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**Assessment Cover Page**

***Stimulating Ireland’s Innovation Ecosystem***

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I further confirm that this work has not previously been submitted for assessment by myself or someone else in CCT College Dublin or any other higher education institution.

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# 1. Introduction

**Innovation ecosystems are increasingly recognized as complex, dynamic networks where universities, industry, government, and society interact to foster knowledge creation and economic growth (Etzkowitz & Leydesdorff, 1995; Carayannis & Campbell, 2009). In today’s rapidly changing global context, factors such as shifting economic alliances, technological advancement, and evolving societal needs all play a role in shaping the landscape of innovation. While political and economic developments remain important contextual elements, this study focuses on understanding how Ireland’s innovation ecosystem can be assessed and strengthened through robust, data-driven analysis.**

**The Global Innovation Index 2024 (WIPO, 2024) highlights the necessity of a holistic and flexible approach to measuring innovation, emphasizing not only technological breakthroughs but also social and business model innovations that drive positive change. Ireland, as a knowledge-driven economy, stands to benefit from such multidimensional evaluation, especially as innovation is increasingly seen as a key driver of national competitiveness and societal well-being (GII, 2024; Etzkowitz & Leydesdorff, 1995)**

# **2. Problem Definition:**

Ireland’s innovation economy confronts increasing pressures from global geopolitical volatility. The aftermath of Brexit, rising economic nationalism, and disruptions to supply chains and regulatory frameworks threaten the foundational elements that have supported Ireland’s competitive advantage. Heavy dependence on foreign direct investment, international research partnerships, and a global talent pool is now challenged by uncertain political and economic conditions. Without effective adaptation, these forces risk causing stagnation in key sectors, reduced startup dynamism, and diminished global economic standing. This study seeks to address the critical question: how can Ireland navigate this complex geopolitical landscape to protect and advance its innovation-driven future?

This limitation poses a challenge for policymakers and researchers seeking to understand the factors that drive or inhibit innovation performance. Without access to comprehensive, detailed datasets, it becomes difficult to identify the specific external and internal drivers-such as patent activity, R&D investment, and enterprise engagement-that shape Ireland's innovation landscape. As Carayannis and Campbell (2009) and Etzkowitz and Leydesdorff (1995) emphasize, innovation is the product of dynamic interactions among diverse actors and influences, and its measurement must reflect this complexity.

# 3. Objectives

## **3.1.General Objective:**

To comprehensively understand and enhance Ireland’s innovation ecosystem by applying data-driven methods that integrate multiple relevant datasets. This project involves conducting a thorough investigation of available datasets as a representative statistical sample, leveraging advanced data processing, statistical analysis, and machine learning techniques in Python and Jupyter Notebook to generate actionable insights that inform policy interventions and support the sustainable growth of knowledge-based startups.

## **3.2.1.Objective:**

To utilize Python tools and libraries effectively for data cleaning, integration, visualization, and modeling, ensuring a robust and reproducible analytical workflow that supports the exploration of innovation-related datasets.

## **3.2.2.Objective:**

To analyze technological adoption patterns, enterprise engagement, research and development investment, and intellectual property activities, focusing on patent counts and ownership nationalities, to identify external factors that stimulate Ireland’s innovation ecosystem and the flow of investment.

**3.2.3.Objective:**

**To position this integrated data analysis as one of multiple key indicators of innovation performance, recognizing its role within a broader framework of innovation metrics for comprehensive ecosystem assessment.**

# 4. Literature Review

Ireland’s innovation ecosystem has been shaped by proactive government policies, sustained investment in education, and its strategic position within the European Union (European Commission, 2023). EU membership has enabled access to collaborative research networks and funding streams, reinforcing Ireland’s role in the European knowledge economy. However, recent challenges such as Brexit have disrupted established trade and innovation linkages with the UK, underscoring the importance of diversifying markets and research partnerships (The Guardian, 2025). The need for industrial diversification is further highlighted by Ireland’s reliance on a limited set of high-growth sectors.

# 5. Scope Methodology

**Milestone based in the CRISP-DM[[1]](#footnote-2)**

|  |  |  |  |
| --- | --- | --- | --- |
| ****Phase**** | ****Description**** | ****Time**** | ****Tools & Actions**** |
| **Phase 1: Business Understanding** | Define objectives, and key questions. Conduct a literature review (qualitative). | 1WEEK | Secondary data (European Commission, Eurofound, Irish Government), Literature review. |
| **Phase 2: Data Understanding** | Collect and understand datasets (quantitative). Analyze economic indicators (trade, employment). | 2ND WEEK | Python (Pandas), Excel for data exploration. |
| **Phase 3: Data Preparation** | Clean data, handle missing values, outliers (quantitative). | 3nd WEEK | Python (Pandas), Jupyter Notebook for preprocessing. |
| **Phase 4: Modeling** | Apply machine learning models (regression, classification, unsupervised learning). | 5rd WEEK | Python (Scikit-learn, TensorFlow), Jupyter Notebook. |
| **Phase 5: Evaluation** | Evaluate models (accuracy, precision, recall). Refine models. (quantitative). | 7rd WEEK | Python (Scikit-learn), metrics libraries. |
| **Phase 6: Deployment** | Provide actionable insights and recommendations. Summarize findings (quantitative). | 9rd WEEK | Python (Matplotlib, Seaborn), Jupyter Notebook, Git, GitHub. |

## 5.1.Out of Scope:

We won’t be going out into the field to do **primary data collection,** that means no surveys, interviews, or any form of hands on data. Our focus will be entirely on using **existing, publicly available datasets**. Also, we won’t be doing any **data identification** or creating new datasets.

