When specialization helps diversification: linking industrial districts to economic complexity across Italian regions

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Abstract

This paper explores how industrial districts are related to economic complexity across Italian regions (NUTS-3), examining their role in fostering both specialization and diversification. Using panel data and regression analysis, we find the presence of industrial districts alone does not automatically translate into improved outcomes. Instead, their impact depends on their nature and density within a province. Further, relatedness, measuring occupational similarity between districts, consistently shows positive and statistically significant effects across all models, underscoring its pivotal role in shaping economic fitness. The findings demonstrate that industrial districts can enhance regional productive capabilities, offering valuable insights for policies aimed at reducing regional disparities and promoting sustainable growth.

Keywords: industrial district, cluster, economic complexity, employment, specialization, diversification

JEL codes: R11, R12, O18

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1. Introduction

The interplay between specialization and diversification lies at the heart of modern economic development, particularly in regions characterized by strong industrial clustering. Italy's industrial districts, celebrated as global exemplars of localized economic specialization, provide a unique lens to examine how concentrated industrial activities influence broader patterns of diversification and economic complexity. This article explores the role of industrial districts in shaping regional economic fitness, revealing their potential to simultaneously foster specialization and contribute to the diversification of regional productive capabilities.

Industrial districts have long been recognized as engines of regional economic growth, thanks to their ability to generate agglomeration economies, facilitate knowledge spillovers, and enhance innovation. Rooted in Marshallian economic theory and refined through the works of Becattini (2002), these clusters are defined by the spatial concentration of interrelated firms and industries, which benefit from shared infrastructure, networks of skilled labor, and tacit knowledge exchange. Yet, while districts often represent focused specialization in sectors such as textiles, leather, or mechanical industries, they also exhibit the potential to drive regional diversification. By fostering innovation and enabling firms to branch into related industries, districts can serve as catalysts for regional economic complexity, a key determinant of long-term growth and resilience.

Italy offers a particularly compelling context to investigate this dual dynamic. Its industrial districts are deeply embedded in the economic fabric of the country, accounting for a significant share of national production and employment. However, stark regional disparities persist, with Northern provinces often benefiting disproportionately from the presence of industrial districts, while Southern and insular regions lag behind. The relationship between district density, specialization, and economic fitness becomes even more intriguing when viewed through the lens of economic complexity, a framework that highlights the productive capabilities underlying diversified, high-value economies (Hausmann et al., 2014).

This study examines these dynamics through an empirical analysis of Italian provinces, using novel measures of district characteristics and their interactions with regional economic fitness and GDP per capita. We employ a range of econometric methods to assess how the presence, density, and specialization of industrial districts influence regional economic complexity. Furthermore, we explore how the type of district specialization—from traditional sectors like textiles to high-value industries like chemicals—modulates these effects. By linking the traditionally separate concepts of specialization and diversification, this article aims to contribute to the broader understanding of how localized economic structures drive national and regional development.

Our findings reveal that industrial districts contribute to Italy's economic landscape, but their impact is not determined by mere presence alone. Instead, their effectiveness is strongly linked to their number and the degree of relatedness (for multi-district provinces), where occupational similarity facilitates diversification into complex industries. Relatedness consistently shows a significant positive effect on economic fitness, highlighting the importance of industrial ecosystems that enable

knowledge spillovers and reduce barriers to transformation. The study underscores the need for nuanced policy interventions that go beyond preserving the district model to fostering adaptability, innovation, and sectoral integration. By situating industrial districts within the broader framework of economic complexity, this article highlights their dual role in reinforcing specialization while unlocking diversification, offering important insights for policymakers and scholars alike.

The paper is structured as follows. Section 2 introduces the theoretical framework, Section 3 presents the data and methodologies employed, Section 4 reports the results and Section 5 concludes.

2. Theoretical framework

a. Economic complexity, relatedness and regional economic growth

Economic complexity and relatedness significantly influence regional economic growth by shaping diversification patterns and development trajectories. Studies demonstrate that regions benefit when their economic activities are highly complex and technologically related. For example, Queiroz et al. (2024) analyzed Brazilian regions, revealing that sectoral complexity promotes stability and growth in advanced areas while challenging less complex regions to retain industries. Policies that enable diversification into complex yet related sectors are critical for bridging developmental disparities. Similarly, research in European regions has shown that technological complexity, measured through patent diversity, is positively associated with GDP growth. A 10% increase in technological complexity correlates with a 0.45% growth in GDP per capita, emphasizing its pivotal role in regional prosperity (Mewes & Broekel, 2022).

