Supplementary material for: Saturation in European Regional Development Fund Absorption: Evidence from Italian Local Governments

Formal derivation of the econometric model

Our dependent variable is censored with a lower limit equal to 0 and an upper limit equal to 1 (two-limit Tobit model), leading to the following generalized panel Tobit model:

$$y_{it}^* = \alpha_i + x_{it}\beta + \varepsilon_{it}, \quad \varepsilon_{it} \sim \mathcal{N}[0, \sigma_\varepsilon^2] \tag{1}$$

$$\text{with} \quad y_{it}^* = \begin{cases} 0 & y_{it}^* > 1 \\ y_{it}^* & 0 \leq y_{it}^* \leq 1 \\ 0 & y_{it}^* < 0 \end{cases}$$

The model in Eq. 1 can be estimated via maximum likelihood, however the fixed-effect estimator for this model has been shown to be inconsistent due to the incidental parameters problem (Cameron 2010). Therefore, we adopt a random-effect specification that can be obtained maximizing the following likelihood function:

$$f(y_i \mid X_i, \beta, \sigma_\varepsilon^2, \sigma_\alpha^2) = \int \prod_{t=1}^{T} \left[\left(\frac{1}{\sigma_\varepsilon} \phi_{it} \right)^{d_{it}} (1 - \Phi_{it})^{1-d_{it}} \right] \frac{1}{\sqrt{2\pi}\sigma_\alpha} \exp\left(-\frac{\alpha_i^2}{2\sigma_\alpha^2} \right) d\alpha_i \tag{2}$$

$$\begin{aligned} \text{with} \quad \phi_{it} &= \phi\left(\tfrac{y_{it} - \alpha_i - x_{it}\beta}{\sigma_\varepsilon} \right) \quad \text{Standard normal} \\ \Phi_{it} &= \Phi\left(\tfrac{\alpha_i - x_{it}\beta}{\sigma_\varepsilon} \right) \quad \text{Standard normal CDF} \\ \alpha_i &\sim N[0, \sigma_\alpha^2] \end{aligned}$$

Control variables: Project characteristics

Project-level characteristics may affect absorption performance by influencing the complexity of project implementation. Although these characteristics are included as control variables in all main specifications, their coefficients are not reported in the main results table in order to preserve readability and maintain the focus on the municipality-level determinants of absorption capacity. This section provides the complete estimates and discuss the results of the analysis.

Specifically, we consider two dimensions of project characteristics. First, project size is proxied by *AVG FUNDS*, measured as the average amount of funding associated with the projects implemented by each municipality in each year. This variable captures differences in the financial scale of the projects managed by municipalities, as larger projects may entail more complex planning, coordination, and implementation processes (Milio 2007; Darvas et al. 2019). Second, we account for the nature of the projects through three dummy variables indicating whether, in a given municipality-year, at least one project involves the purchase of goods (*GOODS*), the purchase or provision of services (*SERVICES*), or the implementation of public works (*PUBLIC WORKS*). The complete estimates are reported in Table 1.

