dedicated teams connecting with regional partners, and reward structures valuing local impact.

## **6.4 Limitations**

This research relied on published documents, which may reflect official perspectives and overlook informal practices. The snapshot approach may miss longer-term dynamics. Comparing only two governance models simplifies the broader spectrum found in Europe. These factors limit the direct generalisability of findings.

## **6.5 Future Research Directions**

Future studies should combine document analysis with qualitative interviews involving policymakers, university leaders, and industry representatives to capture practical dynamics. Examining more countries will test governance impacts across contexts. Employing network mapping and long-term evaluations can deepen insights, while studying responses to recent crises would reveal governance's role in regional resilience.

## **Ethics Declaration**

This paper contains publicly available knowledge. Future research will include expert insight from Triple Helix actors, RIS3 bodies and EU lobby groups.

## **AI Declaration**

All ideas and concepts presented are original from the author or include citation. AI tools, including ChatGPT and Grammarly, were used for support with formatting, spelling and grammar, repetition and reducing word count. ChatGPT was consulted for questions, such the origins of the Triple Helix model by Leydesdorff and Etzkowitz and in locating relevant sources. The author exercised discretion in applying suggestions, often choosing to retain original phrasing to preserve their individual writing style. All references were organised using Zotero. The final paper was reviewed and refined by the author. Any AI-suggested references were independently verified, and additional sources were obtained through academic databases.

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