

Are place-based innovation policies more effective than space-neutral ones? Evidence from environmental patenting across EU regions

Background and motivation

The proposal for Cohesion Policy post-2027 signals a significant shift in the European Union's approach to territorial development. In particular, it features an enhanced focus on strategic objectives, such as achieving leadership in emerging technologies (e.g. artificial intelligence and clean technologies), strengthening defence and security capabilities, and accelerating Europe's competitiveness and strategic autonomy. This orientation is increasingly accompanied by a shift towards more top-down governance and stronger central steering of investment priorities. Such an approach draws on the experience of the NextGenerationEU instrument and aligns with the strategic competitiveness agenda highlighted in the Draghi Report, which calls for stronger coordination and scaling of investments in key technologies.

While this strategic turn reflects legitimate concerns about Europe's position in a rapidly evolving global economy, it raises a fundamental policy question: can a stronger focus on strategic priorities and competitiveness be reconciled with the traditional objective of Cohesion Policy to foster regional convergence? This question is particularly relevant because the capacity of regions to absorb innovation-oriented investments and translate them into tangible innovation outputs remains deeply uneven across the EU. The risk is that an increasingly strategic and technology-driven Cohesion Policy could deliver limited results in less developed territories, while reinforcing advantages in already innovative and prosperous regions.

This paper addresses this tension by examining the territorial effectiveness of green innovation investment policies, which have become central to EU policy agendas under the Green Deal, the Net-Zero Industry Act, and broader competitiveness strategies. Green technologies represent a unique and policy-relevant case: they are essential for climate mitigation and adaptation, but they are also increasingly framed as a pillar of industrial leadership and economic competitiveness. Understanding whether green innovation policies deliver across different regional contexts is therefore crucial to evaluating whether the post-2027 shift can support both competitiveness and convergence.

Research gaps and hypotheses

There is extensive research on innovation policy and green innovation, including on the role of environmental regulation, subsidies, and incentives. Yet, despite growing policy attention, there is limited research systematically exploring green innovation policies from a territorial perspective. Most empirical work remains firm-level, with relatively few studies examining regional dynamics. Even fewer studies investigate how the effectiveness of green innovation investment policies depends on structural regional conditions such as development levels, innovation capacity, human capital, institutional quality, or sectoral composition.

This paper contributes to filling this gap by focusing on regional-level impacts of green R&D investment policies across European regions. It explores whether green innovation subsidies translate into higher green patenting and, critically, whether such effects are territorially uneven. Moreover, it compares the impacts of two major EU funding streams that reflect contrasting policy logics:

1. Cohesion Policy R&I funding, which is spatially selective and place-based, and
2. Horizon 2020 funding, which is largely place-neutral and allocated based on scientific excellence.

This comparison provides insights into whether place-based innovation policy approaches deliver stronger effects than space-neutral instruments, and whether the two types of subsidies reinforce each other or instead substitute.

Research questions and hypotheses

The paper investigates three main questions:

1. Do green innovation investment policies increase green innovation outputs across EU regions?
2. Do these effects vary systematically depending on regional development levels and innovation capacity?
3. Are place-based innovation policies more effective than space-neutral ones, and do they complement or substitute each other?

The analysis is structured around five hypotheses. First, it is expected that green patenting is uneven across Europe and concentrated in richer regions. Second, green innovation investment policies are expected to have a positive effect on green patenting growth. Third and fourth, the effectiveness of these policies is expected to vary by regional income and innovation capacity. Finally, place-based innovation policies (Cohesion Policy) are expected to have stronger effects than place-neutral ones (Horizon 2020).

Data and empirical design

The empirical strategy adopts a cross-sectional long-difference design. It relates cumulative EU green R&I funding received during the 2014–2020 programming period to changes in regional green patent stock intensity between 2013 and 2021. The analysis covers 231 EU regions (excluding Cyprus, EU outermost regions, and a small set of special territories due to data limitations).

Green innovation outcomes are measured through environment-related patent stocks, identified using the OECD classification. Patent stocks are estimated using the perpetual inventory method with a 5% depreciation rate. Green patent stock is expressed per million inhabitants and used as the core measure of green technological capability.

The treatment variables capture EU green R&I subsidies. They are extracted from project-level databases of Cohesion Policy and Horizon 2020 and identified via text-mining techniques applied to project descriptions and classifications, allowing the isolation of funding targeted to the “green transition”. Funding is expressed in per capita terms and used in logarithmic form in the econometric models.

A key challenge is that these funds are not randomly assigned. Allocation depends on eligibility rules, institutional capacity, baseline innovation characteristics, and structural features that are also correlated with patenting outcomes. To address this, the paper employs a Double/Debiased Machine Learning (DML) framework, implemented through the post-double-selection LASSO procedure (Belloni et al., 2014; Chernozhukov et al., 2018).

This approach is particularly suited for settings with many potential confounders. It selects controls based on their predictive relevance for both the treatment and the outcome, reducing model dependence and improving causal interpretation while allowing valid inference. The model includes 34 potential pre-treatment regional characteristics, capturing baseline innovation capacity, human capital, economic structure, institutional quality, industrial specialisation, and environmental performance.