Table 1 Panel Tobit estimates including project characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
SOCIO-ECONOMIC CONDITIONS (SE)						
INCOME	0.0619***	0.0613***	0.0624***	0.0587***	0.0460***	0.0524***
	(8.03)	(7.94)	(7.99)	(7.47)	(5.32)	(6.38)
EMPLOYMENT	0.0166***	0.0172***	0.0174***	0.0179***	0.0167***	0.0170***
	(3.01)	(3.12)	(3.15)	(3.24)	(3.01)	(3.08)
BANK	0.0167**	0.0143**	0.0143**	0.0154**	0.0150**	0.0164**
	(2.48)	(2.08)	(2.05)	(2.22)	(2.11)	(2.33)
LESS DEVELOPED REGIONS	-0.236***	-0.233***	-0.234***	-0.230***	-0.207***	-0.212***
	(-13.40)	(-13.05)	(-13.12)	(-12.91)	(-10.97)	(-11.29)
ADMINISTRATIVE CAPACITY (ADM)						
MAQI1		0.00891***	0.00885***	0.00890***	0.00949***	0.00934***
		(3.03)	(3.00)	(3.02)	(3.22)	(3.17)
MAQI2		0.00678	0.00643	0.00587	0.00612	0.00614
		(1.64)	(1.55)	(1.42)	(1.47)	(1.48)
MAQI3		0.00848***	0.00836***	0.00827***	0.00842***	0.00845***
		(2.78)	(2.74)	(2.71)	(2.76)	(2.77)
POLITICAL FACTORS (POL)						
ENGAGEMENT			0.0000267	0.000201	-0.00111	-0.000666
			(0.01)	(0.04)	(-0.22)	(-0.13)
ELECTION			-0.00635***	-0.00586**	-0.00614***	-0.00605***
			(-2.77)	(-2.55)	(-2.67)	(-2.63)
SATURATION (SAT)						
CURRENT FUNDS				-0.0110***	-0.00995***	-0.0106***
				(-3.31)	(-2.98)	(-3.18)
PREVIOUS CYCLE					-0.0430***	
					(-2.84)	
PREVIOUS CYCLE × FUNDS					-0.0226***	
					(-2.80)	
OVERLAP						-0.0351**
						(-2.36)
OVERLAP × FUNDS						-0.0116*
						(-1.70)
PROJECT CHARACTERISTICS (CONTROLS)						
AVG FUNDS	-0.0249***	-0.0247***	-0.0229***	-0.0215***	-0.0207***	-0.0207***
	(-5.24)	(-5.20)	(-4.78)	(-4.48)	(-4.30)	(-4.30)
GOODS	-0.00249	-0.00236	-0.00263	-0.00302	-0.00339	-0.00318
	(-0.27)	(-0.26)	(-0.28)	(-0.33)	(-0.37)	(-0.34)
SERVICES	-0.0382***	-0.0390***	-0.0396***	-0.0393***	-0.0391***	-0.0392***
	(-3.32)	(-3.40)	(-3.45)	(-3.42)	(-3.40)	(-3.41)
PUBLIC WORKS	0.0729***	0.0731***	0.0722***	0.0770***	0.0792***	0.0785***
	(6.88)	(6.90)	(6.82)	(7.21)	(7.40)	(7.34)
Constant	0.322***	0.324***	0.330***	0.313***	0.338***	0.326***
	(25.05)	(24.93)	(24.95)	(22.07)	(20.65)	(21.56)
σ_u	0.369***	0.368***	0.369***	0.368***	0.368***	0.367***
σ_e	0.217***	0.217***	0.217***	0.217***	0.217***	0.217***
Year dummies	✓	✓	✓	✓	✓	✓
Observations	13,483	13,483	13,483	13,483	13,483	13,483
BIC	10,677.9	10,686.7	10,698.1	10,696.7	10,700.6	10,706.9

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. 3
AVG FUNDS measures the average amount of funding associated with projects implemented by each municipality in each year. GOODS, SERVICES, and PUBLIC WORKS are dummy variables indicating the presence of at least one project of the corresponding type in a municipality-year.
Previous cycle and overlap are dummy variables indicating the presence of funded projects in the 2007–2013 programming cycle and in the 2014–2015 overlapping period, respectively; funds refer to the corresponding amount of funding received in that period.

The results provide exploratory evidence that project characteristics are associated with municipalities' absorption capacity. First, average project funding (AVG FUNDS), which is used as a proxy for project size, shows a negative and highly statistically significant coefficient across all six specifications. This result suggests that municipalities managing projects of larger average financial size tend to exhibit lower absorption rates, other things being equal. This finding is coherent with previous studies showing that larger projects may require more complex planning, coordination, and implementation processes (Milio 2007) and that that managing larger amounts of EU funding may place greater demands on public administrations, particularly where administrative capacity is constrained (Darvas et al. 2019).

The results also indicate that absorption capacity varies according to the nature of the project. The presence of service-related projects (SERVICES) is negatively associated with absorption capacity in all specifications. By contrast, the presence of public works projects (PUBLIC WORKS) is positively associated with absorption capacity throughout the analysis. The coefficient also remains stable as administrative, political, and saturation-related factors are progressively introduced. The indicator for the purchase of goods (GOODS), instead, is statistically non-significant. The finding shows that differences in the composition of municipalities' project portfolios may be relevant to understanding absorption performance. The role of project nature may reflect differences in implementation schedules, constraints, institutional arrangements, or other unobserved characteristics associated with different types of projects.

Robustness analyses

To assess the robustness of the empirical findings, we conduct a series of additional analyses addressing different aspects of the empirical specification and measurement strategy. The robustness analysis is organized into five subsections. First, the *Fractional regression* subsection examines whether the results are sensitive to the econometric specification by estimating a fractional response model, given the fractional nature of the dependent variable. Second, the *Alternative measure of absorption capacity* subsection assesses the sensitivity of the findings to the operationalization of the dependent variable by replacing actual payments with sustained costs. Third, the *Alternative measure of local sectoral structure* subsection replaces the sectoral concentration index with the share of employment in manufacturing, providing an alternative measure of the local productive structure. Fourth, the *Alternative measure of political engagement* subsection tests whether the results concerning political engagement depend on the electoral context considered by replacing turnout in municipal elections with turnout in European Parliament elections. Finally, the *Lag selection* subsection examines the temporal sensitivity of the estimated relationships by comparing the baseline two-year lag specification with alternative one- and three-year lag structures.

Fractional regression

The first robustness analysis examines the sensitivity of the findings to variations in model, using Fractional Regression Model on the same set of variables.

