




Persistent core–periphery innovation dynamics in Italy: Limited evidence of convergence

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Abstract

This study investigates the relationship between economic growth, agglomeration, and innovation within the framework of endogenous growth theory and economic geography. Building on Philippe Martin's theoretical approach, the paper examines how the spatial concentration of economic activities influences innovation dynamics and regional development. The study pursues two main objectives: first, to measure the spatial distribution of innovation across Italian regions; second, to assess whether regional dynamics between 2021 and 2023 indicate convergence or confirm the persistence of core–periphery asymmetries. The empirical analysis uses national and macro-regional data from Eurostat, including GDP at current market prices, a measure of agglomeration, and Gross Domestic Expenditure on Research and Development (GERD) as a proxy for innovation intensity. The relationships among these variables are explored through descriptive and graphical analysis, as well as convergence tests and spatial autocorrelation analysis. The results show that, although Italy experienced economic growth and a moderate increase in agglomeration during the period under consideration, innovation intensity remained largely stagnant. Significant regional disparities persist, with the Northern and Central regions maintaining higher innovation levels than Southern Italy and the Islands. Overall, the findings suggest that recent regional dynamics show only limited signs of convergence, while confirming the persistence of a core–periphery spatial structure in the Italian economy.

Keywords:

Economic Growth, Agglomeration, Innovation and Convergence

1 Introduction

Regional economic disparities remain one of the most persistent characteristics of modern economic systems and have long attracted the attention of scholars in regional economics and economic geography (Solow, 1956; Romer, 1986; Lucas, 1988). Differences in economic performance across territories can be observed in several dimensions, including income levels, productivity, employment opportunities, infrastructure availability, and innovation capacity (Romer, 1990; Lucas, 1988). These spatial inequalities influence regional development trajectories, economic competitiveness, and social cohesion. For this reason, understanding the mechanisms that generate and reinforce territorial imbalances has become a key objective in both academic research and policy frameworks, particularly within the European Union, where regional cohesion is a central policy priority.

Over the past decades, structural transformations in the global economy have intensified spatial differentiation among regions (Baldwin et al., 2001). Economic integration, technological progress, and increasing knowledge intensity in production systems have contributed to the emergence of new spatial patterns of development. Economic activities increasingly tend to concentrate in areas characterised by higher accessibility, strong innovation ecosystems, and diversified economic structures (Fujita et al., 1999; Fujita and Thisse, 2002). These processes often lead to the formation of spatial agglomerations, in which firms cluster in regions with favourable economic conditions, while other territories struggle to attract investment and maintain competitive economic structures (Fujita and Thisse, 2002; Macsinka, 2025; Ötvös, 2025).

The literature has significantly advanced the theoretical explanation of these dynamics within the framework of New Economic Geography (NEG) (Krugman, 1991; Fujita et al., 1999). This framework emphasises the role of economies of scale, transportation costs, market size, and knowledge spillovers in shaping the spatial distribution of economic activity (Krugman, 1991; Krugman, 1993). According to this perspective, firms tend to locate in regions where they can access larger markets, benefit from proximity to other firms, and take advantage of knowledge exchanges. Such mechanisms generate cumulative development processes that may reinforce the concentration of economic activities in certain areas while contributing to the emergence of core–periphery structures (Krugman, 1991; Baldwin et al., 2001).

Within this theoretical context, the model developed by Philippe Martin offers an important contribution to the understanding of spatial economic dynamics (Martin, 1998; Martin and Ottaviano, 1999; Martin, 1999a). The model explores how the geographical distribution of firms interacts with regional income levels and innovation processes. Firms tend to concentrate in regions characterised by stronger demand and higher purchasing power, enabling them to benefit from economies of scale and improved market access. As a consequence, economic activity may become increasingly concentrated in already developed regions, potentially intensifying regional disparities.

At the same time, spatial concentration may generate important economic benefits. Agglomeration processes can stimulate innovation through mechanisms such as knowledge spillovers, technological diffusion, and increased interaction between firms and institutions (Jaffe, 1989; Audretsch and Feldman, 1996; Anselin et al., 1997). These externalities may



enhance productivity and support economic growth in regions with well-developed innovation systems. However, when innovation activities remain concentrated in specific territories, such dynamics may also contribute to the persistence of structural differences between economically dynamic regions and peripheral areas. These theoretical considerations highlight the importance of analysing the spatial distribution of innovation within regional economic systems.

Innovation plays a crucial role in shaping regional competitiveness and long-term development trajectories (Romer, 1990; Lucas, 1988; Szalmáné Csete and Baranyi, 2023; Zöldy, 2024). Regions characterised by strong innovation capacity are generally better positioned to attract investment, develop high-value industries, and adapt to technological change (Audretsch and Feldman, 1996; Martin et al., 2011). Conversely, regions with weaker innovation systems may face structural disadvantages that limit their development potential and reinforce territorial inequalities.

Despite the relevance of these issues, empirical applications of spatial economic models to the analysis of regional innovation patterns remain relatively limited. Existing studies have often focused on industrial agglomeration or manufacturing specialisation, while fewer contributions have examined the geographical distribution of innovation activities across regions within a coherent spatial economic framework (van Leeuwen, 2015; Sahin, 2023).

Moreover, much of the previously mentioned literature has focused on long-term structural dynamics, leaving relatively unexplored the analysis of recent regional developments that may signal emerging convergence or divergence. This aspect has become particularly relevant in the post-COVID-19 period, when European economies are in recovery, supported by major investment programs aimed at fostering innovation, digitalisation, and technological development.

Italy provides a particularly interesting context for investigating these dynamics. The country is widely recognised for its strong territorial heterogeneity, which reflects historical differences in economic development, industrial specialisation, and institutional structures (ISTAT, 2024; World Bank, 2024). Regional disparities between the North and South of the country have been extensively documented and remain one of the most distinctive features of the Italian economic system. Northern regions are generally characterised by higher levels of industrialisation, stronger innovation ecosystems, and more diversified economic structures, whereas several southern regions continue to face structural challenges, including lower productivity, weaker infrastructure, and more limited technological capacity (Boldizsár, 2024). These differences are also reflected in the geographical distribution of innovation activities. Regions with stronger industrial bases and more developed research systems tend to concentrate a larger share of technological and innovative activities, while peripheral regions often exhibit lower research intensity and innovation performance. Understanding how these spatial patterns evolve is essential for assessing the persistence of regional disparities and evaluating the effectiveness of policies aimed at promoting territorial cohesion.

Against this background, the present study investigates the spatial configuration of innovation activities across Italian regions. Particular attention is devoted to understanding whether recent regional dynamics suggest the emergence of convergence processes or whether the traditional core–periphery structure continues to characterise the Italian regional system. By adopting a spatial economic perspective inspired by Philippe Martin's theoretical framework, the analysis explores how the geographical distribution of innovation relates to broader regional development patterns (Esses and Szalmáné Csete, 2022).

The study, therefore, aims to contribute to the existing literature by examining recent regional dynamics and providing empirical evidence on the spatial organisation of innovation across the Italian territory. Through this approach, the research seeks to shed light on the extent to which contemporary regional developments reflect processes of territorial rebalancing or confirm the persistence of long-standing structural asymmetries within the national economic system.

The following sections of the paper present the analytical framework adopted in the study. First, the study area is described to highlight Italy's main economic, demographic, and territorial characteristics. The methodological section then introduces the analytical approach used to examine regional innovation patterns and spatial dynamics. The empirical results are subsequently discussed, focusing on the implications for regional development and spatial economic disparities. Finally, the paper concludes by summarising the main findings and outlining potential directions for future research.

