

Digital Innovation and NextGenerationEU: Spatial Patterns in Italian Local Government Performance ‡

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Workshop PRIN PNRR 2022

Ancona — February 3, 2026

‡ Research project “A survey-based Impact Evaluation of NRRP on Italian Municipalities” - PRIN 2022 PNRR (Project code P2022RR82F, CUP I53D23007340001) financed by the European Union - NextGenerationEU within the National Recovery and Resilience Plan - Mission 4 “Education and Research” - Component 2 “From research to enterprise” - Investment 1.1 “National Research Programme and Projects of National Interest (PRIN).

I. RESEARCH QUESTIONS

- ▶ Assessment of the Spatial Diffusion of Next Generation EU (NGEU) Projects Promoting the Digitalisation of Public Administration in Italian Municipalities
- ▶ Investigation of the Role of Selected Factors in Driving Italian Municipalities' Participation in NRRP Projects Promoting the Digitalisation of Public Administration
 - ▶ Territorial economic structure
 - ▶ Government capacity
- ▶ Is there evidence of strategic interactions among municipalities in the participation of digitalization projects?

II. MOTIVATION

▶ NextGenEU Context

- ▶ National Recovery and Resilience Plans (NRRPs) of the 27 EU member states: the total estimated expenditure on digital public services amounts to 53.73 billion Euros (European Commission, 2024)
- ▶ The NextGenerationEU mandates that at least 20% of the substantial funding allocated to each EU country be earmarked for investments and reforms related to the digital transition (Italia Domani, 2021).
- ▶ The Department for Digital Transformation of the Italian Government launched *Digital Italy 2026*, a strategic plan for digital transition and connectivity funded by the NextGenEU.
- ▶ Digitizing the public administration, with the objective of “*making the public administration the best ally of citizens and businesses*” (Dipartimento per la Trasformazione Digitale, 2023).

III.1 RELEVANT LITERATURE

- ▶ Efficiency-oriented local governments exhibit a greater propensity to adopt digital innovations earlier and to implement them more widely across a broader range of functions (Jun and Weare, 2011). Their implementation depends largely on the support of political and administrative actors (Haug et al., 2024).
- ▶ Strong technological and political capabilities are essential to support effective planning and implementation of digital innovation in public administration (Moon and Norris, 2005; Gallego-Álvarez et al., 2010).
- ▶ Competition can incentivize local governments to pursue digital innovation in response to neighboring jurisdictions (Jun and Weare, 2011).
- ▶ The diffusion of digital innovation and e-government among neighbouring local jurisdictions can be driven both by inter-jurisdictional competition and the desire to gain institutional legitimacy.

III.2 RELEVANT LITERATURE

- ▶ The digitalisation of public administration is strongly conditioned by the underlying socio-economic structure of a territory.
- ▶ In such contexts, firms act as both key stakeholders and co-creators of public value. They determine their own needs and address them in partnership with governments, which are supported by new governance frameworks, digital innovation projects and the design of user-driven services (OECD, 2016).
- ▶ Xu and Jin (2024) and Liu and Feng (2025) find a clear correlation—and a mutually reinforcing effect—between the emergence of a more favorable business environment, improved resource allocation efficiency at the micro level, and the digital transformation of public governance.
- ▶ The responsiveness of public administration to digital transformation can be interpreted through the lens of external demand-pull innovation and need-based holism, beyond purely internal administrative choices (Dunleavy et al., 2006; Hong et al., 2022).
- ▶ The stronger the technological and organizational capabilities of the regional institutional and economic environment (Arduini et al., 2010), i.e. local business and productive systems, the greater the pressure on local governments to modernise administrative processes and service delivery.

IV. DATA

- ▶ Italian municipalities that implemented NRRP projects related to the digitalisation of public administration in 2021 as sole **implementing entity**
 - ▶ Given their proximity to citizens and firms, particularly in small municipalities, local governments better understand and respond to community needs
- ▶ **IFEL database** - Institute for Finance and Local Economy (IFEL)
- ▶ Italian municipalities belonging to Ordinary Statute Regions
- ▶ **Final sample of 6,422 municipalities out of about 7,900 Italian municipalities**

DEPENDENT VARIABLES

- ▶ Number of digital projects - per capita, per 1,000 residents
- ▶ Average funding per project - in log

INDEPENDENT VARIABLES

- ▶ Territorial economic structure
 - ▶ High-Tech Specialization;
 - ▶ Entrepreneurship Rate;
 - ▶ Firms' density
- ▶ Government capacity
 - ▶ Bureaucratic-administrative Capacity (Cerqua et al., 2025);
 - ▶ Politicians Capacity (Cerqua et al., 2025).
- ▶ Other controls
 - ▶ population density, per capita income, unemployment rate, tertiary education, geographical macro-area (Center-North and South), urbanization level, coastal location.