Following the approach of (Papke and Wooldridge 2008), we implement a quasi–maximum likelihood fractional logit estimator within a generalized estimating equations (GEE) framework. This approach specifies the conditional mean through a logistic link and a binomial variance function, while accounting for within-unit correlation using an exchangeable correlation structure and cluster-robust standard errors. The estimator naturally handles fractional outcomes, including values at the boundaries of the unit interval, and delivers population-averaged effects. We report this specification as part of our robustness analysis, and the results closely align with those presented in the main body of the paper. Results are presented in Table 2.

Table 2 Fractional response panel model estimates with absorption capacity based on payments at $t+2$ as dependent variable.

	(1)	(2)	(3)	(4)	(5)	(6)
SOCIO-ECONOMIC CONDITIONS (SE)						
INCOME	0.208***	0.207***	0.208***	0.191***	0.148***	0.166***
	(8.11)	(8.08)	(7.95)	(7.20)	(5.12)	(6.01)
EMPLOYMENT	0.0683***	0.0693***	0.0691***	0.0711***	0.0677***	0.0672***
	(3.47)	(3.50)	(3.49)	(3.59)	(3.40)	(3.38)
BANK	0.0960***	0.0872***	0.0905***	0.0909***	0.0920***	0.0996***
	(4.18)	(3.72)	(3.77)	(3.78)	(3.74)	(4.08)
LESS DEVELOPED REGIONS	-0.905***	-0.889***	-0.903***	-0.893***	-0.826***	-0.834***
	(-15.99)	(-15.47)	(-15.74)	(-15.53)	(-14.15)	(-14.24)
ADMINISTRATIVE CAPACITY (ADM)						
MAQI1		0.0278**	0.0273**	0.0280**	0.0309***	0.0301**
		(2.36)	(2.32)	(2.37)	(2.60)	(2.54)
MAQI2		0.0198	0.0192	0.0162	0.0181	0.0193
		(1.21)	(1.17)	(0.99)	(1.09)	(1.17)
MAQI3		0.0307**	0.0301**	0.0301**	0.0309**	0.0309**
		(2.46)	(2.40)	(2.38)	(2.43)	(2.45)
POLITICAL FACTORS (POL)						
ENGAGEMENT			0.0185	0.0189	0.0148	0.0173
			(1.06)	(1.07)	(0.84)	(0.98)
ELECTION			-0.0246***	-0.0226**	-0.0241**	-0.0242**
			(-2.60)	(-2.39)	(-2.54)	(-2.54)
SATURATION (SAT)						
CURRENT FUNDS				-0.0623***	-0.0582***	-0.0602***
				(-4.28)	(-3.97)	(-4.13)
PREVIOUS CYCLE					-0.142***	
					(-2.80)	
PREVIOUS CYCLE × FUNDS					-0.0658***	
					(-2.63)	
OVERLAP						-0.146***
						(-3.13)
OVERLAP × FUNDS						-0.0121
						(-0.54)
Constant	-0.667***	-0.659***	-0.644***	-0.739***	-0.657***	-0.687***
	(-13.66)	(-13.32)	(-12.77)	(-13.35)	(-10.50)	(-11.78)
Project characteristics	✓	✓	✓	✓	✓	✓
Year dummies	✓	✓	✓	✓	✓	✓
Observations	13,483	13,483	13,483	13,483	13,483	13,483

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications include project characteristics as control variables and year dummies.
Project characteristics include average project funding and indicators for project type (i.e., goods, services, and public works).
Previous cycle and overlap are dummy variables indicating the presence of funded projects in the 2007–2013 programming cycle and in the 2014–2015 overlapping period, respectively; funds refer to the corresponding amount of funding received in that period.

The robustness analysis confirms the stability of the main findings across alternative model specifications. The results obtained using the panel Tobit model (Table 3 in the manuscript) are consistent with those derived from the fractional regression models (Table 2), both in terms of sign and statistical significance of the key coefficients.

Across all specifications, the socio-economic variables exhibit a robust relationship with absorption capacity. Coefficients of INCOME, EMPLOYMENT and BANK remain positive and statistically significant across all fractional response specifications, consistently with the Tobit results. Notably, the positive association of BANK is further supported by the fractional response estimates, where the coefficient is statistically significant at the 1% level across all specifications. LESS DEVELOPED REGIONS remains negative and highly statistically significant across all specifications, confirming that municipalities located in less developed regions exhibit lower absorption capacity than municipalities in more developed regions.

Administrative capacity indicators also display strong robustness. The coefficients of MAQI1 and MAQI3 are positive and statistically significant in both sets of models , although their significance is at the 5% level in the fractional response specifications, reinforcing the conclusion that higher bureaucratic quality and managerial capacity are positively associated with the ability of local governments to absorb ERDF funds. Conversely, coefficient of MAQI2 remains statistically non-significant, consistently with the main Tobit estimates.