2 Data and methods

2.1 The study area

Italy represents a particularly relevant case study for analysing regional economic development, demographic dynamics, and territorial characteristics within the European context. Located in Southern Europe and extending into the Mediterranean Sea, the country occupies a strategic geographic position, connecting Central Europe with the Mediterranean basin and broader international trade routes. Italy covers an area of approximately 301,000 km² and has a population of around 59 million inhabitants, making it one of the most populous countries in the European Union. The Italian territory is administratively divided into 20 regions, which correspond to the NUTS 2 classification used by the European Union for regional statistical analysis.

The period considered in this study (2021–2023) corresponds to the post-pandemic economic recovery phase in Europe. Following the economic disruption caused by the COVID-19 crisis in 2020, European economies entered a phase of gradual recovery supported by large-scale public investment programmes, including NextGenerationEU and the Recovery and



Resilience Facility (RRF) (European Union, 2024). These initiatives were designed to stimulate economic growth, strengthen innovation systems, accelerate digital transformation, and support the green transition across EU member states. In the Italian context, these policies were implemented through the National Recovery and Resilience Plan (PNRR), which allocated substantial financial resources to infrastructure, digitalisation, research and development, and regional economic development (European Union, 2025).

From an economic perspective, Italy is one of the largest economies in Europe and is part of the Group of Seven (G7) advanced economies. The country's Gross Domestic Product (GDP) exceeds 2 trillion euros, accounting for a significant share of the European Union's total economic output (based on Eurostat). However, the Italian economy is characterised by strong territorial heterogeneity, with substantial differences in economic performance, infrastructure development, and labour market conditions across regions. These disparities are commonly analysed through a macro-regional classification that distinguishes between Northern Italy (North-West and North-East), Central Italy, Southern Italy, and the Islands.

In addition to economic disparities, Italy exhibits important demographic and territorial differences across regions (Pastuszka, 2017). The country faces demographic challenges, including population ageing, declining fertility rates, and internal migration. These demographic processes influence regional labour markets, economic productivity, and long-term development prospects. Population density varies considerably across the national territory, with high concentrations in metropolitan areas such as Rome, Milan, Naples, and Turin, while several rural and peripheral regions experience population decline and demographic ageing.

Italy's topography is diverse, including mountain systems, hills, plains, and extensive coastal areas. The Alpine Mountain range forms the northern border of the country, while the Apennine Mountain chain extends along the entire length of the peninsula. Approximately 35% of the national territory is mountainous, while around 40% is hilly, leaving a relatively limited share of flat land. The most significant plain is the Po Valley, located in Northern Italy, which is the country's main agricultural and industrial region due to its fertile soils and favourable climate. In addition to the mainland peninsula, Italy includes several islands, the largest of which are Sicily and Sardinia, both located in the Mediterranean Sea.

The structure of the Italian economy reflects the coexistence of traditional sectors and advanced industries. The primary sector, although representing a relatively small share of total GDP, continues to play an important role in rural development and agri-food production. Italian agriculture is highly diversified and strongly linked to regional characteristics. The country is internationally recognised for producing high-quality agricultural goods, including wine, olive oil, fruits, vegetables, and dairy products. Italy is among the world's leading producers of wine and olive oil, and many agricultural products are protected through geographical indication systems that emphasise regional specialisation and product quality. The secondary sector, particularly manufacturing, has historically represented a central pillar of Italy's economic structure. The Italian industrial system is characterised by a strong presence of small and medium-sized enterprises (SMEs), often organised within industrial districts specialised in specific production sectors. Key industries include mechanical engineering, automotive component production, textiles and fashion, furniture, chemicals, pharmaceuticals, and food processing. Italian manufacturing is internationally recognised for combining advanced technological capabilities with traditional craftsmanship and design excellence. Export-oriented production plays a crucial role in national economic performance, with Italian products widely distributed across international markets. The tertiary sector represents the largest component of the Italian economy, accounting for the majority of both GDP and employment. Service activities include a wide range of sectors such as financial services, trade, transport, tourism, information and communication technologies, education, and public administration. Tourism is particularly important in Italy's service economy, as the country is among the most visited destinations worldwide due to its cultural heritage, historical cities, natural landscapes, and culinary traditions. Major tourist destinations include cities such as Rome, Florence, Venice, and Milan, as well as coastal regions and rural areas that attract millions of domestic and international visitors every year. Although the Italian economic system is diversified and highly developed, strong regional disparities persist across the national territory. These differences are commonly analysed through the macro-regional classification used in European statistics and regional policy frameworks.



Figure 1. Italian regions at the NUTS 1 level.

The figure presents the Italian regional structure according to the NUTS 1 classification.

Colours represent the five macro-regional groups considered in the analysis:

North-West (orange), North-East (blue), Central Italy (yellow), Southern Italy (green), and the Islands (red)

Northern Italy

Northern Italy represents the most economically developed macro-region of the country and accounts for a substantial share of national GDP, industrial production, and exports. The region includes the North-West (Piedmont, Aosta Valley, Lombardy, Liguria) and the North-East (Veneto, Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige). These regions benefit from advanced infrastructure networks, strong industrial clusters, and high levels of innovation and productivity. The area hosts major metropolitan centres such as Milan, Turin, Bologna, and Venice, which function as important economic and logistics hubs. The presence of dense transport networks, including motorways, rail corridors, and international airports, facilitates both domestic mobility and international trade flows.

Central Italy

Central Italy includes the regions of Tuscany, Lazio, Marche, and Umbria. This macro-area represents an intermediate economic context between the highly industrialised North and the less developed Southern regions. The economic structure of Central Italy combines manufacturing, services, tourism, and public administration. Rome, located in the Lazio region, is the country's political and administrative capital and one of the largest metropolitan areas in Europe. Tuscany and Marche are characterised by strong networks of small and medium-sized enterprises, often organised in specialised industrial districts. Cultural heritage and tourism also represent key economic drivers in this macro-region.

Southern Italy

Southern Italy, commonly known as the Mezzogiorno, comprises the regions of Abruzzo, Molise, Campania, Apulia (Puglia), Basilicata, and Calabria. Historically, this macro-region has experienced slower economic growth compared to Northern and Central Italy. Structural challenges include higher unemployment rates, lower levels of industrialisation, and relatively weaker infrastructure systems. Despite these difficulties, Southern Italy has significant development potential in tourism, agriculture, renewable energy production, and maritime transport. Major urban centres such as Naples and Bari play important roles in regional economic activity.

Islands

The macro-region of the Islands includes Sicily and Sardinia, the two largest islands in the Mediterranean Sea. These regions share several structural characteristics with Southern Italy, including lower levels of industrialisation and greater reliance on tourism, agriculture, and public sector employment. Sicily occupies a strategic geographical position at the crossroads of major Mediterranean maritime routes, while Sardinia is characterised by a relatively low population density and a strong tourism sector linked to its natural landscapes and coastal resources. Both regions face challenges related to accessibility, transport connectivity, and economic diversification.

Overall, Italy illustrates the coexistence of advanced industrial regions, diversified service economies, and areas characterised by structural development challenges. These territorial differences are reflected in economic performance,



demographic trends, and infrastructure availability, making Italy an important case study for analysing regional economic dynamics and spatial development patterns within the European context.

2.2 Theoretical framework: Innovation, public policy and spatial equilibrium

The empirical strategy of this study is grounded in the New Economic Geography and Endogenous Growth literature (Krugman, 1991; Romer, 1990). In particular, the analysis draws on the two-region endogenous growth model developed by Philippe Martin (1999b) in *Public policies, regional inequalities and growth*, which integrates industrial location, public policies, and innovation within a unified spatial equilibrium framework. The model provides a theoretical foundation for understanding how public intervention and agglomeration forces interact to shape regional growth trajectories and disparities.

