Innovation effects of place-based investment-incentives: Evidence from Italy

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February 2026

Abstract

This paper studies whether the Italian Mezzogiorno's investment tax-credit (2016-2019) fostered regional innovation leveraging both a 1980-2019 patent-data panel of 91 NUTS-3 provinces and Differences-in-Differences-based (DiD) designs, finding a delayed, robust increase in forward-citation-weighted patent fractional-counts per-capita associated to the policy, but no effects on unweighted patenting or inventors' number, suggesting quality upgrading rather than extensive-margin expansion.

Keywords: place-based policy; investment tax-credit; regional innovation; patents; difference in differences.

JEL codes: C23; C54; H25; H71; O31; O38; R11; R58.

1 Introduction

Place-based policies, typically deploying geographically-targeted incentives to foster capital accumulation and narrow persistent spatial disparities in productivity and living standards in underperforming areas, have become a central component of regional development strategies. Yet, despite their salience, evidence on whether such interventions translate into innovation remains comparatively limited.

The related empirical literature has largely examined effects on employment [Neumark and Kolko, 2010, Busso et al., 2013, Criscuolo et al., 2019, Slattery and Zidar, 2020], productivity [Kline and Moretti, 2013], firm location/entry [Devereux et al., 2007], investments [Chirinko and Wilson, 2008, Corinth and Feldman, 2024], R&D subsidies [Einiö, 2014], and the establishment of new universities/research institutions [Cowan and Zinovyeva, 2013, Kantor and Whalley, 2014, Liu, 2015, Bonander et al., 2016, Castelnovo et al., 2018, Valero and Van Reenen, 2019, Castelnovo and Dal Molin, 2020, Bastianin et al., 2021, Robbiano, 2022].[1]

This paper contributes to this literature being, as far as is known, the first studying the innovation effects of a Italian major place-based-investment policy, i.e. the 2016-2019 Mezzogiorno's investment

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[1]See also Bottasso et al. [2022, 2023, 2025a,b,c].

tax-credit;[2] it targets NUTS-3-regions belonging to the assisted Southern (the Mezzogiorno) lagging areas and grants firms a tax-credit for initial investments in new capital goods allocated to production units.

Conceptually, this policy may affect innovation by lowering the user cost of capital, relaxing financial constraints and facilitating the adoption of modern equipment and complementary intangible inputs that support R&D. Alternatively, if the incentive mainly induces "replacement" investment or reallocates activity within firms without strengthening knowledge creation, innovation responses may be limited. Therefore, determining which mechanism dominates is ultimately an empirical question, particularly in contexts where baseline innovation gaps are large and persistent.

Leveraging a 1980-2019 patent-panel of Italian NUTS-3-provinces and DiD-based designs, the analysis finds that the policy is associated with an increase of $\approx 49\%$ in per-capita forward-citation-weighted patent fractional-counts, emerging from the second post-treatment year onwards. In contrast, impacts on unweighted patent counts and inventors are indistinguishable from zero, implying gains concentrated in the technological salience of innovation rather than in patenting volume or the extensive margin of inventorship, consistent with an investment-led mechanism——capital upgrading and complementary intangible accumulation——requiring time to translate into innovation.

2 Data and Empirical Strategy

This study leverages 1980-2019 patents/inventors data from the European Patent Office, regionalised following the inventors' region of residence—i.e. per-capita forward-citation-weighted patent fractional-counts—for 91 Italian NUTS-3-regions (3,640 observations). Patents, although capturing inventions rather than the full-set of innovative activities [Smith, 2006], are fundamental instruments for appropriating returns to inventive activity [Pakes and Griliches, 1980], remaining widely used indicators of local technological capacity; forward-citations proxy instead the (indirect) value and technological relevance of inventions [Trajtenberg, 1990, Hall et al., 2005]. Descriptive statistics are shown in Table A.1, in Appendix.