The findings concerning political factors are also robust across alternative model specifications. The coefficient of ELECTION shows a negative and significant effect in both Tobit and fractional regression results, indicating that political instability undermines local governments' ability to manage ERDF funds. In contrast, coefficients of ENGAGEMENT remains statistically non-significant across all specifications, further confirming that political engagement does not play a meaningful role in shaping absorption capacity.

Moreover, the results shows robustness of the saturation mechanism. Saturation variables, capturing both current cycle saturation effects, exposure to previous programming periods and overlaps with subsequent programming periods, exhibit comparable magnitudes and levels of statistical significance in the two estimation approaches. The negative saturation effects observed in the Tobit specifications are fully replicated in the fractional regression models, with the coefficient of OVERLAP remaining negative and becoming statistically significant at the 1% level in the fractional response specification. The interaction between OVERLAP and FUNDS is not statistically significant in the fractional response specification, representing the main difference within the saturation variables. However, this interaction is statistically significant only at the 10% level ($p < 0.10$). These results reinforce the conclusion that the simultaneous management of projects from multiple programming periods reduces the absorption capacity of municipalities.

Overall, the robustness checks validate the empirical findings of the main analysis. The consistency of the results across two different modeling strategies enhances the robustness of the conclusions.

Alternative measure of absorption capacity

As a second robustness check, we re-estimate all model specifications using an alternative measure of absorption capacity based on sustained costs rather than actual payments. While the main analysis measures absorption as the ratio of cumulative payments to the financial resources allocated, the alternative measure uses cumulative sustained costs, which capture expenditure already incurred in project implementation, including expenditure not yet liquidated. This alternative operationalization reflects the expenditure-based approach to measuring absorption adopted in part of the existing literature. Results are presented in Table 3.

Table 3 Results of different specifications of the panel Tobit model with absorption capacity based on sustained costs at $t+2$ as dependent variable.

	(1)	(2)	(3)	(4)	(5)	(6)
SOCIO-ECONOMIC CONDITIONS (SE)						
INCOME	0.0692***	0.0688***	0.0695***	0.0610***	0.0500***	0.0564***
	(9.01)	(8.95)	(8.95)	(7.82)	(5.82)	(6.91)
EMPLOYMENT	0.0146***	0.0149***	0.0151***	0.0162***	0.0151***	0.0160***
	(2.65)	(2.72)	(2.74)	(2.95)	(2.76)	(2.91)
BANK	0.00991	0.00804	0.00829	0.0107	0.0106	0.00951
	(1.47)	(1.18)	(1.20)	(1.56)	(1.51)	(1.36)
LESS DEVELOPED REGIONS	-0.147***	-0.141***	-0.143***	-0.134***	-0.114***	-0.116***
	(-8.32)	(-7.89)	(-7.97)	(-7.51)	(-6.05)	(-6.16)
ADMINISTRATIVE CAPACITY (ADM)						
MAQI1		0.0106***	0.0105***	0.0106***	0.0111***	0.0111***
		(3.64)	(3.63)	(3.67)	(3.84)	(3.83)
MAQI2		0.00471	0.00445	0.00329	0.00353	0.00303
		(1.15)	(1.09)	(0.80)	(0.86)	(0.74)
MAQI3		0.0105***	0.0104***	0.0102***	0.0104***	0.0105***
		(3.41)	(3.38)	(3.34)	(3.38)	(3.42)
POLITICAL FACTORS (POL)						
ENGAGEMENT			0.00150	0.00191	0.000811	0.000673
			(0.30)	(0.38)	(0.16)	(0.13)
ELECTION			-0.00588***	-0.00470**	-0.00497**	-0.00474**
			(-2.61)	(-2.09)	(-2.21)	(-2.10)
SATURATION (SAT)						
CURRENT FUNDS				-0.0254***	-0.0245***	-0.0250***
				(-7.66)	(-7.36)	(-7.54)
PREVIOUS CYCLE					-0.0381**	
					(-2.54)	
PREVIOUS CYCLE × FUNDS					-0.0186**	
					(-2.31)	
OVERLAP						-0.0201
						(-1.36)
OVERLAP × FUNDS						-0.0249***
						(-3.39)
Constant	0.291***	0.292***	0.298***	0.259***	0.281***	0.267***
	(22.99)	(22.83)	(22.84)	(18.57)	(17.44)	(17.93)
σ_u	0.372***	0.371***	0.372***	0.370***	0.370***	0.370***
σ_e	0.209***	0.209***	0.209***	0.209***	0.208***	0.209***
Project characteristics	✓	✓	✓	✓	✓	✓
Year dummies	✓	✓	✓	✓	✓	✓
Observations	13,483	13,483	13,483	13,483	13,483	13,483
BIC	9,879.7	9,881.9	9,894.0	9,845.1	9,852.9	9,850.0

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications include project characteristics as control variables and year dummies.
Project characteristics include average project funding and indicators for project type (i.e., goods, services, and public works).
Previous cycle and overlap are dummy variables indicating the presence of funded projects in the 2007–2013 programming cycle and in the 2014–2015 overlapping period, respectively; funds refer to the corresponding amount of funding received in that period.