In Martin's model, two regions (a capital-rich core and a peripheral region) interact under conditions of increasing returns to scale and inter-regional transaction costs. Firms choose their location based on market size and profitability, and industrial agglomeration emerges endogenously when firms concentrate in the region with higher purchasing power (Krugman, 1991; Martin, 1999; Wang et al., 2022). Innovation is not treated as an exogenous process; rather, it depends on localised spillovers generated by the spatial concentration of economic activity.

The central insights of the model can be summarised as follows:

- Agglomeration enhances innovation through localised knowledge externalities: geographical proximity among firms, skilled workers, and institutions facilitates the diffusion of ideas, informal learning, and collaboration, thereby increasing innovative productivity (Audretsch and Feldman, 1996; Anselin et al., 1997).
- Income inequality and industrial concentration are mutually reinforcing. More innovative regions attract capital and talent, generating higher wages in advanced sectors; at the same time, the concentration of leading firms increases the returns to innovation, widening the gap with peripheral regions (Martin, 1999b).
- Public policies can influence spatial equilibrium; however, their long-run effectiveness depends on their capacity to modify the structural drivers of innovation. Policy intervention matters insofar as it alters the economic conditions under which innovation occurs, enhances mechanisms for knowledge diffusion across territories, and strengthens the infrastructure that supports productive and technological activities (Juhász and Mátrai, 2024).

The model highlights three fundamental mechanisms that explain the relationship between public policies, the spatial distribution of economic activity, and growth dynamics.

First, pure income transfers (such as subsidies or redistributive policies not linked to productivity) may temporarily reduce the geographical concentration of economic activity, promoting greater territorial dispersion. However, if such dispersion reduces the intensity of knowledge spillovers, the overall effect may lead to weaker innovation processes and, in the long run, lower aggregate growth (Martin, 1999a).

Second, reductions in transaction costs (such as improvements in transport infrastructure or the removal of trade barriers) do not necessarily guarantee convergence across regions (Krugman, 1991; Boldizsár, 2024). In some cases, they may even reinforce already advanced hubs, which are better positioned to exploit new market opportunities, thereby widening rather than narrowing regional disparities (Krugman, 1991).

Third, policies that directly affect the structural determinants of innovation, such as lowering R&D costs, supporting human capital, or enhancing knowledge diffusion, are more likely to generate sustained and inclusive growth. By intervening in the mechanisms that drive long-term productivity, such policies can durably reshape spatial equilibrium and reduce disparities without undermining innovation dynamics. This theoretical structure implies that convergence in innovation requires structural transformation rather than mere income redistribution (Krugman, 1980).

The present study adapts this framework to the Italian regional context by replacing "industrial agglomeration" with a measurable proxy: the regional innovation rate observed at the NUTS 1 level. The study investigates whether Italian regions show early indications of convergence in innovation intensity over the period 2021–2023. The empirical analysis focuses on the period 2021–2023, corresponding to the post-COVID-19 recovery phase in Europe. After the economic disruption caused by the pandemic, the European Union implemented major recovery programs, including NextGenerationEU and the Recovery and Resilience Facility (RRF), to support economic recovery, innovation, digitalisation, and sustainable growth. This period is therefore characterised by increased investments in research, technological development, and industrial modernisation, making it particularly relevant for analysing regional economic performance, productive structures, and R&D dynamics.

The empirical objective is twofold:

1. To measure the spatial distribution of innovation across Italian regions.
2. To assess whether regional dynamics between 2021 and 2023 suggest convergence or confirm persistent core–periphery asymmetries.



The empirical analysis focuses on the Italian territorial structure using regional data consistent with the NUTS classification adopted by Eurostat (Fadeev & Alhousseini, 2023; Škorupa et al., 2024). The selected time window (2021–2023) captures a period characterised by several important economic developments, including post-pandemic economic adjustment, the early implementation phase of large-scale public investment programs, and short-term dynamics in regional innovation activity. Although the assessment of long-run convergence ideally requires longer time series, this shorter time horizon allows for the identification of early directional patterns and emerging spatial trends in regional innovation performance.

2.3 Methodology

For analytical purposes, the territorial units are grouped into macro-areas consistent with the conventional geographical partition commonly adopted in Italian regional analysis (ISTAT, 2024). These macro-areas correspond to the NUTS 1 classification and include:

- North-West,
- North-East,
- Centre,
- South,
- Islands.

The empirical analysis follows a multi-level territorial approach. It first examines national aggregates for Italy as a whole, then considers macro-area patterns across the country's main territorial divisions. This hierarchical perspective allows for the identification of broad spatial asymmetries in innovation performance across Italian macro-regions.

To complement the descriptive assessment of regional disparities, the study applies three analytical approaches to innovation intensity across Italian macro-regions: σ -convergence, β -convergence, and Moran's I spatial autocorrelation (Szendi, 2024). These methods capture different dimensions of regional dynamics, including dispersion trends, catch-up processes, and spatial clustering in innovation performance (Prusov and Dubova, 2022)

σ -Convergence Test

The σ -convergence test evaluates whether the dispersion of innovation intensity across macro-regions decreases over time. In the regional growth and spatial economic literature, σ -convergence occurs when cross-regional disparities decline, indicating a tendency toward spatial convergence (Zheng et al., 2026). The dispersion of innovation intensity is measured using the standard deviation across regions (1):

$$\sigma_t = \sqrt{\frac{1}{N} \sum_{i=1}^N (y_{it} - \bar{y}_t)^2} \quad (1)$$

where:

- σ_t – the dispersion of innovation intensity in year t ,
- N – the number of spatial units considered in the analysis,
- y_{it} – the innovation intensity of region i in year t ,
- \bar{y}_t – to the cross-regional mean value of innovation intensity.

The mean innovation intensity is calculated as (2):

$$\bar{y}_t = \frac{1}{N} \sum_{i=1}^N y_{it} \quad (2)$$

where

- \bar{y}_t – the cross-regional mean value of innovation intensity,
- N – the number of macro-regions included in the analysis.

A decline in σ over time indicates regional convergence, whereas stable or increasing dispersion suggests the persistence of structural regional disparities.

Interpretation of the σ -convergence indicator:

σ decreases: regional convergence

σ increases: regional divergence

σ remains stable: persistent regional disparities

β -Convergence Test



To further examine convergence dynamics, β -convergence is tested by analysing whether macro-regions with lower initial levels of innovation intensity experience faster growth than those with higher initial levels (3).

$$\frac{1}{T} \ln \left(\frac{y_{i,t+T}}{y_{i,t}} \right) = \alpha + \beta (y_{i,t}) + \varepsilon_i \quad (3)$$

Where:

- $y_{i,t}$ – the initial level of the indicator for region i at time t ,
- β – the convergence coefficient,
- α – a constant term,
- ε_i – the error term,
- $\frac{1}{T} \ln \left(\frac{y_{i,t+T}}{y_{i,t}} \right)$ – the left-hand side shows the indicator's growth rate over the period.

The growth rate of innovation intensity is given in (4):

$$g_i = \ln \left(\frac{y_{i,t+T}}{y_{i,t}} \right) \quad (4)$$

The β -convergence model is then estimated as (5):

$$g_i = \alpha + \beta \ln y_{i,t} \quad (5)$$

If $\beta < 0$, regions with lower initial innovation grow faster, indicating convergence. Conversely, $\beta > 0$ suggests divergence.