VI. EMPIRICAL ANALYSIS

Spatial Model Selection

- ▶ Bayesian posterior model probabilities comparison for cross-section data (LeSage, 2015)
 - Spatially-lagged X model (SLX);
 - Spatial Durbin Model (SDM);
 - Spatial Durbin Error Model (SDEM).

▶ Bayesian Probabilities

Weight Matrix Selection

- ▶ 22 spatial matrix (W):
 - first and second order contiguity matrices;
 - inverse distance matrices at 15, 25 and 50 km;
 - 17-nearest-neighbor weight matrices, which consider the k municipalities closest to the one considered, with k ranging from 4 to 20.

VI. EMPIRICAL ANALYSIS

► Selected Spatial Model

$$\textit{Spatial Durbin Model} : y = \rho Wy + \alpha + X\beta + WX\gamma + \varepsilon \quad (1)$$

► Selected Weight Matrices

- Number of digital projects \Rightarrow W: 11-nearest-neighbor spatial weights matrix (W11)
- Average funding per project \Rightarrow W: 5-nearest-neighbor spatial weights matrix (W5)

VII. BASELINE RESULTS [▶ Details](#)

Variable	Per-capita Number of Projects				Project Average Funding			
	Coefficient (1)	Direct (2)	Indirect (3)	Total (4)	Coefficient (5)	Direct (6)	Indirect (7)	Total (8)
High Tech Specialization	-0.021 (0.013)	-0.019 (0.015)	0.052 (0.0145)	0.033 (0.0152)	-0.007 (0.010)	-0.002 (0.011)	0.062* (0.033)	0.060 (0.040)
Entrepreneurship Rate	-0.036** (0.011)	-0.029*** (0.011)	0.160*** (0.060)	0.131** (0.062)	0.0001 (0.003)	0.0006 (0.003)	0.006 (0.007)	0.006 (0.008)
Firms'density	0.018*** (0.005)	0.016*** (0.005)	-0.045 (0.024)	-0.029 (0.026)	0.006*** (0.001)	0.005*** (0.001)	-0.006 (0.007)	-0.0005 (0.007)
Burocratic Capacity	0.090*** (0.024)	0.098*** (0.027)	0.193 (0.183)	0.291 (0.198)	-0.006 (0.005)	-0.008 (0.006)	-0.020 (0.031)	-0.027 (0.035)
Politicians' Capacity	-0.062*** (0.009)	-0.080*** (0.010)	-0.452*** (0.092)	-0.531*** (0.097)	0.012*** (0.003)	0.012*** (0.004)	0.007 (0.017)	0.019 (0.019)
Neighbourhood effects	W11				W5			
<i>Lagged</i> High Tech Specialization	0.031 (0.046)				0.027*** (0.010)			
<i>Lagged</i> Entrepreneurship Rate	0.076*** (0.019)				0.002 (0.003)			
<i>Lagged</i> Firms'density	-0.027*** (0.008)				-0.006** (0.003)			
<i>Lagged</i> Burocratic Capacity	-0.001 (0.055)				-0.003 (0.010)			
<i>Lagged</i> Politicians Capacity	-0.101** (0.036)				-0.005 (0.008)			
Rho	0.694*** (0.080)				0.675*** (0.191)			

A constant term is included among the regressors. Standard errors in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

VIII. DRIVERS OF SPATIAL INTERACTION

- ▶ To investigate the spatial interdependence in municipal digitalization investment, focusing on Government Capacity and the structure of the local productive and entrepreneurial fabric, we estimated the following two-regime spatial Durbin model (Bordignon et al., 2003; Allers and Elhorst, 2005; Elhorst and Fréret, 2009) for both outcome variables:

$$y = \rho_{D=1} MWy + \rho_{D=0} (I_N - M)Wy + \phi_{D=1} + \phi_{D=0} + X\beta' + WX\gamma + \varepsilon \quad (2)$$