To control for predetermined regional characteristics, the paper complements patents with measures of regional size, production structure and labour costs from the ARDECO database.[3] Moreover, to control for market-accessibility, the ESPON's potential-multimodal-accessibility index—a gravity-type regional measure integrating road, rail, and air networks (with intermodal transfers) to summarise absolute accessibility changes over time—is also collected.[4]

Paper's identification rests on the following DiD model [Wooldridge, 2025]:

$$\log Innov_{it}^{PC} = \alpha + \gamma \cdot \left(Treated_i \times Post_t\right) + \mathbf{X_i'}\theta + \left((Treated_i \times Post_t) \cdot \mathbf{\tilde{X}_i}\right)'\varsigma + \left(\delta_t \cdot \mathbf{X_i}\right)'\pi + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

where $Innov_{it}^{PC}$ is the innovation outcome, i.e. per-capita forward-citation-weighted (unweighted) patent fractional-counts or inventors' number, for region i in year t, $Treated_i = 1$ for eligible NUTS-3-regions, while $Post_t = 1$ from 2016 onwards;[5] the coefficient γ is the ATT of the policy on regional innovation; ε_{it} is an error term. To increase the degree of comparability between treated and control

[2] Law 28 December 2015, n. 208.

[3] `https://territorial.ec.europa.eu/ardeco/explorer?lng=en`.

[4] `https://database.espon.eu/indicator/1541/#metadata-download`.

[5] The Appendix provides details on eligible provinces.

units, the specification includes both province (μ_i) and year (δ_t) fixed effects. Similarly, a full-set of economic, labour-market, market-accessibility and innovation predetermined covariates, namely $\mathbf{X_i}$ (taken at the start of the sample) is included.[6]

The paper also estimates a dynamic version of Equation 1 to test pre-trends; let define the indicators $\text{Lead}_t^{(-\ell)} = \mathbf{1}\{t = 2016 - \ell\}$ for $\ell = 1,2,3$, $\quad \text{Lead}_t^{(-4^-)} = \mathbf{1}\{t \leq 2016 - 4\}$:

$$\begin{aligned} \log Innov_{it}^{PC} = \alpha + \sum_{\ell=1}^{-4^-} \beta_\ell \left(Treated_i \times Lead_t^{(-\ell)}\right) + \mathbf{X_i'}\theta \\ + \sum_{\ell=1}^{-4^-} \left((Treated_i \times Lead_t^{(-\ell)}) \cdot \tilde{\mathbf{X}}_\mathbf{i}\right)' \varsigma + \left(\delta_t \cdot \mathbf{X_i}\right)' \pi + \mu_i + \delta_t + \varepsilon_{it} \end{aligned} \tag{2}$$

in which the ℓ leads of the treatment-interaction span from 4 (and backward) to 1 years before the treatment and the β's represent pre-trends coefficients [Freyaldenhoven et al., 2019].

3 Results

Table 1 reports the estimated effect of the Mezzogiorno's investment tax-credit on regional innovation; focusing on the forward-citation-weighted measure, columns (1)–(2) show a positive and statistically significant ATT. The point estimate falls from ≈ 0.57 ($\approx +76\%$) in the most parsimonious specification to ≈ 0.40 in the fully-saturated DiD-model, implying an increase of $\approx +49\%$ in citation-weighted patenting per-capita for treated provinces after 2016.

Table 1: The impact of the Mezzogiorno's investment tax-credit on regional innovation. DiD-based estimation results.