Further, diversification into related industries plays a path-dependent role, as highlighted by Freitas et al. (2024). Their framework identifies that industries sharing occupational or geographical ties are likelier to thrive and integrate into regional economies. This relatedness-driven diversification underpins regional economic cohesion, enabling sustainable growth. However, the relationship between complexity and inequality at regional scales is nuanced. While complexity reduces inequality at the national level by driving inclusive institutional growth, it may exacerbate disparities locally as complex activities tend to concentrate in certain areas, creating 'winner-take-most' dynamics (Hartmann & Pinheiro, 2022).

b. Industrial districts and knowledge spillovers

The Italian model of "distretti industriali", or industrial districts, epitomizes the interplay between localized specialization and knowledge spillovers, contributing significantly to innovation and economic performance. These industrial districts, deeply rooted in Marshallian agglomeration economies, thrive on proximity-based interactions and shared competencies. Munari et al. (2012) highlight the critical role of focal firms in Northern Italy's packaging machinery district, acting as gatekeepers that mediate both local and external knowledge flows, thereby reinforcing technological innovation.

While specialization underpins the strength of industrial districts, it also presents challenges when juxtaposed with the diversification emphasized in economic complexity frameworks. Camisón and

Villar-López (2011) argue that firms must develop internal absorptive capacities to maximize benefits from district-based spillovers, as mere proximity does not guarantee knowledge diffusion. Globally, Türkcan (2014) underscores the role of social networks in industrial districts, such as Izmir's metalwork cluster, in diffusing knowledge through informal collaborations, showcasing parallels with the Italian experience. These findings affirm the importance of structural flexibility and collaborative frameworks in enabling districts to balance specialization with adaptive diversification, aligning them with broader economic complexity goals.

3. Data and estimation framework

a. Data-sources, descriptive statistics and spatial visualization

This work relies upon two main sources of data: ISTAT, the Italian national statistical office, and Eurostat. Precisely, we exploit Eurostat databank to obtain GDP and population at NUTS-3 level, while also exploiting structural business statistics on employment at 3-digit level of NACE classification to estimate the values of exogenous fitness (see next sub-section for more details).

From ISTAT, we retrieved data on local, NUTS-3 employment at 3-digits ATECO (the Italian version of NACE classification). This was used to compute fitness at province-level. Further, from the same source, we derived the information to characterize the presence of industrial district in each province. According to ISTAT, 141 industrial districts were identified in 2011 based on local labor systems (SLL) and their productive specialization, as recorded during the 9th General Census of Industry and Services. Industrial districts account for about a quarter of Italy's production system in terms of SLLs (23.1%), employees (24.5%), and local production units (24.4%). They employ over a third of the country's manufacturing workforce, consistent with data from a decade earlier, and house around 22% of Italy's population. Made in Italy districts dominate, representing 130 (92.2%) of all industrial districts. They are most prevalent in mechanics (27.0%), textiles and clothing (22.7%), home goods (17.0%), and leather, footwear, and tanning (12.1%).

In terms of period, the analysis is limited by data availability on several dimensions. First, the EU data contains missing values across countries, industries, and years. Given the need for a complete series of industrial employment shares across these dimensions and following Caldarola et al. (2024), the data has been linearly interpolated but limited to the period 2010-2018. Second, the available Italian data does not go back more than 2012. For these reasons, we only focus on seven years, between 2012 and 2018. Nevertheless, we stress how the period is worth investigating as it starts immediately after the district census (2011) and ends before the Covid-19 pandemic.

b. Economic fitness estimation

Two notable differences from traditional economic complexity estimations are present in this study. First, instead of endogenous fitness, given our application to sub-national units, we opt for exogenous fitness. Our Exogenous Fitness utilizes European employment data to estimate sector complexities, which are then used as weights to create the fitness indicator. This method links sector complexity to the skills or tacit knowledge required for production, independent of the region. By relying on European employment data, exogenous fitness minimizes biases introduced by local factors such as

trade barriers or subsidies, offering a broader and more reliable assessment of regional economic potential.

In fact, analyzing economic complexity at the sub-national level presents unique challenges, particularly the lack of nestedness (triangular matrix structure) in regional networks. Nestedness describes the tendency of less diversified regions to focus on a subset of products produced by more diversified regions (Tacchella et al., 2012). At smaller geographic scales, this pattern weakens, complicating trend identification and reducing the reliability of complexity methodology. To address this, our method combines both: the exogenous fitness with the Bipartite Weighted Configuration Model (BiWCM). Essentially, by incorporating complexity scores calculated at the European level into sub-national data, this approach reintroduces nestedness, providing a clearer and more robust framework for understanding regional economic structures.