- ▶ M is a diagonal matrix with ones on the diagonal where the dummy variable D equals 1, and zeros elsewhere. Conversely, $(I_N - M)$ is a diagonal matrix with ones on the diagonal where D equals 0. The coefficients $\phi_{D=1}$ and $\phi_{D=0}$ capture the intercepts of two reaction functions, with the corresponding ρ 's coefficients capturing their slopes.
- ▶ The Equation 2 includes two spatial lag terms of the dependent variable, associated with coefficients $\rho_{D=1}$ and $\rho_{D=0}$, where D is a dummy variable equal to 1 if the indicator of municipal quality or entrepreneurial structure is above the mean (or 75th percentile) of its distribution and 0 otherwise.
- ▶ This specification allows us to test whether spatial dependence varies with municipalities' demand-side and/or administrative characteristics.

VIII. DRIVERS OF SPATIAL INTERACTION

► Estimation Results of Two Spatial Regimes Model: Mean Value

Per-capita Number of Projects										
	High Tech Specialization		Entrepreneurship Rate		Firms' density		Burocratic Capacity		Politicians' Capacity	
	Low	High	Low	High	Low	High	Low	High	Low	High
ρ	0.868*** (0.074)	0.583*** (0.089)	0.951*** (0.077)	0.803*** (0.097)	0.859*** (0.068)	0.434*** (0.113)	0.875*** (0.105)	0.868*** (0.092)	0.932*** (0.085)	0.781*** (0.120)
ρ Quality Test	0.0003		0.070		0.000		0.943		0.151	
ϕ Test	0.003		0.531		0.000		0.104		0.851	
Project Average Funding										
	High Tech Specialization		Entrepreneurship Rate		Firms' density		Burocratic Capacity		Politicians' Capacity	
	Low	High	Low	High	Low	High	Low	High	Low	High
ρ	0.692*** (0.128)	0.706*** (0.156)	0.539*** (0.137)	0.806*** (0.148)	0.913*** (0.171)	0.464*** (0.136)	0.702*** (0.228)	0.496*** (0.146)	0.662*** (0.142)	0.863*** (0.208)
ρ Quality Test	0.926		0.162		0.036		0.395		0.348	
ϕ Test	0.958		0.167		0.032		0.410		0.375	

A constant term is included among the regressors. Standard errors in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

VIII. DRIVERS OF SPATIAL INTERACTION

► Estimation Results of Two Spatial Regimes Model: 75th percentile

Per-capita Number of Projects											
		High Tech Specialization		Entrepreneurship Rate		Firms'density		Burocratic Capacity		Politicians' Capacity	
		Low	High	Low	High	Low	High	Low	High	Low	High
ρ		0.870*** (0.074)	0.597*** (0.092)	0.848*** (0.113)	0.914*** (0.085)	0.862*** (0.068)	0.431*** (0.114)	0.844*** (0.114)	0.996*** (0.089)	0.892*** (0.080)	0.580*** (0.112)
ρ	Quality Test	0.0007		0.486		0.000		0.196		0.0002	
ϕ	Test	0.004		0.677		0.000		0.058		0.074	
Project Average Funding											
		High Tech Specialization		Entrepreneurship Rate		Firms'density		Burocratic Capacity		Politicians' Capacity	
		Low	High	Low	High	Low	High	Low	High	Low	High
ρ		0.707*** (0.131)	0.663*** (0.147)	0.555*** (0.138)	0.861*** (0.191)	1.076*** (0.135)	0.323*** (0.120)	0.752*** (0.176)	0.561*** (0.185)	0.638*** (0.148)	0.757*** (0.251)
ρ	Quality Test	0.765		0.118		0.0008		0.380		0.643	
ϕ	Test	0.734		0.113		0.000		0.404		0.677	

A constant term is included among the regressors. Standard errors in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

IX. CONCLUSION

- ▶ Presence and drivers of spatial interdependences on municipal performance on e-government across neighboring municipalities
- ▶ Positive and statistically significant spatial interdependences among neighboring municipalities are mainly driven by:
 - ▶ Firms' high-tech specialization
 - ▶ Firms' density
 - ▶ Political structure of local authorities
- ▶ Areas with a lower density of productive activity tend to emulate neighbouring areas, by more actively mirroring the behavior of neighboring municipalities in terms of participation in NRRP initiatives
- ▶ Local governments led by lower-quality politicians tend to imitate the performance of neighboring municipalities, probably to compensate for their own limitations in governance and policy implementation.