The robustness check based on sustained costs provides evidence on the consistency of the main results to alternative definition of absorption capacity. Overall, the results are highly consistent with those obtained using actual payments as the dependent variable, although some differences emerge in the magnitude and statistical significance of individual coefficients.

Regarding socio-economic conditions, the effect of INCOME remains positive and highly statistically significant across all model specifications, with coefficients slightly larger than those obtained using the payment-based measure. EMPLOYMENT also remains positive and statistically significant across all specifications, confirming the robustness of its relationship with absorption capacity. The main difference concerns BANK: while the payment-based models identify a positive and statistically significant association across all specifications, the coefficient becomes statistically non-significant when absorption is measured through sustained costs. LESS DEVELOPED REGIONS, by contrast, remains negative and highly significant in all specifications.

The results concerning administrative capacity are stable across the two definition of absorption. MAQI1 and MAQI3 remain positive and statistically significant in all relevant specifications, whereas MAQI2 remains statistically non-significant. This provides additional support for the robustness of the relationship between administrative capacity and municipalities' ability to absorb ERDF resources.

Similarly, the findings for political factors are largely unchanged. ENGAGEMENT remains statistically non-significant, while ELECTION maintains a negative and statistically significant coefficient across all specifications in which it is included. Thus, the conclusions concerning political factors do not appear to depend on whether absorption is measured through payments or sustained costs.

Some differences are more evident for the saturation variables, although the overall evidence continues to support the relevance of saturation effects. CURRENT FUNDS remains negative and highly significant. PREVIOUS CYCLE also remains negative and statistically significant, as does its interaction with PREVIOUS CYCLE FUNDS. The main difference concerns the overlap specification: OVERLAP, which is negative and statistically significant in the payment-based model, becomes statistically non-significant when sustained costs are used. Conversely, the interaction between OVERLAP and FUNDS becomes negative and highly significant under the sustained-cost specification, whereas it is only weakly significant in the main payment-based analysis. Hence, while the precise channel through which the 2014–2015 overlap is captured differs between the two measures, the results continue to indicate a negative association between overlapping funding commitments and subsequent absorption capacity.

Overall, therefore, the robustness analysis confirms the main substantive conclusions of the study.

Alternative measure of local sectoral structure

As a third robustness check, we replace the sectoral concentration index with the share of employees working in manufacturing sector. The latter is used as an alternative indicator of the local productive structure, rather than as a comprehensive measure of socio-economic development.

We find a positive and statistically significant association between manufacturing employment and absorption capacity. This suggests that the productive composition of local economies may be relevant for the implementation of ERDF. The manufacturing employment share is also commonly used in regional empirical analyses to account for differences in local productive and industrial structure (Glaeser et al. 1995; Martin 2012; Martynovich et al. 2023). Territories with a stronger manufacturing base are typically characterized by denser production networks, specialized labor markets, and a greater presence of firms and intermediate organizations, which may facilitate the implementation of investment projects. This interpretation is consistent with the regional economics literature emphasizing the broader local effects of manufacturing through local demand and agglomeration mechanisms (Moretti 2010). At the same time, manufacturing employment may also capture broader differences in the level of economic development and productive capacity across Italian territories. The estimated relationship should therefore be interpreted as evidence of an association between the local productive structure and fund absorption. Importantly, this result also indicates that the relationship between productive structure and absorption capacity is not limited to the overall degree of sectoral concentration captured by the Herfindahl–Hirschman Index, but also emerges when considering the relative importance of a specific productive sector. We find a positive and statistically significant association between manufacturing employment and absorption capacity. This suggests that the productive composition of local economies may be relevant for the implementation of ER. The manufacturing employment share is also commonly used in regional empirical analyses to account for differences in local productive and industrial structure (Glaeser et al. 1995; Martin 2012; Martynovich et al. 2023). Territories with a stronger manufacturing base are typically characterized by denser production networks, specialized labor markets, and a greater presence of firms and intermediate organizations, which may facilitate the implementation of investment projects. This interpretation is consistent with the regional economics literature emphasizing the broader local effects of manufacturing through local demand and agglomeration mechanisms (Moretti 2010). At the same time, manufacturing employment may also capture broader differences in the level of economic development and productive capacity across Italian territories. The estimated relationship should therefore be interpreted as evidence of an association between the local productive structure and fund absorption. Importantly, this result also indicates that the relationship between productive structure and absorption capacity is not limited to the overall degree of sectoral concentration captured by the Herfindahl–Hirschman Index, but also emerges when considering the relative importance of a specific productive sector.

Table 4 Robustness analysis using manufacturing employment as an alternative measure of the local economic structure.