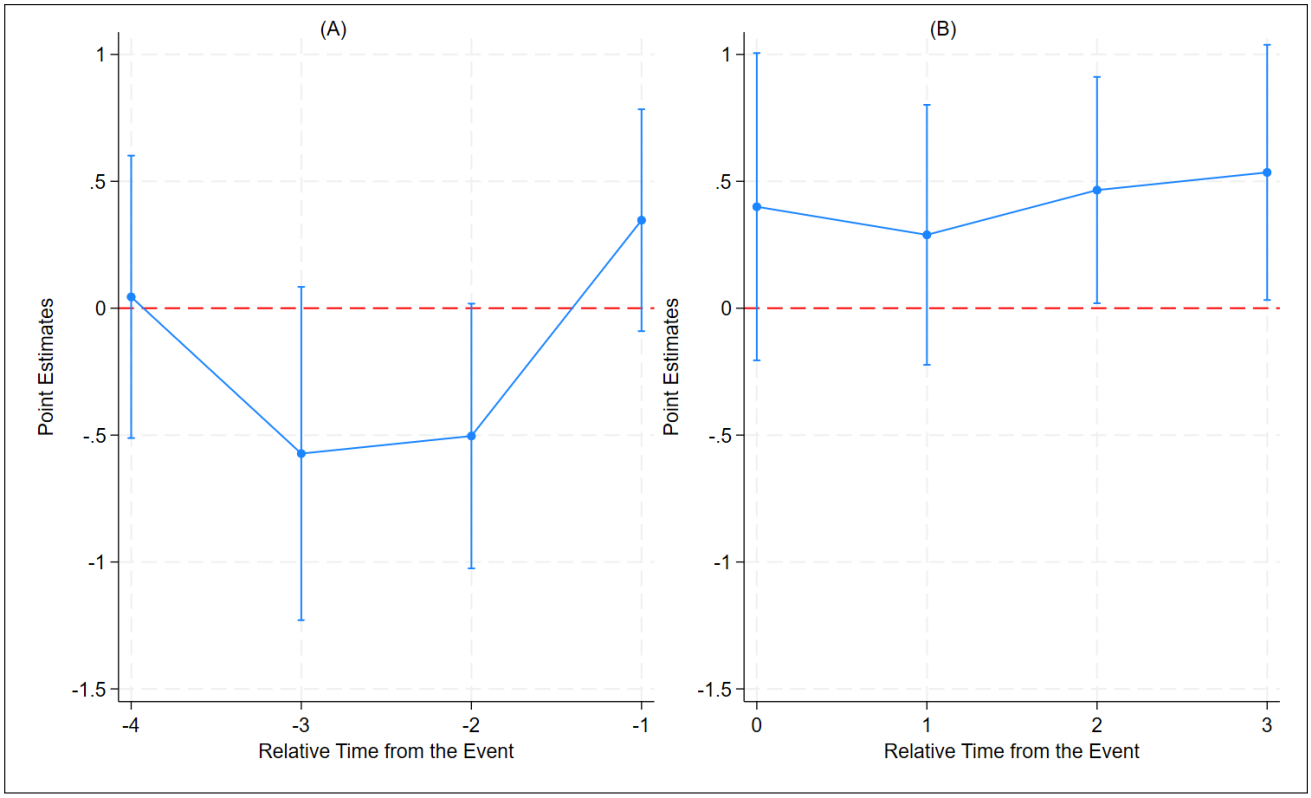
Per-Capita Dependent variable (log):	Forward-Citation-Weighted PFC					Unweighted PFC	Inventors	*Fake* Forward-Citation-Weighted PFC
	DiD	DiD	SDiD	PSM-DiD	DiD	DiD	DiD	DiD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Treated_i \cdot Post_t$	0.567***	0.403**	0.402***	0.402**		0.013	−0.001	0.100
	(0.140)	(0.205)	(0.087)	(0.184)		(0.132)	(0.143)	(0.255)
Fake $Treated_i \cdot Post_t$					−0.093			
					(0.064)			
NUTS-3-region FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Predetermined controls	✗	✓	✓	✓	✓	✓	✓	✓
Observations	3,640	3,640	3,640	2,722	3,640	3,640	3,640	3,640