Descriptive evidence: territorial heterogeneity in green innovation

The descriptive analysis confirms stark territorial disparities in green innovation across Europe. Green patenting activity is highly concentrated in a small set of regions, primarily metropolitan and industrial areas in Northern and Western Europe. These include regions such as Stockholm, Madrid, Helsinki, Île-de-France, Rhône-Alpes, Stuttgart, Oberbayern, and Lombardy. By contrast, Central and Eastern European regions, as well as many Southern European territories, exhibit very low green patent stocks.

The analysis also shows that more developed regions have increased their green patent stocks more strongly over time in absolute terms. Although less developed regions show higher relative growth rates, this does not translate into meaningful convergence in absolute levels.

Furthermore, EU green R&I funding displays its own uneven geography: Horizon 2020 green funding is strongly biased toward more developed and innovative regions, while Cohesion Policy green R&I funding is more balanced and displays a stronger orientation toward less developed areas.

Results

The econometric results show that green innovation policies have significant but highly heterogeneous effects. In the pooled sample, both Cohesion Policy and Horizon 2020 green funding are positively associated with growth in regional green patent stocks once a robust set of controls is included through the post-double-selection framework. This supports the hypothesis that green innovation subsidies contribute to the expansion of green technological capabilities at the regional level.

However, the most striking finding is that these effects are not territorially uniform. When the sample is split by regional development status (more developed vs. transition and less developed regions), the positive and statistically significant effects of both Cohesion Policy and Horizon 2020 green funding are found to be driven almost entirely by more developed regions. In transition and less developed regions, neither funding stream shows statistically significant causal effects on green patent growth.

A parallel heterogeneity analysis based on innovation capacity (innovation leaders/followers vs. moderate/modest innovators) reveals the same pattern. Strong positive effects are observed only in regions with higher innovation performance, while no statistically significant impacts are detected in weaker innovation regions.

These results suggest that EU green R&I subsidies alone are insufficient to shift green patenting trajectories in lagging regions, where structural barriers prevent the translation of investment into patentable technological outputs. This finding resonates with the concept of the regional innovation paradox: the territories most in need of innovation-driven transformation are often those least capable of absorbing innovation policies effectively.

The analysis also provides evidence of a negative and statistically significant interaction term between Cohesion Policy and Horizon 2020 funding in most specifications. This indicates that the two funding streams are not additive and may exhibit substitution effects. In other words, the combined effect of receiving both types of subsidies is smaller than the sum of their individual effects.

Importantly, this substitution pattern is primarily visible in more developed and innovative regions, where both funding streams are more likely to target similar firms, institutions, and technologies. In lagging regions, where neither funding stream generates statistically significant impacts, the interaction term is also generally insignificant. This suggests that the main constraint in weaker regions is not overlap between policy instruments but rather the lack of enabling conditions required for innovation outcomes.

Robustness checks support these interpretations. Results remain stable when capital regions are excluded, suggesting that findings are not driven by a small set of highly innovative metropolitan territories. A placebo analysis using non-green patents as the dependent variable shows no significant effects, reinforcing the interpretation that estimated impacts are specific to green innovation rather than capturing general increases in patenting.

Policy implications

The results have direct relevance for the current debate on Cohesion Policy post-2027. They highlight a critical risk: a stronger emphasis of Cohesion Policy on strategic priorities such as green technologies may achieve very little in relation to convergence if adequate enabling conditions are not in place. Instead, such a shift may unintentionally reinforce regional disparities and deepen innovation divides.

The findings suggest that green innovation policies are most effective in regions that already possess strong innovation ecosystems, including complex knowledge bases, diversified industrial structures, high levels of human capital, and strong institutional capacity. Conversely, less developed and less innovative regions face structural constraints that prevent them from converting R&D subsidies into measurable green technological outputs. Without addressing these constraints, strategic investments may flow disproportionately toward already leading territories, producing limited additionality and weak convergence outcomes.

This poses a challenge for the post-2027 reform agenda. The EU's push toward competitiveness, strategic autonomy, and leadership in clean technologies, reinforced by the Draghi Report and the NextGenerationEU governance logic, may require stronger central steering. Yet, if Cohesion Policy increasingly prioritises strategic technologies without simultaneously reinforcing place-based enabling conditions, it may drift away from its foundational mission of convergence.

Moreover, the evidence of substitution effects between Cohesion Policy and Horizon 2020 suggests that policy coordination becomes increasingly important. In advanced regions, overlap between place-based and place-neutral instruments may reduce additionality and weaken the coherence of the EU policy mix. This reinforces the need for stronger complementarity and sequencing between funding streams.

This paper provides novel evidence on the territorial effectiveness of green innovation investment policies across EU regions. It shows that EU green R&I subsidies have significant but highly heterogeneous effects, with positive impacts concentrated in more developed and innovative territories. In less developed and less innovative regions, no statistically significant causal effects on green patenting are detected, indicating that green innovation policies may deliver limited convergence benefits unless accompanied by strong enabling conditions.

The results highlight a potential contradiction at the heart of the post-2027 Cohesion Policy debate. A strategic, competitiveness-oriented Cohesion Policy may strengthen Europe's leadership in key technologies, but it risks exacerbating territorial divides if it does not address the structural conditions that shape policy effectiveness. Ensuring that green innovation policies contribute to both competitiveness and convergence requires a renewed emphasis on regional innovation ecosystems, absorptive capacity, and institutional quality, particularly in lagging regions.