	(1)	(2)	(3)	(4)	(5)	(6)
SOCIO-ECONOMIC CONDITIONS (SE)						
INCOME	0.0569***	0.0564***	0.0575***	0.0541***	0.0415***	0.0478***
	(7.22)	(7.15)	(7.23)	(6.75)	(4.74)	(5.73)
MANUFACTURING EMPLOYMENT	0.0237***	0.0239***	0.0240***	0.0239***	0.0229***	0.0234***
	(4.14)	(4.17)	(4.18)	(4.18)	(3.99)	(4.07)
BANK	0.0139**	0.0114*	0.0113*	0.0122*	0.0122*	0.0134*
	(2.12)	(1.71)	(1.67)	(1.81)	(1.75)	(1.95)
LESS DEVELOPED REGIONS	-0.233***	-0.229***	-0.231***	-0.227***	-0.205***	-0.209***
	(-13.24)	(-12.88)	(-12.94)	(-12.75)	(-10.84)	(-11.13)
ADMINISTRATIVE CAPACITY (ADM)						
MAQI1		0.00888***	0.00881***	0.00885***	0.00945***	0.00931***
		(3.02)	(2.99)	(3.01)	(3.21)	(3.16)
MAQI2		0.00640	0.00603	0.00547	0.00577	0.00576
		(1.55)	(1.46)	(1.32)	(1.39)	(1.39)
MAQI3		0.00847***	0.00836***	0.00827***	0.00841***	0.00845***
		(2.78)	(2.74)	(2.71)	(2.76)	(2.77)
POLITICAL FACTORS (POL)						
ENGAGEMENT			-0.000426	-0.000246	-0.00153	-0.00112
			(-0.08)	(-0.05)	(-0.30)	(-0.22)
ELECTION			-0.00631***	-0.00582**	-0.00612***	-0.00602***
			(-2.75)	(-2.53)	(-2.66)	(-2.61)
SATURATION (SAT)						
CURRENT FUNDS				-0.0107***	-0.00966***	-0.0103***
				(-3.21)	(-2.90)	(-3.09)
PREVIOUS CYCLE					-0.0433***	
					(-2.88)	
PREVIOUS CYCLE × FUNDS					-0.0220***	
					(-2.74)	
OVERLAP						-0.0352**
						(-2.38)
OVERLAP × FUNDS						-0.0117*
						(-1.73)
Constant	0.322***	0.324***	0.330***	0.314***	0.338***	0.326***
	(25.11)	(24.98)	(25.00)	(22.17)	(20.78)	(21.67)
σ_u	0.368***	0.368***	0.368***	0.367***	0.367***	0.367***
σ_e	0.218***	0.217***	0.217***	0.217***	0.217***	0.217***
Project characteristics	✓	✓	✓	✓	✓	✓
Year dummies	✓	✓	✓	✓	✓	✓
Observations	13,483	13,483	13,483	13,483	13,483	13,483
BIC	10,669.8	10,679.1	10,690.5	10,689.7	10,693.8	10,699.8

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Manufacturing employment measures the share of employees working in the manufacturing sector and is used as an alternative measure of the local economic structure.
All specifications include project characteristics as control variables and year dummies.
Project characteristics include average project funding and indicators for project type (i.e., goods, services, and public works).
Previous cycle and overlap are dummy variables indicating the presence of funded projects in the 2007–2013 programming cycle and in the 2014–2015 overlapping period, respectively; funds refer to the corresponding amount of funding received in that period.

The alternative specification largely confirms the results obtained in the main analysis. The signs and statistical significance of the coefficients associated with the other explanatory dimensions remain highly consistent with the baseline specification. The main difference concerns BANK. While its coefficient remains positive across all specifications, its statistical significance is weaker when manufacturing employment is used as an alternative measure of the local productive structure, reaching the 5% level in Model (1) and the 10% level in Models (2)–(6).

The positive and statistically significant coefficient of MANUFACTURING EMPLOYMENT indicates that, conditional on the other socio-economic, administrative, political, and project-level characteristics, municipalities with a more manufacturing-oriented productive structure exhibit higher absorption capacity. This finding should be interpreted as an association with the composition of the local economy rather than as evidence that manufacturing employment constitutes a general measure of socio-economic development.

Alternative measure of political engagement

As a fourth robustness check, we assess whether the results concerning political engagement are sensitive to the measure used to operationalize this dimension. In the main analysis, ENGAGEMENT is measured through voter turnout in municipal elections, reflecting citizens' participation in local political processes. In the alternative specification, we replace this measure with voter turnout in European Parliament elections. This alternative measure captures political participation in an electoral process directly related to the European institutional context and therefore provides a complementary operationalization of political engagement. The purpose of this analysis is to assess whether the findings concerning political engagement depend on the specific electoral turnout measure adopted. The results are reported in Table 5.

Table 5 Robustness analysis using turnout in European elections as an alternative measure of political engagement.