Notes: DiD-based-estimates of Equation 1 on the effects of the Mezzogiorno's investment tax-credit on per-capita regional innovation, measured by forward-citations-weighted patents fractional-counts (columns 1-5), unweighted patent fractional-counts (column 6), number of inventors (column 7). All specifications include NUTS-3-region and year fixed effects. Controls include predetermined regional characteristics at the beginning of the sample period (innovation levels, GVA, wage/salary earners, unit labour costs, compensations per hour worked, share of industry on GVA, potential multimodal accessibility index. Column (3) provides Synthetic-DiD estimates [Arkhangelsky et al., 2021]; in column (4) a propensity-score-matching weighted DiD is estimated leveraging the observable characteristics from controls (nearest neighbour[s] within caliper = 0.05), and keeping observations within the common support [0.1, 0.9]. Column (5) provides placebo estimates by replacing in Equation 1 the treatment interaction with a *fake* one, drawn from Bernoulli distributions with success probability t derived from the original sample distributions; in column (8) Equation 1 is estimated after replacing the original outcome with a *fake* one that is drawn from random forward-citations-weighted PFC distributions resembling sample ones (same mean and variance). Robust standard errors for specifications in columns (1)-(2), (4)-(8) are clustered at NUTS-3-region level, while those in column (3) are obtained via unit-level block bootstrap with re-estimation of the weights: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

The paper checks the validity of DiD results—based on the parallel-trends assumption between treated and control units— and examines post-treatment dynamics by both estimating Equation 2 and augmenting Equation 1 with relative-time indicators. Results depicted in Panel (A) of Figure 1 show no differential pre-trends, while those in Panel (B) suggest a delayed positive response that aligns with an adjustment period and a medium-run upgrading and knowledge-creation mechanism rather than an instantaneous rise in observed patenting—consistent with channels through which an investment tax-credit is expected to influence innovation, as firms need time to (i) plan/approve investment projects, (ii)

[6] $\mathbf{X_i}$ includes innovation levels, GVA, wage/salary earners, unit labour costs, compensations per hour worked, share of industry on GVA, and the potential multimodal accessibility index. Notice that $\delta_t \cdot \mathbf{X_i}$ allows for heterogeneous time trends by $\mathbf{X_i}$, and $(Treated_i \cdot Post_t) \cdot \tilde{\mathbf{X}}_\mathbf{i}$ (with $\tilde{\mathbf{X}}_\mathbf{i} = \mathbf{X_i} - \bar{\mathbf{X}}_{\text{treated}}$) allows the ATT to vary with $\mathbf{X_i}$.

Figure 1: Event study representation of the impact of the Mezzogiorno's investment tax-credit on regional innovation.



Notes: Panel (A) provides event-DiD estimates of Equation 2 on the effects of the Mezzogiorno's investment tax-credit on regional innovation, as proxied by the per-capita (log) forward-citation-weighted patent fractional-count. Panel (B) provides evidence on post-treatment dynamics. The blue dots represent the estimated pre-trend (post-treatment) coefficients of the treatment-interaction, spanning from 4 (and backward) to 1 year before the treatment (the implementation year to 3 years later). The vertical whiskers represent the respective 95% confidence intervals. Robust standard errors are clustered at NUTS-3-region level.

acquire/install capital goods and complementary intangibles, and (iii) converting them into observable innovation.

Concerns related to systematic differences between treated and control regions are mitigated by also leveraging the Arkhangelsky et al. [2021]'s Synthetic-DiD, that provides ATT estimates by contrasting treated regions with weighted synthetic-counterparts, assigning higher weights to controls with similar pre-treatment paths and to time-windows most comparable to the treated period.[7] Results in column (3) of Table 1 corroborate the baseline-DiD evidence, being strikingly close to those in column (2). Column (4) of Table 1 reaches similar conclusions when treated/control units' comparability is enhanced via propensity-score-matching and the DiD is re-estimated on the matched sample within the common support, suggesting that main findings are not driven by extrapolation from dissimilar controls.