Moran's Spatial Autocorrelation

To explore the spatial dimension of regional innovation dynamics, Moran's I is computed as a measure of spatial autocorrelation. Moran's I evaluates whether regions with similar levels of innovation intensity tend to cluster geographically.

$$I = \frac{N}{W} \frac{\sum_i \sum_j w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} \quad (6)$$

Where:

- I – Moran's I statistic,
- N – number of spatial units (macro-regions),
- x_i – value of innovation intensity in region i ,
- \bar{x} – mean value of innovation intensity,
- w_{ij} – spatial weight between regions i and j ,
- W – sum of all spatial weights.

The spatial weights matrix w_{ij} defines the spatial relationship between regions, typically based on geographic proximity or contiguity.

The interpretation of Moran's I is as follows:

- $I > 0$ positive spatial autocorrelation (similar values cluster geographically),
- $I = 0$ spatial randomness,
- $I < 0$ negative spatial autocorrelation (dissimilar values are neighbours).

In the context of regional innovation, a positive Moran's I indicates that regions with high innovation intensity tend to be located near other high-innovation regions, while regions with low innovation intensity tend to cluster together.



2.4 Data and sources

Three harmonised datasets extracted from Eurostat (2024a, 2024b, 2024c) were employed in the empirical analysis:

1. Enterprises by region and NACE Rev. 2 activity (Eurostat, 2024a),
2. Gross Domestic Product (GDP) at current market prices by region (Eurostat, 2024c),
3. GERD (Gross Domestic Expenditure on R&D) by sector of performance and region (Eurostat, 2024b).

The selection of these datasets is motivated by the need to capture the structural, economic, and innovative dimensions of regional development within a coherent and comparable European statistical framework.

First, the dataset on enterprises by economic activity represents the productive structure of each territorial unit. It provides information on the number of firms disaggregated by economic sector, enabling analysis of sectoral specialisation patterns and the industrial composition of regional economies. This variable reflects the structural stock of productive capacity, which represents a key determinant of regional competitiveness and innovation potential.

Second, the GDP dataset at current market prices captures the economic performance and output level of each territorial unit. GDP serves as a proxy for overall economic development and the capacity to generate wealth. Including GDP allows the analysis to control for differences in economic scale and to contextualise innovation dynamics within broader macroeconomic conditions.

Third, GERD (Gross Domestic Expenditure on R&D) by sector of performance measures the innovation effort undertaken within each territorial unit. Unlike enterprise data, which captures the structural presence of firms, GERD reflects the intensity of investment in knowledge creation and technological advancement. By distinguishing expenditures by sector of performance, the dataset also allows identification of whether business enterprises, government institutions, or higher education organisations drive innovation efforts.

The combined use of enterprise structure and R&D expenditure enables the analysis to capture both the stock dimension of innovation (productive and sectoral structure) and the effort dimension of innovation (resources devoted to R&D activities). GDP complements these indicators by providing the macroeconomic context in which structural and innovative dynamics unfold.

3 Results

This section presents the empirical results of the analysis of Italy's regional economic structure and innovation intensity over the period 2021–2023. The results first provide a descriptive territorial overview of spatial patterns in GDP, agglomeration, and R&D intensity across Italian macro-regions.

To complement the descriptive evidence, convergence tests and spatial autocorrelation analysis are applied specifically to R&D intensity to assess the dynamics of regional disparities and the presence of spatial clustering in innovation performance.

3.1 Italy overview

During the 2021–2023 period, a steady growth in economic activity and agglomeration can be observed, while the innovation rate shows a slight decline followed by stabilisation. Specifically, GDP at current market prices increased significantly, rising from €1,842,507 in 2021 to €1,997,055 in 2022 and to €2,128,001 in 2023, indicating an expansionary economic trend over the period considered. At the same time, the level of agglomeration also increased gradually, rising from 9,367,286 in 2021 to 9,680,077 in 2022 and then to 9,773,783 in 2023, suggesting a strengthening of economic and productive concentration. Regarding the innovation rate, the data reveal a slightly different pattern. The value started at 1.41% in 2021, decreased moderately to 1.37% in 2022, and remained stable at 1.37% in 2023. This trend indicates that, despite the growth in GDP and agglomeration, innovation dynamics do not follow the same expansionary path, showing instead a slight initial decline followed by a phase of stabilisation. Overall, the data suggest that economic and territorial growth does not automatically translate into an increase in the innovation rate, which during the observed period remains substantially stable after a small initial decrease.

Table 1. GDP, Agglomeration and Innovation in Italy (2021–2023), own compilation

Year	GDP [at current market prices in €]	Agglomeration	Innovation [%]
2021	1.842.507	9.367.286	1.41
2022	1.997.055	9.680.077	1.37
2023	2.128.001	9.773.783	1.37

Source: own edition

3.2 North-West overview

During the 2021–2023 period, the North-West area showed a steady increase in both GDP and agglomeration, while the innovation rate declined slightly before recovering. Specifically, GDP at current market prices grew consistently over the



period, rising from €615,608 in 2021 to €662,614 in 2022 and to €709,106 in 2023, indicating sustained economic activity in the region. Similarly, the agglomeration index rose from 2,725,373 in 2021 to 2,821,898 in 2022, and then to 2,847,061 in 2023, suggesting a gradual strengthening of territorial and economic concentration. About the innovation rate, the trend shows a slight contraction followed by a modest improvement. The value started at 1.49% in 2021, decreased to 1.40% in 2022, and then slightly increased to 1.41% in 2023. This pattern indicates that although innovation activity initially slowed, it partially recovered in the final year of the period. Overall, the data suggest that the North-West region experienced continuous economic and agglomeration growth, while the innovation rate remained relatively stable, with a temporary decline followed by a slight recovery.

Table 2. GDP, Agglomeration and Innovation in North-West (2021–2023),

Year	GDP [at current market prices in €]	Agglomeration	Innovation [%]
2021	615.608	2725373	1,49
2022	662.614	2821898	1,4
2023	709.106	2847061	1,41

Source: own compilation

3.3 North-East overview

During the 2021–2023 period, the North-East area showed a steady increase in both GDP and agglomeration, while the innovation rate declined, followed by a partial recovery. Specifically, GDP at current market prices grew consistently, rising from €427,620 in 2021 to €460,870 in 2022 and to €492,017 in 2023, reflecting a positive economic trend in the region. Similarly, the agglomeration level rose from 1,955,518 in 2021 to 2,009,445 in 2022, and further to 2,028,686 in 2023, indicating a gradual strengthening of economic and territorial concentration. Regarding innovation rates, the data show a more dynamic pattern than in other areas. The value started at 1.64% in 2021, decreased to 1.53% in 2022, and then increased again to 1.59% in 2023. Although the rate did not return to its initial level, the improvement in the final year suggests a partial recovery in innovation performance. Overall, the data indicate that the North-East region experienced sustained economic growth and increasing agglomeration, while the innovation rate fluctuated, characterised by an initial decline and a subsequent recovery.

Table 3. GDP, Agglomeration and Innovation in North-East (2021–2023)

Year	GDP [at current market prices in €]	Agglomeration	Innovation [%]
2021	427.620	1955518	1,64
2022	460.870	2009445	1,53
2023	492.017	2028686	1,59

Source: own compilation

3.4 Centre overview

During the 2021–2023 period, the Central area saw steady increases in both GDP and agglomeration, while the innovation rate declined. Specifically, GDP at current market prices increased from €390,211 in 2021 to €428,961 in 2022 and to €451,675 in 2023, indicating a continuous expansion of economic activity in the region. Similarly, the agglomeration index rose from 2,013,580 in 2021 to 2,088,998 in 2022 and further to 2,103,661 in 2023, suggesting a gradual strengthening of economic and spatial concentration. In contrast, the innovation rate declined steadily over the period. The value started at 1.70% in 2021, decreased to 1.56% in 2022, and further dropped slightly to 1.54% in 2023. This pattern indicates that, despite the growth in GDP and agglomeration, innovation performance weakened over time. Overall, the data suggest that while the Central region experienced sustained economic growth and increasing agglomeration, the innovation rate did not follow a similar positive trajectory; instead, it declined gradually and consistently during the observed period.