The scale of analysis significantly influences these effects. Globally, developed countries tend to produce a wide range of complex goods, while less developed countries focus on simpler, more common products (Hidalgo and Hausmann, 2009). At the firm level, nestedness often manifests as in-block structures, where firms cluster based on similar characteristics or sectoral focus (Laudati et al., 2023). At the sub-national level, similar patterns emerge but are less pronounced, necessitating adjustments like those provided by our method.

According to this framework, we calculate sector complexities using the BiWCM and Eurostat data, then they are applied to sub-national regions through the matrix $\boldsymbol{M_{i,s}}$ which assigns a complexity score $\boldsymbol{Q_s}$ to a region $\boldsymbol{i}$ if it specializes in sector $\boldsymbol{s}$, as follows:

$$\boldsymbol{Q_{i,s}} = \begin{cases} Q_s, & M_{i,s} = 1 \\ 0, & M_{i,s} = 0 \end{cases}$$

The exogenous fitness for each region is calculated by summing linearly the complexity values of all sectors in which the region specializes:

$$\overline{\boldsymbol{F_i}} = \sum_s Q_{i,s}$$

In addition to ensure comparability of fitness scores over time, we employ the "dummy trick" (Mazzilli et al., 2024). This involves introducing a hypothetical "dummy country" into the matrix $\boldsymbol{M_{i,s}}$ which is assumed to specialize in all industries and is assigned a constant fitness value of 1. The dummy country establishes a stable reference scale for longitudinal comparisons. Without it, structural changes in the trade network over time could distort fitness scores. By incorporating the dummy country, we ensure that variations in fitness scores reflect only economic changes rather than structural shifts in the data.

c. Estimation framework

Our estimation framework employs panel regression methods to robustly analyze the impact of industrial districts on regional economic performance. Specifically, we utilize a model that accounts for either random or fixed effects (RE and FE, henceforth), considering heteroskedasticity-robust standard errors. The inclusion of fixed effects (time and space) ensures control over unobserved heterogeneity that may bias the estimates, while the robustness to heteroskedasticity aligns with the need to account for variability in error variances commonly observed in economic data (Wooldridge, 2010).

The dependent variable is log-transformed GDP per capita) to linearize the relationship and interpret coefficients as elasticities. The primary independent variable is regional economic fitness, also log-transformed which proxies the productive capabilities and complexity of the region. These log transformations are standard in economic growth models to address skewness and allow for multiplicative interpretations (Baltagi, 2008).

To capture the presence of industrial districts, we include three characterizations:

1) A binary variable that indicates whether a given NUTS-3 province contains at least one industrial district. This variable test the baseline presence effect of districts on economic outcomes.
2) A counting variable that measures the number of districts within each province. This continuous measure allows for a deeper exploration of how district density correlates with regional outcomes.
3) A specialization variable that represents the dominant district type (e.g., mechanical, textile) in each province. This variable is constructed as a weight reflecting the concentration of specific industries.
4) A relatedness variable for provinces with more than one district, which exploiting the concept of product space measures the relatedness of districts in multi-district provinces.[1]

Finally, the estimation proceeds in a stepwise manner starting from the equation below:

$$\log(fitness)_{i,t} = \alpha_i + \beta_i X_{it} + u_{it}$$

Where, α_i corresponds to the unobserved entity-specific term, which can be "absorbed" in the fixed-effect estimations (a macro-regional#year component in our case), u_{it} corresponds to the error term, while X_{it} is a vector of explanatory variables, which in its simplest form contains the logarithm of GDP per capita, and then, it integrates also one-by-one each of the above district specifications.

The time-fixed nature of our target variables, those relative to district presence, may come at odds with a panel estimation framework. Nevertheless, we opt for this approach for two main reasons related to econometric robustness: 1) we control for time-variant dynamics such as GDP and unobservable factors that may affect the relationship under study, and 2) we get cleaner estimates of the estimated coefficients.