6.**Data Sources:**

To address the data gaps identified in the literature, this study draws on the most detailed and current datasets available from Ireland’s Central Statistics Office (CSO). The three primary datasets selected capture enterprise engagement in intellectual property activities, R&D expenditure by ownership and category, and the distribution of R&D-active enterprises across expenditure bands. These datasets provide a representative statistical sample of Ireland’s innovation ecosystem, enabling analysis of investment flows, patent activity, and organizational participation.

# 7.Ethical Considerations

As we move forward with the project, ethical considerations are key to ensuring the integrity. Here’s how we’ll address them:

* **Avoiding Bias & Misrepresentation**: Committed to using validation techniques to ensure that our analysis is free from biases.
* **Compliance with GDPR & EU Regulations**: The project will comply with all necessary regulations, especially the General Data Protection Regulation (GDPR).
* **Data Privacy & Anonymity**: All datasets used will be publicly available and anonymized.
* **No Harm Principle**: The goal is to create recommendations that benefit all stakeholders, ensuring that the insights and strategies do not cause harm to businesses or communities.
* **Transparency & Objectivity**: Ensure full transparency in the methods and data used, providing a clear rationale for each decision made throughout the process

# 8.Data understanding

The data exploration began with a thorough review of available sources, guided by the recognition that Ireland’s innovation ecosystem is shaped by a complex interplay of investment, enterprise engagement, and intellectual property activity (WIPO, 2024; European Commission, 2023). After surveying international repositories such as Eurostat, OECD, and WIPO, it became clear that the most granular and relevant datasets were available through Ireland’s Central Statistics Office (CSO). The selected datasets encompass R&D expenditure by ownership and category, enterprise participation in research and development, and engagement in intellectual property activities.

# 9.Data preparation

To ensure analytical rigor and comparability, all datasets were standardized with consistent naming conventions and formats. Categorical variables, such as ownership and expenditure bands, were encoded as integer codes, while missing values in categorical columns were imputed using the mode and numeric columns with the mean. The data were merged on shared keys (year, ownership, expenditure band), and only columns essential for analysis were retained. Outliers and skewed distributions were identified and, where appropriate, addressed through log transformation or robust modeling choices.

# 10.Machine learning implementation

The modeling phase began with a baseline linear regression to predict total R&D expenditure using all available predictors. While the linear model provided a useful benchmark, its performance was limited by the non-normality and heteroscedasticity observed in the data. To address these limitations, a random forest regressor was employed, leveraging its capacity to model nonlinear relationships and handle categorical variables natively. The random forest model demonstrated substantially improved predictive accuracy, as evidenced by higher R² and lower RMSE values. Cross-validation and model comparison further confirmed the superiority of tree-based approaches for this dataset.

# 11.Findings

The analysis revealed several key insights into Ireland’s innovation ecosystem. First, R&D expenditure and enterprise engagement are highly concentrated, with a small number of actors accounting for the majority of investment and activity. Ownership nationality emerged as a significant driver, with foreign-owned enterprises typically investing more in R&D than their Irish-owned counterparts. Intellectual property activity, while positively associated with R&D investment, displayed greater variability and was influenced by both ownership and expenditure levels. The results underscore the importance of robust, non-parametric modeling in capturing the complexity of innovation dynamics, and highlight the value of integrating multiple data sources for a more nuanced understanding.

# 12.Conclusions

Any The analysis demonstrates that Ireland’s innovation ecosystem is constrained by limited access to up-to-date, granular data. To assemble a workable dataset, three separate CSO sources on R&D expenditure, enterprise engagement, and intellectual property activity had to be merged, highlighting gaps in official repositories. Patenting activity and ownership nationality emerged as key drivers of innovation investment, yet detailed patent counts at the national level are scarce and WIPO data is not refreshed frequently enough to support timely decision-making. The reliance on a single national statistics portal, which often experiences downtime, further impedes continuous monitoring and evaluation. These challenges underscore the need for a more robust data infrastructure and greater transparency in reporting innovation metrics.

# 13.Future recommendations

To strengthen Ireland’s innovation ecosystem, the following actions are recommended:

Enhance open-data infrastructure by investing in a resilient, high-availability portal that publishes detailed R&D, patent, and enterprise engagement statistics in real time. Ensuring uninterrupted access to these datasets will empower continuous analysis and evidence-based policy.

Establish a formal data-sharing agreement with WIPO and other international bodies to receive more frequent updates on patent filings and grants at the national level. This collaboration will fill critical gaps and allow Ireland to benchmark its performance against peer economies.

Promote the triple-helix model through targeted funding and regulatory incentives that encourage universities and private firms to co-develop research projects. Emphasizing joint patent applications and technology transfer will accelerate commercialization and job creation.

Mandate the CSO to publish standardized innovation indicators-covering patent counts, R&D expenditure by ownership nationality, and enterprise participation rates-on a quarterly basis. Regular updates will support agile policymaking and foster a culture of transparency.

Incorporate these improved data practices into the National Smart Specialisation Strategy, aligning regional priorities with national innovation goals. By leveraging richer, more timely data and deepening collaboration among government, academia, and industry, Ireland can build a resilient, dynamic innovation ecosystem that drives sustainable growth.

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1. CRISP-DM provides a structured framework for data analysis (Shearer, 2000). [↑](#footnote-ref-2)