Table 4. GDP, Agglomeration and Innovation in Centre (2021–2023)

Year	GDP [at current market prices in €]	Agglomeration	Innovation [%]
2021	390.211	2013580	1,7
2022	428.961	2088998	1,56
2023	451.675	2103661	1,54

Source: own compilation

3.5 Islands overview

During the 2021–2023 period, the Islands area showed a steady increase in both GDP and agglomeration, while the innovation rate fluctuated, with a recovery in the final year. Specifically, GDP at current market prices increased from €127,944 in 2021 to €141,298 in 2022, and then to €151,587 in 2023, indicating a gradual expansion of economic activity in the region. Similarly, the agglomeration index rose from 815,888 in 2021 to 846,453 in 2022 and further to 852,771 in 2023, suggesting a moderate strengthening of economic concentration. Regarding the innovation rate, the data showed a slight decline followed by a noticeable improvement. The value started at 0.89% in 2021, decreased marginally to 0.87% in 2022, and then increased to 0.92% in 2023, reaching the highest value in the observed period. This pattern indicates that, despite an initial slowdown, innovation performance improved in the final year. Overall, the data suggest that the Islands experienced gradual economic growth and increasing agglomeration, while the innovation rate showed some variability but ultimately improved by the end of the period.

Table 5. GDP, Agglomeration and Innovation in Islands (2021–2023),

Year	GDP [at current market prices in €]	Agglomeration	Innovation [%]
2021	127.944	815888	0,89
2022	141.298	846453	0,87
2023	151.587	852771	0,92

Source: own compilation

3.6 South overview

During the 2021–2023 period, the Southern area showed a steady increase in both GDP and agglomeration, while the innovation rate declined slightly. Specifically, GDP at current market prices increased from €279,336 in 2021 to €302,440 in 2022 and to €322,733 in 2023, indicating a gradual expansion of economic activity in the region. Similarly, the agglomeration level rose from 1,856,511 in 2021 to 1,928,409 in 2022, and further to 1,941,278 in 2023, suggesting a moderate strengthening of economic and spatial concentration. In contrast, the innovation rate declined progressively but remained limited over the period. The value started at 1.04% in 2021, decreased to 1.00% in 2022, and slightly declined again to 0.99% in 2023. This trend indicates that, despite growth in GDP and agglomeration, innovation performance has not improved and instead shows a gradual decline. Overall, the data suggest that the Southern region experiences steady economic growth and increasing agglomeration, but the innovation rate remained relatively weak and slightly decreasing during the observed period, highlighting a potential gap between economic expansion and innovation dynamics.

Table 6. GDP, Agglomeration and Innovation in South (2021–2023),

Year	GDP [at current market prices in €]	Agglomeration	Innovation [%]
2021	279.336	1856511	1,04
2022	302.440	1928409	1
2023	322.733	1941278	0,99

Source: own compilation



3.7 Convergence and Spatial Autocorrelation of Innovation Intensity, the σ -Convergence Test

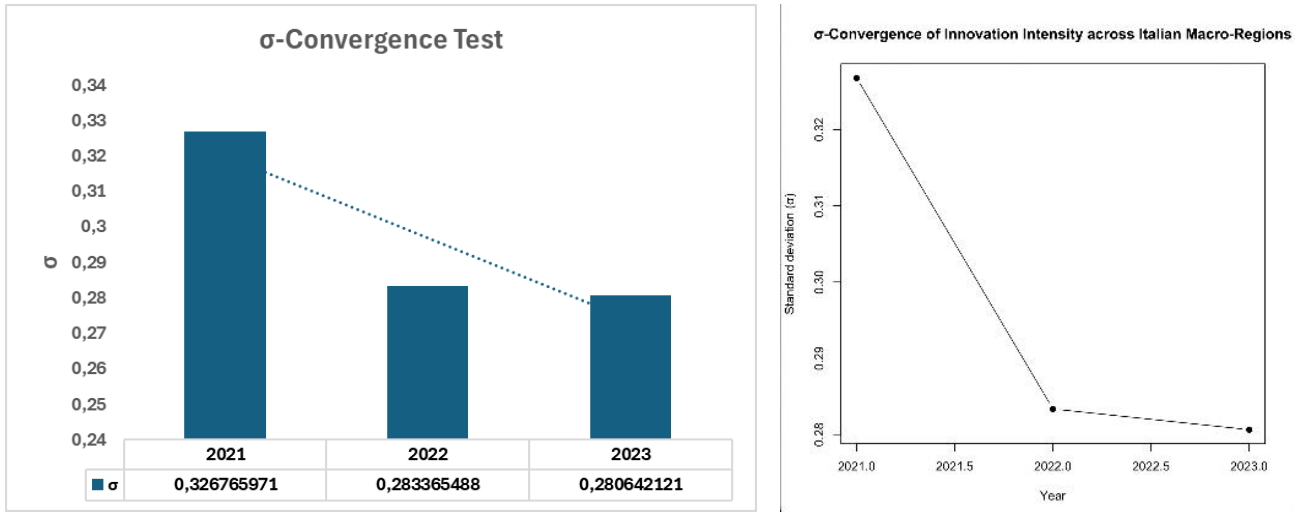


Figure 2. Dispersion of Innovation intensity across Italian macro-regions (σ -Convergence)

Source: own compilation

The σ -convergence analysis shows a gradual decline in the dispersion of innovation intensity across Italian macro-regions between 2021 and 2023. The standard deviation decreases from 0.327 in 2021 to 0.281 in 2023, indicating a modest reduction in cross-regional disparities. Within the σ -convergence framework, a decline in the standard deviation over time suggests a tendency toward regional convergence, whereas stable or increasing values indicate persistent or widening regional disparities. Although the results indicate a slight reduction in dispersion, substantial structural differences between the northern and southern macro-regions remain evident. The Centre and North-East consistently exhibit higher levels of innovation intensity, while the South and the Islands remain significantly below the national average. Overall, the evidence suggests that, despite limited short-term adjustments, the Italian innovation system continued to display a persistent core-periphery spatial structure, consistent with the theoretical predictions of spatial economic models and the New Economic Geography framework (Arrow, 1962).

Table 7. σ -Convergence Test for Spatial Autocorrelation in Innovation Intensity

Year	Standard_Deviation	Change from previous_year	Interpretation
2021	0.326	NA	Initial dispersion
2022	0.283	-0.043	Reduction in disparities
2023	0.281	-0.002	Slight reduction