Thanks for the attention!

► List of variables and their sources

Variable	Definition	Year	Source
High Tech Specialization	Number of employees in high-tech manufacturing and service sectors on total number of employees (*100)	2021	Istat - <i>A Misura di Comune</i>
Entrepreneurship Rate	Number of firms out of the Average resident population (*100).	2021	Authors' elaborations on Istat Data - <i>A Misura di Comune</i>
Firms' density	Number of local units of firms out of the municipal area (km2). According to ISTAT, a local unit corresponds to a firm or part of it located in an identified location. The following types are local units, provided they are manned by at least one person: agency, hotel, clinic, bar, quarry, depot, garage, laboratory, warehouse, mine, shop, workshop, hospital, restaurant, school, factory, professional studio, office, etc.	2021	Authors' elaborations on Istat Data - <i>A Misura di Comune</i>
Burocratic Capacity	It is a composite indicator on the quality of public administration, it contains information about public employees in Italian municipalities. It is the first Pillar of the MAQI, that is a composite index to measure administration quality.	2021	Dataset of Cerqua et al. (2025)
Politicians Capacity	It is a composite indicator on the quality of local politicians, it contains information about education and personal characteristics of politicians. It is the second Pillar of the MAQI, that is a composite index to measure administration quality.	2021	Dataset of Cerqua et al. (2025)
Density	Total Resident Population out of the territorial surface of the municipality	2021	Authors' elaborations on Istat Data
Female population	Total female population out of total Population(*100).	2021	Authors' elaborations on Istat Data - <i>A Misura di Comune</i>
Per Capita Income (in Log)	The total income at municipal level out of the resident population in the same municipality	2021	Authors' elaborations on Ministry of Economy and Finance Data
Unemployment	Unemployed over 15-aged people out of the total labour force (*100).	2021	Istat - <i>A Misura di Comune</i>
Tertiary Education	Total graduates out of total Population	2021	Authors' elaborations on Istat Data - <i>A Misura di Comune</i>
Urban Area	Variable that is equal to 1 if the municipality has an urbanization rate less than 3, 0 if the municipality has an urbanization is 3. ISTAT assigns a degree of urbanization equal to 1 to cities or densely populated areas, 2 to small cities or areas with intermediate population density, 3 to sparsely populated or rural areas.	2023	Authors' elaborations on Istat Data
Coastal Area	Variable that is equal to 1 if the municipality is located along the coast or has at least half of the surface at a distance from the sea of less than 10 km, 0 otherwise	2023	Authors' elaborations on Istat Data
Macro-Area	Variable that takes on the value of 1 if the municipality is located in the North-East, North-West and Central Italy, 0 otherwise.	2023	Authors' elaborations on Istat Data

For details about the data, see MAQI for the dataset of Cerqua et al. (2025) and *A Misura di Comune* for the ISTAT data at municipal level.

► Model Comparison: Bayesian Posterior Probabilities

[► Back to Model Selection](#)

Neighbours	Per capita number of projects			Row Total	Project Average Funding			Row Total
	SLX	SDM	SDEM		SLX	SDM	SDEM	
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0468	0.0000	0.0468
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.8840	0.0000	0.8840
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016	0.0000	0.0016
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0583	0.0000	0.0583	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.9417	0.0000	0.9417	0.0000	0.0004	0.0000	0.0004
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0017	0.0000	0.0000	0.0017
WC1	0.0000	0.0000	0.0000	0.0000	0.0238	0.0000	0.0000	0.0238
WC2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WD15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WD25	0.0000	0.0000	0.0000	0.0000	0.0035	0.0000	0.0000	0.0035
WD50	0.0000	0.0000	0.0000	0.0000	0.0379	0.0000	0.0000	0.0379