The evidence is far weaker when innovation is proxied instead by both per-capita unweighted patent fractional-counts (column 6) and the inventors' number (column 7), with estimated coefficients statistically indistinguishable from zero, implying that the policy does not generate a broad-based expansion in patenting volume or in the extensive margin of inventorship. Taken together with the strong citation-weighted result, this pattern is consistent with an upgrading in the quality (or technological value) of patented inventions rather than a increase in the number of patent-filings. A rationale is that the tax-

[7]Key endogeneity concern is not reverse causality (these regions do not choose eligibility) but differential time-varying confounding between the Mezzogiorno and the rest of Italy.

credit, by lowering the user cost of capital, facilitated the adoption of more-advanced machinery and complementary intangible inputs, enabling firms undertaking projects with higher inventive content and greater subsequent influence. From a policy perspective, this is potentially encouraging: cohesion-oriented fiscal incentives may foster better innovation even when they do not immediately enlarge the local base of inventors——a margin that may be more tightly linked to slow-moving constraints such as human capital, research capacity, and innovation ecosystems.

Some falsification exercises further strengthen the credibility of the estimated effects. Equation 1 is firstly re-estimated after introducing *fake* treatments, and secondly after replacing the original innovation measure with a *fake* one. Given that, one should not observe any significant ATT; comfortingly, estimates shown in both column (5) and (8) of Table 1 confirm this prediction.

4 Conclusions

This paper asks whether the Italian Mezzogiorno's investment tax-credit produced measurable gains in regional innovation, using a 1980-2019 panel of 91 NUTS-3 provinces, patent-based outcomes capturing both the scale and technological relevance of inventive activity, and DiD-based designs. It finds (i) a sizeable and robust increase of $\approx 49\%$ in forward-citation-weighted patent fractional-counts per-capita; (ii) a delayed response, with statistically significant effects emerging only from the second post-treatment year onwards, consistent with the time needed for investment project selection, procurement and installation of capital goods, and for capital upgrading and complementary intangibles to translate into patentable inventions; and (iii) weak evidence for both unweighted patent counts and inventors per-capita, indicating stronger gains in the technological salience of innovation than in filing volumes or the extensive margin of inventorship, i.e. strengthening incumbent innovators in the short-run.

These province-level patterns complement firm-level evidence for 2016-2020 by Andini and D'Ignazio [2025], who show that the same credit increased tangible investment and employment——especially in 2018-2020 and among smaller firms, service-sector firms, and firms without prior incentives. The timing coherence (regional innovation effects emerging from 2018 onwards) supports a sequencing from capital deepening to more valuable inventive output, and the divergence between citation-weighted and unweighted/inventor outcomes is consistent with an investment/financing channel in which subsidised capital upgrading and associated intangible accumulation raise invention influence without mechanically increasing applications or inventors.

From a policy perspective, the tax-credit can meaningfully raise impact-weighted innovation in lagging regions——arguably the margin most relevant for long-run productivity——but it does not, by itself, broaden participation in inventing or increase patenting volumes. Investment incentives thus appear most effective as part of a wider strategy: building a thicker local innovation base likely requires complementary interventions in skills, R&D capacity, and university-industry linkages, alongside careful design to ensure additionality rather than windfalls (eligibility rules, monitoring of incremental investment, and complementarities with intangible capital).

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Declaration of Interests and Competing Funding

The Author declares no potential conflicts of interest. This work does not received any source of funding.

Data Statement

The data used to produce the manuscript are mainly from the PATSTAT database, managed by the European Patent Office. The database is accessible upon subscription at the following link: https://www.epo.org/en/searching-for-patents/business/patstat. Researcher who want to replicate the analyses presented can do so by selecting all patents filed in Italy, and generate the forward citations-weighted measure of patent fractional count.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the author used ChatGPT in order to search for and correct linguistic errors and typos. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.