	(1)	(2)	(3)	(4)	(5)	(6)
SOCIO-ECONOMIC CONDITIONS (SE)						
INCOME	0.0619***	0.0613***	0.0516***	0.0483***	0.0382***	0.0432***
	(8.03)	(7.94)	(6.13)	(5.70)	(4.22)	(4.95)
EMPLOYMENT	0.0166***	0.0172***	0.0166***	0.0170***	0.0161***	0.0162***
	(3.01)	(3.12)	(2.98)	(3.06)	(2.89)	(2.91)
BANK	0.0167**	0.0143**	0.0146**	0.0156**	0.0148**	0.0163**
	(2.48)	(2.08)	(2.11)	(2.26)	(2.08)	(2.33)
LESS DEVELOPED REGIONS	-0.236***	-0.233***	-0.233***	-0.229***	-0.207***	-0.212***
	(-13.40)	(-13.05)	(-13.00)	(-12.80)	(-10.93)	(-11.27)
ADMINISTRATIVE CAPACITY (ADM)						
MAQI1		0.00891***	0.00940***	0.00945***	0.00997***	0.00987***
		(3.03)	(3.17)	(3.19)	(3.37)	(3.33)
MAQI2		0.00678	0.00710*	0.00656	0.00673	0.00683
		(1.64)	(1.71)	(1.58)	(1.61)	(1.64)
MAQI3		0.00848***	0.00861***	0.00852***	0.00867***	0.00870***
		(2.78)	(2.81)	(2.78)	(2.83)	(2.84)
POLITICAL FACTORS (POL)						
ENGAGEMENT			0.0205***	0.0201***	0.0172***	0.0184***
			(3.34)	(3.29)	(2.79)	(2.98)
ELECTION			-0.00642***	-0.00593**	-0.00620***	-0.00613***
			(-2.78)	(-2.56)	(-2.67)	(-2.64)
SATURATION (SAT)						
CURRENT FUNDS				-0.0108***	-0.00975***	-0.0104***
				(-3.22)	(-2.91)	(-3.10)
PREVIOUS CYCLE					-0.0372**	
					(-2.44)	
PREVIOUS CYCLE × FUNDS					-0.0227***	
					(-2.81)	
OVERLAP						-0.0325**
						(-2.16)
OVERLAP × FUNDS						-0.0114*
						(-1.69)
Constant	0.322***	0.324***	0.327***	0.310***	0.332***	0.322***
	(25.05)	(24.93)	(24.56)	(21.78)	(20.13)	(21.13)
σ_u	0.369***	0.368***	0.368***	0.367***	0.367***	0.367***
σ_e	0.217***	0.217***	0.218***	0.218***	0.217***	0.218***
Project characteristics	✓	✓	✓	✓	✓	✓
Year dummies	✓	✓	✓	✓	✓	✓
Observations	13,483	13,483	13,331	13,331	13,331	13,331
BIC	10,677.9	10,686.7	10,587.4	10,586.5	10,592.5	10,597.7

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
In this robustness analysis, ENGAGEMENT is measured using voter turnout in European Parliament elections rather than turnout in municipal elections.
All specifications include project characteristics as control variables and year dummies.
Project characteristics include average project funding and indicators for project type (i.e., goods, services, and public works).
Previous cycle and overlap are dummy variables indicating the presence of funded projects in the 2007–2013 programming cycle and in the 2014–2015 overlapping period, respectively; funds refer to the corresponding amount of funding received in that period.

Overall, the results are largely consistent with the main specification, with the signs and statistical significance of the variables associated with the other hypotheses remaining substantially unchanged. The main difference concerns ENGAGEMENT. While voter turnout in municipal elections is not statistically significantly associated with absorption capacity in the main specification, ENGAGEMENT becomes positive and statistically significant at the 1% level across all specifications when measured using turnout in European Parliament elections. This suggests that the relationship between political engagement and absorption capacity is sensitive to the electoral context used to measure political participation. One possible interpretation is that turnout in European elections may capture a dimension of political engagement that is more closely related to the institutional context in which ERDF funds are allocated and implemented.

Lag selection

The last robustness check, presented in Table 6 investigates the robustness of the findings by varying the temporal lag of the explanatory variables in Model (5) of Table 3 (Manuscript). This model was selected because it allows all the hypotheses developed in the study to be tested simultaneously. Moreover, among the two alternative specifications used to test the saturation effects associated with previous programming periods, Model (5) exhibits a lower Bayesian Information Criterion (BIC) than Model (6), indicating a comparatively better model fit after accounting for model complexity. For these reasons, Model (5) provides the reference configuration for assessing whether the results are sensitive to alternative temporal lag structures.

For consistency, the specification corresponding to Model (5) in the manuscript is hereafter referred to as Model (2). In Table 6, Model (1) uses explanatory variables lagged by three years, while Model (3) uses explanatory variables lagged by one year.