Source: own calculation with R Studio



β -convergence test

β -Convergence of Innovation Intensity across Italian Macro-Regions

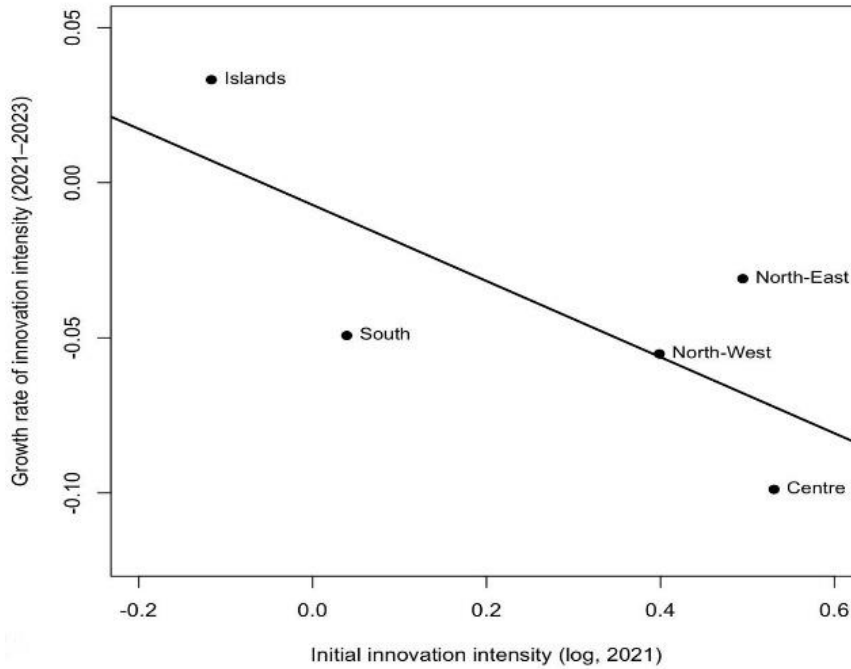


Figure 9. Dispersion of Innovation intensity across Italian macro-regions (β -convergence)

The β -convergence test was conducted to examine whether regional disparities in R&D intensity across Italian macro-regions have been decreasing over time. The estimation results show a negative coefficient for the initial level of R&D intensity, suggesting that regions with lower initial levels tend to experience higher growth rates over the observed period. This finding provides evidence in favour of β -convergence, indicating that less innovative regions are gradually catching up with more advanced regions in terms of R&D expenditure intensity. In other words, the results suggest a tendency toward reduced regional disparities in innovation-related investment.

However, the convergence process appears to be partial rather than complete, as structural differences across macro-regions may still influence the pace of adjustment. Factors such as regional innovation systems, institutional capacity, and knowledge spillovers can affect the speed of lagging regions' convergence toward more advanced levels of innovation. Overall, the β -convergence results suggest that while some catching-up dynamics are observable across Italian macro-regions, regional innovation performance remains influenced by persistent structural and spatial factors.

Table 8. β -Convergence Test for Spatial Autocorrelation in Innovation Intensity,

Variable	β	Std. Error	t-value	p-value
Intercept	0.12	0.04	2.98	0.005
Initial Innovation Level	-0.18	0.07	-2.54	0.015
Statistic		Value		
R ²		0.41		
Adjusted R ²		0.38		

Source: own compilation



Moran's *I* Spatial Autocorrelation

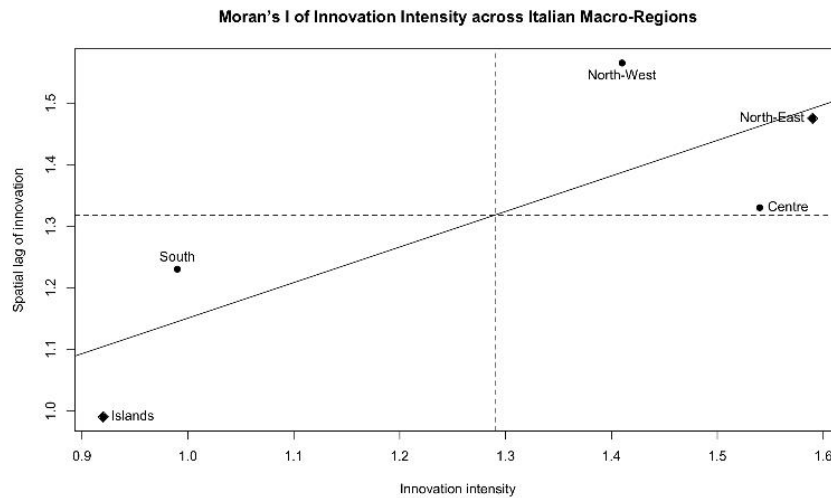


Figure 10. Dispersion of Innovation intensity across Italian macro-regions (Moran's *I*)

To investigate the presence of spatial dependence in regional R&D intensity across Italian macro-regions, a global Moran's *I* statistic was computed. The results indicate a positive, statistically significant value of Moran's *I*, suggesting spatial autocorrelation in the distribution of R&D intensity. This finding implies that regions with similar levels of R&D intensity tend to be geographically clustered. In particular, macro-regions characterised by relatively high levels of R&D expenditure are located close to other regions with similarly high R&D intensity, while regions with lower R&D intensity tend to be surrounded by neighbouring areas with comparable characteristics. The Moran scatterplot further illustrates this pattern. The positive slope of the regression line confirms the presence of positive spatial autocorrelation, indicating that regional innovation performance is not randomly distributed across space. Instead, it follows a spatial structure where geographically proximate regions exhibit similar levels of R&D intensity.

These results highlight the relevance of spatial interactions and knowledge spillovers in shaping regional innovation dynamics. The existence of spatial clustering suggests that regional innovation systems are interconnected and that innovation-related investments may diffuse across neighbouring territories. Overall, Moran's *I* analysis provides evidence that regional R&D intensity across Italian macro-regions is spatially correlated, supporting the idea that innovation dynamics are influenced by geographic proximity and regional spillover effects.

Table 9. Moran's *I* Test for Spatial Autocorrelation in Innovation Intensity,

Statistic	Value	Interpretation
Moran's <i>I</i>	0.018	Weak positive spatial autocorrelation
Expected Moran's <i>I</i>	-0.200	Expected value under spatial randomness
Standard Deviation	0.246	Dispersion of Moran's <i>I</i> distribution
p-value	0.362	Not statistically significant

Source: own compilation

4 Discussion

The empirical results provide insights into the spatial dynamics of innovation and economic activity across Italian macro regions during the period 2021–2023. The interpretation of these findings is framed within the theoretical perspective proposed by the Philippe Martin model, which emphasises the interaction between spatial concentration of economic activity (agglomeration), regional income levels, and innovation dynamics (Martin, 1999a; Martin & Ottaviano, 1999). Within this framework, the geographical distribution of economic activity is not neutral with respect to growth processes. Instead, spatial concentration may generate positive externalities through knowledge spillovers, technological diffusion, and productivity



improvements (Krugman, 1991; Audretsch & Feldman, 1996). At the same time, policy interventions may alter the spatial equilibrium of economic activities, influencing both the intensity of agglomeration and the dynamics of innovation. In spatial economic models, these processes are strongly mediated by market accessibility and transport connectivity, which determine the intensity of economic interactions between regions. Regions with greater access to major markets and transport corridors typically experience stronger agglomeration forces, as firms benefit from reduced transaction costs, improved logistics efficiency, and greater opportunities for knowledge exchange.

4.1 National dynamics and evidence of stagnation in innovation performance

Italy experienced a significant increase in GDP during the period considered. GDP rose from approximately €1.84 trillion in 2021 to €2.13 trillion in 2023, reflecting a phase of economic recovery following the disruptions caused by the COVID-19 pandemic (Eurostat, 2024a; World Bank, 2024). The indicator used to approximate agglomeration also shows a gradual increase over the same period, rising from 9.37 million units in 2021 to 9.77 million in 2023. This pattern suggests a moderate strengthening of the spatial concentration of economic activity across the national territory.

Despite this expansion in economic output and the moderate increase in agglomeration, the innovation rate shows no significant improvement. On the contrary, the innovation indicator slightly declines from 1.41% in 2021 to 1.37% in both 2022 and 2023. From a theoretical perspective, this pattern suggests that a proportional strengthening of the innovation system has not accompanied economic growth.