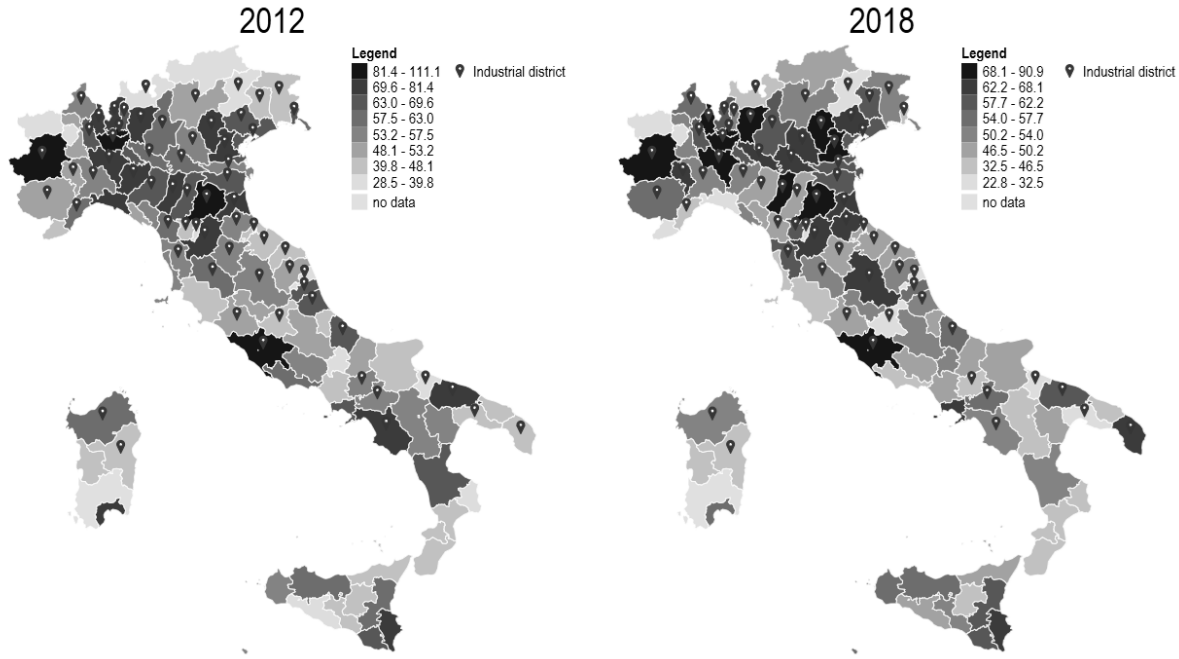
[1] -missing explanation-(provinces with no districts==0, if one==1, otherwise==1+relatedness)

4. Empirical results

a. The district-province fitness relationship

Although from Figure 1 it is already clear that the spatial distribution of economic fitness across Italian provinces reveals persistent regional disparities and significant insights into the role of industrial districts in shaping economic outcomes, Table 1 goes more in detail. Provinces in Northern Italy, such as Bologna, Milan, and Bergamo, consistently dominate fitness rankings in both 2012 and 2018, reflecting the industrial dynamism and economic complexity of the region. These provinces benefit from established industrial districts, robust infrastructure, and strong integration into global value chains.

Figure 1 – The spatial distribution of economic fitness and IDs across Italian provinces



Conversely, Central and Southern Italy exhibit lower fitness levels, with provinces like Prato, Fermo, and Biella consistently ranking among the lowest. This suggests persistent structural disadvantages, including weaker industrial density and limited diversification opportunities.

Table 1. Top and bottom 10 provinces by economic fitness and associated number of districts present – 2012-2018

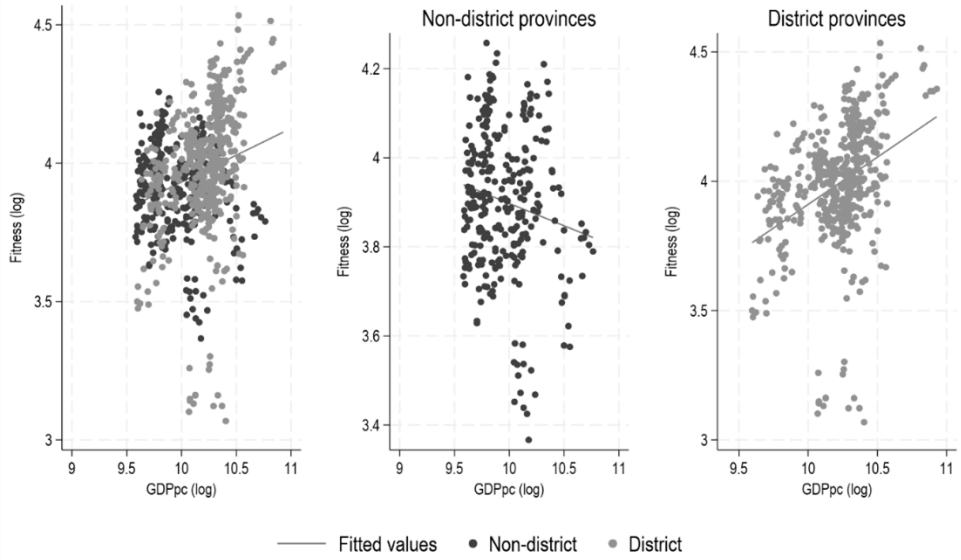
2012				2018			
rank	**Province**	**fitness**	**N districts**	**rank**	**NUTS3_long**	**fitness**	**N districts**
1	Bologna	88.443	1	1	Bologna	82.177	1
2	Milano	85.474	3	2	Milano	78.003	3
3	Torino	78.983	1	3	Bergamo	76.479	8
4	Monza e Brianza	78.782	2	4	Monza e Brianza	72.174	2
5	Roma	75.993	1	5	Roma	71.177	1