The robustness check aims at assessing the stability of the results by varying the temporal lag of the independent variables, as shown in Models (1), (2), and (3), corresponding to 3-year, 2-year, and 1-year lags, respectively. The results confirm the robustness of several key findings.

In particular, the effect of INCOME remains positive and statistically significant across all lag specifications. The variable EMPLOYMENT is positive and significant in Model (1), although its significance disappears when a shorter lag is applied, as in Model (3). BANK maintains a positive association with absorption capacity across all specifications, although its statistical significance decreases from the 1% level with the 3-year lag to the 5% level with the 2-year lag and the 10% level with the 1-year lag. The coefficient of LESS DEVELOPED REGIONS is statistically significant and negative across all lag specifications.

The results concerning administrative capacity are also largely robust. MAQI1 and MAQI3 remain positive and statistically significant across all three lag specifications, although the significance of MAQI1 varies across models. MAQI2, by contrast, is statistically non-significant with the 3-year and 2-year lags and becomes weakly significant at the 10% level when a 1-year lag is considered.

Table 6 Robustness analysis using alternative lag structures.

	(1) 3-year lag	(2) 2-year lag	(3) 1-year lag
SOCIO-ECONOMIC CONDITIONS (SE)			
INCOME	0.0346***	0.0460***	0.0343***
	(3.79)	(5.32)	(4.04)
EMPLOYMENT	0.0234***	0.0167***	0.00693
	(3.95)	(3.01)	(1.30)
BANK	0.0295***	0.0150**	0.0125*
	(4.14)	(2.11)	(1.79)
LESS DEVELOPED REGIONS	-0.220***	-0.207***	-0.207***
	(-11.19)	(-10.97)	(-11.18)
ADMINISTRATIVE CAPACITY (ADM)			
MAQI1	0.00611*	0.00949***	0.00619**
	(1.73)	(3.22)	(2.33)
MAQI2	0.0000618	0.00612	0.00693*
	(0.01)	(1.47)	(1.67)
MAQI3	0.00703**	0.00842***	0.00635**
	(2.14)	(2.76)	(2.14)
POLITICAL FACTORS (POL)			
ENGAGEMENT	0.0103*	-0.00111	0.00435
	(1.89)	(-0.22)	(0.87)
ELECTION	0.0337***	-0.00614***	0.000656
	(11.16)	(-2.67)	(0.31)
SATURATION (SAT)			
CURRENT FUNDS	-0.0404***	-0.00995***	-0.000132
	(-10.34)	(-2.98)	(-0.04)
PREVIOUS CYCLE	-0.0267*	-0.0430***	-0.0542***
	(-1.71)	(-2.84)	(-3.70)
PREVIOUS CYCLE × FUNDS	-0.0162*	-0.0226***	-0.0204***
	(-1.91)	(-2.80)	(-2.59)
Constant	0.345***	0.338***	0.313***
	(20.81)	(20.65)	(19.54)
σ_u	0.381***	0.368***	0.361***
σ_e	0.217***	0.217***	0.204***
Project characteristics	✓	✓	✓
Year dummies	✓	✓	✓
Observations	12,101	13,483	13,282
BIC	10,634.7	10,700.6	9,364.3

t statistics in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Models (1), (2), and (3) use 3-year, 2-year, and 1-year lag structures, respectively.
All specifications include project characteristics as control variables and year dummies.
Project characteristics include average project funding and indicators for project type (i.e., goods, services, and public works).
Previous cycle is a dummy variable indicating the presence of funded projects in the 2007–2013 programming cycle; funds refer to the corresponding amount of funding received in that period.

The results for political factors are more sensitive to the lag structure. ENGAGEMENT is positive and weakly significant at the 10% level with a 3-year lag, but becomes statistically non-significant in the 2-year and 1-year specifications. ELECTION displays greater variation across models with a coefficient that is positive and statistically significant with a 3-year lag, negative and statistically significant with a 2-year lag, and statistically non-significant with a 1-year lag. The change in both sign and statistical significance indicates that the relationship between elections and absorption capacity is particularly sensitive to the temporal distance considered. This suggests that the effect of political instability may be more related to the timing and, more specifically, the time distance from elections, rather than the presence of elections in a given year.

The robustness analysis provides substantial support for the saturation mechanism, although some differences emerge depending on the lag considered. CURRENT FUNDS remains negative and statistically significant at the 1% level with the 3-year and 2-year lags, but becomes statistically non-significant with the 1-year lag. In contrast, PREVIOUS CYCLE remains negative across all specifications and statistically significant at least at the 10% level, with stronger significance in the 2-year and 1-year specifications. The interaction between PREVIOUS CYCLE and FUNDS follows a similar pattern: it remains negative and statistically significant across all three lag structures, at the 10% level with the 3-year lag and at the 1% level with the 2-year and 1-year lags.

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