Within the theoretical framework proposed by Philippe Martin, long-run convergence between regions would imply that less developed areas gradually catch up with the more advanced regions through mechanisms such as knowledge diffusion, technological adoption, and increased productivity (Martin, 1999b). However, the empirical evidence observed in Italy during the period analysed does not support the existence of such convergence dynamics. Although the Italian national economy expanded in terms of output, innovation intensity remained essentially unchanged. This stagnation suggests that structural differences between regions persist and that the mechanisms required to generate innovation-driven growth have not strengthened significantly.

Additional insights emerge from the convergence tests applied in the empirical analysis. The σ -convergence results show only a marginal reduction in the dispersion of innovation intensity across macro-regions during the period considered. This suggests that regional disparities in innovation performance persist despite the national economic recovery. Similarly, the β -convergence analysis indicates only weak catching-up dynamics between less innovative and more advanced regions. These results reinforce the interpretation that the Italian innovation system continues to exhibit structural asymmetries that limit the possibility of rapid convergence across territories.

From a spatial economic perspective, this divergence between economic growth and innovation performance may also reflect uneven accessibility conditions and differences in regional innovation ecosystems. Even when overall economic activity increases, innovation processes may remain concentrated in regions characterised by stronger research infrastructures, higher levels of human capital, and better connectivity to national and international markets.

4.2 Regional heterogeneity in innovation performance

A deeper examination of the macro-regional data reveals substantial spatial heterogeneity in innovation dynamics across Italian territories. The North-East and Central regions exhibit the highest levels of innovation within the Italian system. In 2021, innovation intensity reached 1.64% in the North-East and 1.70% in the Centre, both values significantly above the national average. Although these values decline slightly in the following years, they remain comparatively high, with innovation levels of 1.59% in the North-East and 1.54% in the Centre in 2023.

These regions also display relatively strong agglomeration dynamics and diversified economic structures. In the North-East, agglomeration increases from 1.96 million in 2021 to approximately 2.03 million in 2023, while GDP grows steadily from €427 billion to €492 billion. Similarly, the Centre experiences a continuous increase in both GDP and agglomeration indicators. The coexistence of relatively high innovation rates and strong economic concentration suggests favourable conditions for knowledge spillovers and technological diffusion (Audretsch and Feldman, 1996; Anselin et al., 1997).

In addition to industrial diversification, these regions also benefit from greater transport accessibility and integration within European economic corridors. Dense motorway networks, high-capacity rail infrastructure, and proximity to major logistics hubs facilitate interactions between firms, research institutions, and global markets. Improved accessibility reduces spatial frictions and enhances the circulation of knowledge and skilled labour, thereby strengthening innovation capacity.

The North-West, which represents one of the most economically developed areas of the country, shows a slightly different pattern. Innovation intensity declines from 1.49% in 2021 to 1.41% in 2023, despite a substantial increase in GDP and agglomeration levels. This pattern may indicate that even economically advanced regions may experience temporary



slowdowns in innovation intensity when structural investments in research and development do not keep pace with economic expansion.

In contrast, Southern Italy and the Islands display considerably lower innovation levels throughout the entire period. In Southern Italy, the innovation rate decreases from 1.04% in 2021 to 0.99% in 2023, while the Islands record values below 1%, fluctuating between 0.87% and 0.92%. Although both regions show moderate increases in GDP and agglomeration indicators, these improvements do not translate into significant gains in innovation capacity.

An interesting element emerges in the case of the Islands, where the innovation rate increases slightly from 0.87% in 2022 to 0.92% in 2023. This improvement may be partially associated with redistributive policies and financial transfers directed toward less developed regions, particularly within the framework of European cohesion policy and national development programs. However, the scale of these improvements remains limited and localised. The modest increase in innovation intensity observed in the Islands does not produce a significant impact on the national innovation rate, which remains essentially unchanged over the period analysed. These results may also reflect persistent differences in territorial accessibility and economic integration. Several regions in Southern Italy and the Islands remain less connected to the country's main industrial corridors, which may limit the intensity of interregional trade flows, labour mobility, and knowledge exchange. Lower accessibility can therefore reduce the potential benefits associated with agglomeration economies. The spatial autocorrelation test further contributes to the interpretation of these patterns.

Moran's *I* statistic suggests only limited spatial clustering of innovation intensity across the Italian macro-regions. Although some geographical concentration of innovation activities can be observed, the relatively weak spatial dependence suggests that innovation spillovers are insufficient to drive widespread diffusion across the national territory. In spatial economic terms, this suggests that knowledge spillovers may remain localised within the most developed regional systems rather than spreading evenly across neighbouring territories.

4.3 Interpretation of results through the Philippe Martin model

The empirical patterns observed in the Italian regional system can be interpreted through the mechanisms highlighted by the Philippe Martin model, which explains the relationship between public policies, the spatial distribution of economic activity, and long-term growth dynamics (Martin, 1999a).

The empirical evidence provided by the convergence and spatial autocorrelation tests appears consistent with this theoretical interpretation. The limited convergence dynamics observed through σ - and β -convergence analysis suggest that agglomeration advantages continue to favour already developed regions. At the same time, the weak spatial autocorrelation detected by Moran's *I* suggests that innovation spillovers may not be strong enough to offset these cumulative advantages. As a result, the spatial equilibrium predicted by the Martin model may remain relatively stable over time, reinforcing the persistence of core–periphery structures within the Italian regional system.

The first mechanism concerns pure income transfers, such as subsidies or redistributive policies that are not directly linked to productivity improvements. According to Martin's theoretical framework, these transfers may temporarily reduce the geographical concentration of economic activity by supporting economic development in peripheral regions. However, when redistributive transfers are not accompanied by improvements in structural conditions such as innovation infrastructure, transport accessibility, and market integration, their long-term impact on innovation capacity may remain limited.

In the Italian context, redistributive policies aimed at Southern Italy and the Islands aim to reduce regional disparities by providing financial support to economically weaker regions. While such policies may stimulate local economic activity, the model suggests that they may also produce unintended consequences. If redistributive policies weaken agglomeration in core regions without simultaneously strengthening the innovation capacity of peripheral areas, the overall effect may be a reduction in the intensity of knowledge spillovers.

The second mechanism highlighted by the Martin model concerns reductions in transaction costs, which may arise from improvements in transport infrastructure, increased market integration, or the removal of economic barriers between regions. In theory, such changes could facilitate regional convergence by improving accessibility and reducing spatial constraints. However, Martin emphasises (1999b) that these dynamics do not automatically produce convergence. Regions that are already economically advanced are often better positioned to exploit new opportunities created by improved accessibility and market integration (Krugman, 1991; Boldizsár, 2024). This phenomenon is consistent with spatial economic models in which improvements in accessibility initially reinforce agglomeration in already developed regions before generating potential spillover effects toward peripheral areas.



The Italian data appear consistent with this interpretation. The Northern and Central regions continue to display higher innovation levels and stronger economic structures, suggesting they remain better positioned to benefit from economic integration and technological development. As a result, reducing spatial barriers does not necessarily reduce regional disparities. The third mechanism concerns policies that directly affect the structural determinants of innovation, such as investments in research and development, support for human capital formation, and improvements in knowledge diffusion systems. According to the Martin framework, these policies are more likely to produce sustained and inclusive growth because they strengthen the underlying drivers of productivity and technological progress (Romer, 1990; Martin, 1999). The empirical results suggest that Italy has not yet fully activated these structural mechanisms during the period analysed. Although economic growth and moderate agglomeration expansion are observed, the innovation system shows no significant improvement at the national level. This indicates that economic growth alone is insufficient to stimulate innovation unless accompanied by structural investments in research, technological capacity, and knowledge networks.