6	Bergamo	74.045	8	6	Reggio Emilia	70.869	3
7	Padova	73.694	9	7	Varese	70.498	1
8	Pavia	73.200	5	8	Padova	69.207	9
9	Varese	71.753	1	9	Napoli	69.022	0
10	Firenze	68.420	7	10	Pavia	66.050	5
97	Vibo Valentia	43.227	0	97	Genova	39.442	0
98	Taranto	41.956	1	98	Parma	39.162	1
99	Valle d'Aosta	41.441	0	99	Rieti	38.424	1
100	Imperia	41.405	0	100	Belluno	37.259	3
101	Crotone	39.503	0	101	Valle d'Aosta	35.712	0
102	Belluno	38.641	3	102	Barletta-Andria-Trani	32.766	2
103	Barletta-Andria-Trani	34.955	2	103	Imperia	32.206	0
104	Biella	31.155	0	104	Biella	32.080	0
105	Prato	25.893	1	105	Fermo	23.628	4
106	Fermo	23.136	4	106	Prato	21.509	1

The stability of high-performing provinces, such as Bologna and Milan, suggests enduring competitive advantages driven by innovation hubs, skilled labor pools, and industrial clustering. Padova, with its nine industrial districts, exemplifies how district density correlates strongly with higher economic fitness, aligning with theories that districts foster knowledge spillovers, innovation, and economic complexity (Marshall, 1920). However, exceptions like Naples, which ranks in the top 10 in 2018 despite having no industrial districts, indicate that metropolitan advantages such as port access and service-sector expansion can also drive economic fitness.

Temporal changes further underscore the dynamic nature of regional economies. Provinces like Reggio Emilia and Naples have improved their fitness rankings, showcasing the potential of targeted policies and industrial modernization to uplift historically disadvantaged areas. In contrast, the declining fitness scores of provinces like Turin and Florence suggest challenges in adapting to economic restructuring and global competition. Even district-heavy provinces such as Belluno and Prato remain in the bottom ranks, underscoring that the mere presence of districts is insufficient without sectoral adaptability and innovation (Becattini, 2002).

Figure 2 – The correlation between economic fitness and GDPpc across Italian provinces



Looking at Table and Figure 2, the correlation analysis between economic fitness and GDP per capita offers critical insights into the dynamics of regional economic performance in Italy, especially in relation to the presence of industrial districts. For the full sample of provinces, the positive and statistically significant correlation of 0.2497 suggests that higher levels of economic fitness are modestly associated with higher GDP per capita. This finding is consistent with the theoretical premise that fitness, as a proxy for productive capabilities and economic complexity, is a crucial determinant of regional prosperity. However, this moderate correlation also indicates that other factors, such as institutional quality, infrastructure, and geographic advantages, may mediate the relationship.

A nuanced understanding emerges when disaggregating the data by provinces with and without industrial districts. For non-district provinces, the negative correlation of -0.1631 between fitness and GDPpc challenges conventional expectations. This counterintuitive finding could reflect the limited economic diversification and weaker industrial structures in these provinces. In the absence of industrial districts, high fitness levels might signal isolated pockets of economic activity that fail to translate into broader regional development. The lack of clustering benefits, such as knowledge spillovers and shared resources, likely constrains these provinces' capacity to leverage their fitness for sustained economic growth.

Table 2 - Correlation among economic fitness and GDPpc

Full sample		
	(1)	(2)
(1) fitness	1	
(2) GDPpc	.2497*	1

Non-district provinces			**District provinces**		
	(1)	(2)		(1)	(2)
(1) fitness	1		(1) fitness	1	
(2) GDPpc	-0.1631*	1	(2) GDPpc	.3652*	1

In contrast, district provinces exhibit a significantly higher positive correlation of 0.3652 between fitness and GDPpc. This robust relationship underscores the pivotal role of industrial districts in amplifying the impact of fitness on regional wealth. The clustering of firms within districts fosters synergies that enhance productivity, innovation, and economic complexity, translating into higher GDP per capita. These findings align with the literature on industrial agglomeration and localized spillovers, which emphasize the importance of spatial proximity for fostering economic dynamism (Marshall, 1920; Becattini, 2002).