► Baseline Results

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Variable	Per-capita Number of Projects				Project Average Funding			
	Coefficient (1)	Direct (2)	Indirect (3)	Total (4)	Coefficient (5)	Direct (6)	Indirect (7)	Total (8)
High Tech Specialization	-0.021 (0.013)	-0.019 (0.015)	0.052 (0.0545)	0.033 (0.0152)	-0.007 (0.010)	-0.002 (0.011)	0.062** (0.033)	0.060 (0.040)
Entrepreneurship Rate	-0.036** (0.011)	-0.026*** (0.011)	0.160*** (0.060)	0.131** (0.062)	0.0001 (0.005)	0.0006 (0.003)	0.006 (0.007)	0.006 (0.006)
Firms density	0.018*** (0.005)	0.016*** (0.005)	-0.045 (0.024)	-0.029 (0.026)	0.006*** (0.001)	0.005*** (0.001)	-0.006 (0.007)	-0.005 (0.007)
Bureaucratic Capacity	0.050*** (0.024)	0.058*** (0.027)	0.193 (0.183)	0.261 (0.168)	-0.006 (0.005)	-0.008 (0.006)	-0.020 (0.031)	-0.027 (0.035)
Politicians Capacity	-0.062*** (0.009)	-0.080*** (0.010)	-0.452*** (0.082)	-0.531*** (0.097)	0.012*** (0.003)	0.012*** (0.004)	0.007 (0.017)	0.019 (0.019)
Density	-0.002*** (0.0006)	-0.001*** (0.0004)	0.004** (0.002)	0.003 (0.0018)	-0.0002** (0.0001)	-0.0002** (0.0001)	0.0004 (0.0005)	0.0002 (0.0005)
Female Population	-0.125*** (0.152)	-0.811*** (0.190)	-2.235*** (0.745)	-3.166*** (0.814)	0.0412 (0.024)	0.037 (0.028)	-0.055 (0.114)	-0.018 (0.131)
Per Capita Income (in Log)	-8.439*** (1.538)	-8.792*** (1.480)	-3.943 (3.317)	-12.735** (5.222)	0.171 (0.296)	0.131 (0.293)	-0.468 (0.755)	-0.336 (0.827)
Unemployment	0.181 (0.119)	0.163 (0.115)	-0.485 (0.344)	-0.301 (0.337)	0.019 (0.013)	0.018 (0.013)	-0.009 (0.054)	0.009 (0.053)
Tertiary Education	17.296*** (4.774)	17.650*** (4.549)	11.320 (14.218)	28.844*** (13.751)	1.136 (0.877)	1.294 (0.876)	1.856 (2.726)	3.150 (3.865)
Urban Area	-1.445*** (0.165)	-1.466*** (0.162)	-0.632 (0.835)	-2.101** (0.852)	0.482*** (0.073)	0.482*** (0.078)	-0.121 (0.278)	0.361 (0.314)
Coastal Area	-0.149 (0.216)	-0.166 (0.209)	-0.439 (0.962)	-0.606 (0.859)	0.365*** (0.118)	0.350*** (0.108)	0.176 (0.227)	0.174 (0.190)
Macro-Area	2.856 (1.752)	2.776 (1.682)	-2.058 (2.131)	0.718 (1.186)	-0.126 (0.171)	-0.125 (0.171)	0.009 (0.736)	-0.117 (0.307)
Riba	0.604*** (0.080)				0.635*** (0.191)			
Lagged High Tech Specialization	0.031 (0.046)				0.027*** (0.010)			
Lagged Entrepreneurship Rate	0.076*** (0.019)				0.002 (0.003)			
Lagged Firms density	-0.027*** (0.008)				-0.006** (0.003)			
Lagged Bureaucratic Capacity	-0.001 (0.055)				-0.003 (0.010)			
Lagged Politicians Capacity	-0.101** (0.036)				-0.005 (0.008)			
Lagged Density	0.002*** (0.0005)				0.0003 (0.0003)			
Lagged Female Population	-0.206 (0.245)				-0.047 (0.039)			
Lagged Per Capita Income (in Log)	4.739** (1.714)				-0.280 (0.360)			
Lagged Unemployment	-0.274 (0.147)				-0.016 (0.023)			
Lagged Tertiary Education	-8.423 (5.618)				-0.113 (1.153)			
Lagged Urban Area	0.801* (0.384)				-0.375*** (0.124)			
Lagged Coastal Area	-0.036 (0.354)				-0.309** (0.132)			
Lagged Macro-Area	-3.636 (1.816)				0.068 (0.773)			

A constant term is included among the regressors. Standard errors in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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