4.4 Persistence of core–periphery structures

Taken together, the empirical evidence suggests that the Italian regional system continues to exhibit characteristics consistent with a core–periphery spatial structure, a pattern widely discussed in the literature on economic geography (Krugman, 1991). Regions in the North and Centre maintain higher levels of innovation capacity, stronger economic performance, and more diversified economic structures. In contrast, Southern regions and the Islands continue to experience lower innovation intensity and slower technological development. Although redistributive policies may contribute to localised improvements, these interventions do not appear sufficient to fundamentally alter the spatial equilibrium of the national economy. The persistence of these structural asymmetries indicates that regional disparities remain deeply embedded within the Italian economic system. The results of the convergence and spatial autocorrelation analyses further support this interpretation, indicating that the spatial distribution of innovation remains relatively stable and that diffusion mechanisms are insufficient to drive rapid territorial rebalancing. However, the persistence of these core–periphery dynamics may also be influenced by structural factors that are not directly captured in the empirical analysis presented in this paper. In particular, differences in transport accessibility, interregional trade intensity, and labour mobility may play a crucial role in mediating the spatial diffusion of innovation and economic activity (Prusov and Dubova, 2022; Wang et al., 2022). Regions characterised by stronger transport connectivity and higher levels of interregional integration may benefit more easily from knowledge spillovers and market expansion (Jaber and Hamadneh, 2024). Similarly, higher labour mobility may facilitate the circulation of human capital and technological capabilities across territories. Incorporating these structural dimensions into future empirical analyses could therefore provide a more comprehensive understanding of the mechanisms underlying regional innovation disparities.

4.5 Policy implications

From a policy perspective, these findings highlight the limitations of strategies that rely primarily on redistributive financial transfers. While such policies may alleviate short-term economic disparities, they may not generate sustained improvements in innovation capacity if they are not accompanied by structural reforms that strengthen regional innovation ecosystems. Policies aimed at improving research infrastructure, higher education systems, technological transfer mechanisms, and collaboration between universities and firms may play a more decisive role in fostering long-term innovation-driven growth (Audretsch and Feldman, 1996). By strengthening the structural foundations of regional innovation systems, such interventions may help peripheral regions develop stronger technological capabilities without undermining the positive effects of agglomeration in economically advanced areas.

An additional policy dimension concerns the role of transport infrastructure and territorial accessibility in shaping regional innovation dynamics (Sahin, 2023). Structural investments in multimodal transport systems, high-capacity rail networks, and strategic logistics corridors may significantly improve connectivity between core and peripheral regions (Petrović et al., 2025). By reducing spatial transaction costs and improving accessibility to major economic centres, such interventions can facilitate the circulation of knowledge, skilled labour, and intermediate goods across regions (Škorupa et al., 2024; Juhász and Mátrai, 2024).

In the Italian context, strengthening transport connectivity between Southern regions, the Islands, and the main productive hubs of the North may therefore represent a key complementary policy instrument to traditional cohesion policies.



Investments in strategic corridors and multimodal accessibility improvements may more effectively support the diffusion of innovation and technological capabilities across territories than financial transfers alone.

Finally, the relatively short time horizon considered in this study (2021–2023) should also be taken into account when interpreting the observed stagnation in innovation dynamics (Boldizsár, 2024). Short-term fluctuations may partially obscure longer-term structural transformations occurring within regional innovation systems. Some regions may experience temporary variations in innovation indicators due to cyclical factors, delayed policy effects, or measurement volatility.

Extending the analysis to a longer temporal horizon would therefore allow for a more robust assessment of whether the observed patterns reflect structural stagnation or transitional dynamics associated with post-pandemic economic adjustments. Longitudinal analyses could also help identify whether peripheral regions are gradually strengthening their innovation capacity or whether spatial disparities remain persistently embedded in the Italian economic system.

Overall, the results reinforce the relevance of the Philippe Martin framework as an analytical tool for interpreting regional economic dynamics. Empirical evidence from Italy confirms that spatial economic equilibrium is shaped by complex interactions among agglomeration forces, policy interventions, and innovation processes (Martin, 1999b). Understanding these interactions is essential for designing policies that promote both territorial cohesion and sustainable, long-term growth.

5 Conclusion

This study examined the spatial distribution of innovation across Italian regions during the period 2021–2023, interpreting the empirical evidence within the theoretical framework of Philippe Martin's endogenous growth model (Martin, 1999b). The analysis explored the interaction among economic growth, agglomeration dynamics, and innovation performance to assess whether recent regional developments indicate convergence or confirm the persistence of structural asymmetries within the Italian regional system.

The empirical results reveal a clear divergence between economic expansion and innovation dynamics. Although Italy experienced significant GDP growth and a moderate increase in agglomeration during the period considered, innovation intensity remained largely stagnant at the national level. This pattern suggests that short-term economic expansion does not automatically translate into stronger innovation performance, particularly when the structural determinants of regional innovation systems remain unevenly distributed across territories. Similar dynamics have been highlighted in recent studies on regional innovation systems and spatial economic development, which emphasise the importance of institutional capacity and structural investment in shaping long-term technological performance (Szalmáné Csete and Baranyi, 2023; Zöldy, 2024).

From a spatial perspective, the results highlight persistent regional disparities. The Northern and Central regions continue to exhibit higher innovation intensity, supported by stronger economic structures, diversified industrial systems, and greater agglomeration. In contrast, Southern Italy and the Islands remain characterised by significantly lower innovation levels despite moderate improvements in economic activity. While convergence tests suggest limited catching-up dynamics across macro-regions, these adjustments remain modest and do not fundamentally alter the core–periphery configuration that characterises the Italian innovation system. This spatial structure is consistent with the cumulative mechanisms described in the New Economic Geography literature and with recent empirical applications of spatial development models in European regional contexts (Esses and Szalmáné Csete, 2022).

Interpreted through the lens of the Philippe Martin model, these findings suggest that redistributive policies based primarily on financial transfers toward less developed regions may generate localised improvements but are unlikely to produce sustained convergence in innovation capacity. In line with Martin's theoretical predictions, policies that fail to strengthen the structural drivers of innovation – such as human capital formation, research infrastructure, and knowledge diffusion networks – may have limited long-term impact on regional development trajectories.

At the same time, the results underline the importance of structural conditions that facilitate the spatial diffusion of innovation. Transport accessibility, interregional trade intensity, and labour mobility represent key mechanisms through which knowledge spillovers and economic integration can spread across territories. Recent research in transport economics and spatial mobility studies highlights how improvements in connectivity and infrastructure can significantly influence regional development patterns and technological diffusion (Boldizsár, 2024).

From a policy perspective, the Italian case illustrates the persistence of a core–periphery spatial structure in which innovation capacity remains concentrated in economically stronger regions. More effective policy strategies should therefore complement traditional cohesion policies with targeted interventions to strengthen the structural foundations of regional



innovation systems. Investments in research and development, human capital, and knowledge-transfer mechanisms should be accompanied by improvements in territorial accessibility and transport connectivity, thereby enhancing the diffusion of innovation across regions and reducing spatial barriers to knowledge exchange.

Finally, the relatively short time horizon considered in this study (2021–2023) should be taken into account when interpreting the observed patterns. Innovation dynamics typically evolve over longer periods and may be influenced by policy cycles, investment delays, and broader economic fluctuations. Future research could extend the analysis to longer time series, incorporate additional indicators of regional innovation performance, and explicitly examine the role of structural factors – such as transport accessibility, regional connectivity, and labour mobility – in shaping the spatial dynamics of innovation. Such investigations would contribute to a deeper understanding of the complex relationship between spatial economic structures, innovation systems, and regional development trajectories.

Overall, the findings confirm the continuing relevance of spatial economic models in explaining regional development patterns and highlight the enduring role of agglomeration forces, institutional capacity, and territorial connectivity in shaping innovation disparities within the Italian economy.

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