To better understand this relationship, we now move to the panel estimates (Table 3). The regression results provide a detailed understanding of the relationship between economic fitness and the presence of industrial districts, with additional control for GDP per capita (log-transformed) as a key independent variable.

Table 3 – Panel regression results on the relationship between economic fitness and district presence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	**Economic fitness (log)**								
GDPpc (log)	0.145**	0.415***	0.433***	0.0910	0.392***	0.409***	0.0905	0.374***	0.389***
	(0.0639)	(0.0631)	(0.0646)	(0.0684)	(0.0332)	(0.0327)	(0.0667)	(0.0460)	(0.0462)
District (1/0)				0.100**	0.107	0.107			
				(0.0463)	(0.100)	(0.101)			
District (n)							0.0233***	0.0222**	0.0220**
							(0.00876)	(0.00716)	(0.00723)
Constant	2.507***	-0.229	-0.404	2.989***	-0.0632	-0.228	3.009***	0.150	-0.00849
	(0.647)	(0.638)	(0.653)	(0.682)	(0.331)	(0.335)	(0.669)	(0.457)	(0.459)
Overall R-squared	0.091	0.140	0.151	0.091	0.172	0.183	0.106	0.181	0.191
Within R-squared	0.002	0.134	0.077	0.002	0.108	0.111	0.002	0.117	0.121
Random effects	X			X			X		
Fixed effects		X	X		X	X		X	X
- macro-region		X	X		X	X		X	X
- year			X			X			X
Time periods					7				
Observations					742				
Number of id					106				

Standard errors in parentheses and clustered at macro-regional (NUTS1) level. *** p<0.01, ** p<0.05, * p<0.1

Across all specifications, exception made for one, the results confirm a significant and positive association between GDP per capita and economic fitness, with coefficients ranging from 0.145 to 0.433 depending on the use of random or fixed effects. This suggests that higher regional income levels are strongly linked to greater productive capabilities and complexity, supporting theoretical expectations that wealthier regions tend to exhibit more sophisticated economic structures. The introduction of district-related variables offers further insight into the role of industrial districts in shaping economic fitness. In the RE-based specification of column (4), the inclusion of a binary variable indicating the presence of at least one district in a province yields a positive and statistically significant coefficient. This finding implies that merely having an industrial district is associated with higher economic fitness, while also suggesting that the small variation range in our observed variable may benefit from the use of random effects in the specification. Indeed, the statistical significance weakens when additional controls, such as macro-regional and year fixed effects, are added, indicating potential variability in the relationship across time and space.

Models from (7) to (9), which include the number of districts as a continuous variable, reveal a more robust and consistent relationship. The coefficients for this variable (0.022–0.023) are positive and statistically significant at the 1% or 5% levels, indicating that an increase in the number of districts within a province is strongly associated with higher economic fitness. This highlights the cumulative benefits of district density, aligning with theories that suggest clustering effects—such as knowledge spillovers, specialization, and shared resources—scale with the number of industrial districts (Marshall, 1920; Becattini, 2002).

The constant term in all models is positive and significant only in the baseline models without district variables, suggesting that fitness has underlying regional drivers that are not fully explained by GDP per capita or district presence alone. The inclusion of macro-regional and time fixed effects improves the explanatory power of the models, as evidenced by the increase in both overall and within values. This indicates the importance of controlling for broader regional and temporal factors to better isolate the effects of district variables.

b. Does more relatedness increase the economic complexity of multi-district regions?

The results in Table 4 shed light on the complex relationship between economic fitness, GDP per capita, and the role of industrial districts with respect to variety, captured through relatedness. The coefficients for GDP per capita, which increase from 0.0605 in Model (1) to 0.361 in Model (3), confirming the strict relation between regional wealth and economic fitness.

Table 4. Panel regression results on the relationship between economic fitness and district variety

VARIABLES	(1)	(2)	(3)
	Economic fitness (log)		
GDPpc (log)	0.0605	0.347***	0.361***
	(0.0683)	(0.0252)	(0.0217)
Relatedness	**0.122*** **	**0.108*** **	**0.107*** **
	(0.0417)	**(0.0156)**	**(0.0160)**
District (1/0)	-0.0668	-0.0353	-0.0349
	(0.0725)	(0.0947)	(0.0954)
Constant	3.292***	0.392	0.244
	(0.681)	(0.239)	(0.211)
Overall R-squared	0.138	0.215	0.226
Within R-squared	0.002	0.155	0.158
Random effects	X		
Fixed effects		X	X
- macro-region		X	X
- year			X
Time periods		7	
Observations		742	
Number of id		106	

Standard errors in parentheses and clustered at macro-regional (NUTS1) level. *** p<0.01, ** p<0.05, * p<0.1

The variable for relatedness consistently shows positive and statistically significant coefficients across all models, highlighting its pivotal role in shaping regional economic fitness. Relatedness measures the occupational similarity between industries within a region, reflecting the capacity to diversify into related activities that share underlying knowledge and skills. This result supports the concept of path-dependent diversification, where regions build on existing capabilities to enter new but related industries, fostering both economic resilience and long-term growth. The strong relationship between relatedness and fitness underscores the importance of fostering industrial ecosystems that enhance knowledge spillovers and minimize barriers to diversification.

In line with the previous results, the binary variable representing district presence yields negative and statistically insignificant coefficients, suggesting that the mere existence of industrial districts does not automatically translate into higher economic fitness. This finding suggests that districts require sectoral adaptability, innovation, and integration into high-complexity activities to be effective drivers of regional economic outcomes. Industrial districts dominated by traditional industries, such as textiles or leather, may face challenges in contributing to economic fitness unless they modernize and diversify into more complex and high-value sectors.

c. Distinguishing on the basis of district sectoral features

Complementing the previous findings, Table 5 analysis delves deeper into the relationship between economic fitness and the nature of the predominant industrial district in each province, shedding light on how specific types of districts influence regional economic capabilities. The inclusion of categorical variables representing different district specializations allows for a richer understanding of the heterogeneity within industrial clusters and their varying contributions to economic fitness. First, he results reaffirm the importance of GDP per capita as a significant determinant of economic fitness, with coefficients consistently positive and statistically significant in models (2) and (3). The stability of these findings across specifications underscores the strong baseline relationship between regional wealth and economic complexity, as expected from theoretical frameworks emphasizing the role of productive capabilities in fostering economic development (Becattini, 2002; Hausmann et al., 2014).

Table 5. Panel regression results on the relationship between economic fitness and district typology

	(1)	(2)	(3)
VARIABLES	**Economic fitness (log)**		
GDPpc (log)	0.0867	0.394***	0.412***
	(0.0707)	(0.0390)	(0.0369)
Main district = "Household goods"	0.0496	0.0699	0.0701
	(0.0772)	(0.0701)	(0.0703)
Main district = "Jewelry, goldsmithing, precision instruments"	0.162	0.167	0.167
	(0.133)	(0.108)	(0.110)
Main district = "Chemical, petrochemical, and related industries"	0.186	**0.214***	**0.214***
	(0.159)	**(0.0792)**	**(0.0797)**
Main district = "Mechanical industry"	0.123*	0.104	0.104
	(0.0667)	(0.0642)	(0.0645)
Main district = "Food industries"	**0.193****	**0.173***	**0.172***
	(0.0856)	**(0.0653)**	**(0.0656)**
Main district = "Paper and printing industries"	0.138	**0.190***	**0.190***
	(0.160)	**(0.0815)**	**(0.0818)**
Main district = "Leather, footwear, and related products"	0.0173	0.0764	0.0772
	(0.104)	(0.190)	(0.192)
Main district = "Textiles and clothing" [reference category = "No district"]	0.0671	0.0638	0.0624
	(0.0664)	(0.148)	(0.148)
Constant	3.031***	-0.0815	-0.255
	(0.705)	(0.392)	(0.379)
Overall R-squared	0.091	0.14	0.151
Within R-squared	0.002	0.134	0.077
Random effects	X		
Fixed effects		X	X

- macro-region	X	X
- year		X
Time periods	7	
Observations	742	
Number of id	106	
Standard errors in parentheses and clustered at macro-regional (NUTS1) level. *** p<0.01, ** p<0.05, * p<0.1		

Regarding the nature of districts, several interesting patterns emerge. Districts specialized in food industries show a strong and statistically significant positive association with economic fitness, with coefficients ranging from 0.173 to 0.193 across models. This suggests that food-related districts, which often combine traditional craftsmanship with advanced processing techniques, are particularly effective in driving regional fitness. Similarly, districts in chemical and petrochemical industries, which represent high-value and technologically intensive sectors, also display significant positive coefficients (0.214 in models 2 and 3), highlighting their contribution to economic complexity.

The role of mechanical industry districts is noteworthy, with a modest but positive and statistically significant coefficient (0.123) in model (1). However, the significance diminishes when additional controls are included, suggesting that mechanical districts' impact on fitness may depend on regional or temporal factors. This aligns with previous findings that mechanical districts, while impactful, often require complementary investments in innovation and infrastructure to sustain their advantage.

By contrast, districts specializing in textiles and clothing and leather and footwear exhibit no significant relationship with economic fitness. These industries, historically dominant in Italy's industrial district system, may be facing challenges related to global competition, technological obsolescence, or limited diversification opportunities. This finding reinforces the need for these traditional districts to modernize and adapt to new economic paradigms to remain competitive. Interestingly, districts in household goods and paper and printing industries show positive coefficients but lack consistent statistical significance. This could indicate heterogeneity within these sectors, where only certain subsectors or regions achieve the spillover effects necessary to enhance economic fitness.

Overall, the results highlight that not all industrial districts contribute equally to economic fitness. Some sectors, such as chemicals, food, and mechanical industries, appear to drive regional capabilities, while traditional sectors like textiles and leather show weaker effects. These findings underscore the importance of fostering industrial diversification within districts and aligning specialization with global demand and technological trends to maximize their contribution to economic complexity and fitness.

5. Conclusion

This study provides a comprehensive analysis of the relationship between industrial districts, economic fitness, and regional economic performance in Italy. Our findings confirm that industrial districts remain a cornerstone of Italy's productive system, but their influence varies significantly depending on their presence, density, and specialization. The results demonstrate that provinces with industrial districts consistently exhibit higher levels of economic fitness, as these clusters facilitate knowledge

spillovers, foster innovation, and amplify regional economic complexity. However, not all districts contribute equally, and their impact is contingent on the type of specialization and the broader economic context.

Provinces with a higher density of industrial districts, such as Bergamo and Padova, benefit from robust clustering effects that strengthen their productive capabilities and sustain higher GDP per capita. This aligns with theoretical frameworks emphasizing the synergies generated by agglomeration economies and localized knowledge flows. However, the persistence of regional disparities between Northern and Southern Italy highlights the unequal distribution of districts and their benefits. Provinces without districts or with declining industrial bases, such as Biella and Prato, struggle to convert their economic fitness into broader economic development, underscoring the need for targeted interventions.

The results on relatedness also align with broader empirical evidence from Italy's industrial districts, where high-performing provinces excel in fostering innovation and leveraging district density, while traditional sectors face increasing pressures to adapt. The findings highlight the dual challenge of supporting underperforming districts in traditional industries while enhancing the contribution of high-complexity sectors to regional economic fitness. Ultimately, the analysis provides valuable insights for understanding the interplay between industrial clustering, economic complexity, and regional development, offering a nuanced perspective on the potential and limitations of industrial districts in fostering long-term growth.

The analysis of district specialization reveals that some specific sectors, such as food industries, chemicals, and mechanical industries, are particularly effective in driving regional fitness. These sectors contribute to technological innovation and global competitiveness, reinforcing the notion that industrial complexity and adaptability are critical to economic resilience. Conversely, traditional sectors like textiles and leather exhibit weaker contributions, suggesting that such districts must modernize and diversify to sustain their relevance in an evolving global economy.

Overall, the study reaffirms the centrality of industrial districts in shaping Italy's economic landscape while highlighting the need for strategic policies to address structural challenges. By bridging the gaps between regions and sectors, industrial districts can continue to play a pivotal role in driving inclusive and sustainable economic growth in Italy.

a. Industrial policy implications

Policy implications emerge clearly from these findings. Investments should prioritize fostering high-value districts while supporting the modernization of traditional ones. Enhancing the connectivity between districts and broader regional economies can amplify spillover effects and reduce regional disparities. Policymakers should also consider fostering inter-district collaboration and leveraging complementarities between industrial specializations to maximize the collective impact on national economic complexity.

The findings underscore several key implications for regional economic policy. The significant positive role of relatedness highlights the importance of policies that foster regional innovation ecosystems capable of building on existing capabilities while enabling diversification into related industries. Policymakers should prioritize targeted sectoral support, encourage collaboration among industries, and promote inter-regional knowledge transfer to maximize the benefits of relatedness. The absence of significant results for the district presence variable suggests that policy efforts should extend beyond preserving industrial districts to actively enhancing their adaptability, modernization, and diversification into high-complexity activities. By doing so, districts can better contribute to regional economic complexity and resilience.

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