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Organized Crime, Corruption, and Economic Growth

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ABSTRACT

In this paper, we study the relationship between organized crime, corruption, and economic growth on a data set from Italian regions for the period 1996–2013. Our working hypothesis is that organized crime can embezzle part of the public expenditure aimed at productive uses by threatening and bribing public officers. To assess the consequences for regional growth we estimate a finite mixture covariate measurement model and find that the relationship between public expenditure and per capita GDP is characterized by parameter heterogeneity. Specifically, regions are partitioned in clusters identified by the initial level of organized crime. The effect of public expenditure on per capita GDP differs across clusters of regions: in the regions with the higher levels of organized crime public expenditure has a negative effect on per capita GDP, and the estimated share of embezzled public expenditure is higher, amounting to approximately 10% of its book value. Differently, in the regions with lower levels of organized crime the effect of public expenditure on per capita GDP is positive and the estimated share of embezzled public expenditure is lower. The empirical analysis is shown to be consistent with a theoretical growth model à la Barro (1990) augmented by corruption orchestrated by organized crime.

JEL Classification: K42, O17, R11, O23

1 | Introduction

The pervasive presence of criminal organizations and widespread corruption have been identified as major explanatory factors of economic backwardness, although their effects have been mostly studied separately. For example, Pinotti (2015b) finds that organized crime implied in recent years a cumulated loss of approximately 16% of per capita GDP in the Southern Italian regions of Apulia and Basilicata, while Pinotti (2015a) identifies a negative effect of organized crime on economic development in a cross-section of countries and Ganau and Rodríguez-Pose (2018) show that organized crime has a depressive effect on productivity in Italian SMEs. At the same time, the negative effect of corruption on economic growth has been documented by a vast literature, at cross-country (Mauro 1995), cross-regional (Del Monte and Papagni 2001), or firm (Olken and Pande 2012) level. In addition, the recent literature on the economic effects of institutions, pioneered by North (1990) (see Acemoglu, Johnson and Robinson 2005, for a detailed account), pointed out that institutions may exert an effect at subnational (e.g., regional) level (see Gertler 2010; Rodriguez-Pose 2013, 2020), another key aspect that we will consider in our analysis.

Our work provides a novel perspective in the context of these strands of literature by pointing out that, in the case of Italy, the different regional pervasiveness of organized crime and its interplay with corruption activities can be a source of institutional variation and explain the different development paths followed by the Italian regions, in particular through the public expenditure-growth channel. In fact, the criminal organizations of mafia-type[1] that are considered in this study provide "extra-legal governance" (Gambetta 1993) and may profoundly affect the functioning of official institutions.[2] For example, Alesina, Piccolo and Pinotti (2019) show that, in the case of Sicily, organized crime strategically utilize pre-electoral violence to affect the election results and politicians' behavior, while Gambetta and Reuter (1995), among others, highlight how criminal organizations may interfere with the adjudication of public contracts, altering in this way the effects of policies based on public expenditures. As pointed out by Rodríguez-Pose (2013), in fact, similar policies can have a different impact in different territories for the different levels of subnational institutional quality. In a similar vein, Ezcurra and Rios (2019) find that a poor institutional quality reduces regional resilience to external shocks (see also Cutrini 2023). Italy appears an ideal setting to study the nexus between economic growth, organized crime and corruption in light of the insights of the mentioned literature as existing evidence from Italian regions shows that the less developed regions are characterized by the highest levels of corruption and intensity of organized crime activities (see e.g. Del Monte and Papagni 2001; Lisciandra and Millemaci 2017; Pinotti 2015b).

Specifically, in this paper we focus on the link between organized crime and corruption that exists in the allocation of public funds to productive activities, as organized crime typically specializes in embezzling public funds, diverting them from productive uses and hindering in this way economic growth (see Schelling 1984 and Gambetta and Reuter 1995). In particular, criminal organizations can utilize violence and intimidation to influence the allocation of public funds, along with the typical instrument of corruption: bribes. Barone and Narciso (2015) note that this is one among different ways by which criminal organizations grab public funds.

Here we show first of all that stylized facts from Italian regions for the period 1996–2013 highlight a positive correlation between corruption and organized crime, and a negative correlation between these two variables and regional per capita GDP. Then we propose an econometric model to empirically understand how and to what extent variation in regional public expenditure affects variation in per capita GDP of Italian regions, once Mafia activity is accounted for. Our empirical model, in particular, allows on the one hand to simultaneously obtain groups of regions with a certain level of homogeneity which we argue depends on the strength of the Mafia at regional level and, on the other hand, to estimate how much of the public expenditure is "subtracted" by the Mafia in each region. This model incorporates heterogeneity in the impact that the Mafia has on public expenditure across regions, while still assuming homogeneity within groups. In other words, regions belonging to the same group share similar characteristics, allowing us to account for variations in the impact of organized crime on public spending more effectively. Finally, we show that our empirical findings are consistent with a theoretical growth model in which public expenditure is a productive factor, as in Barro (1990), and a Mafia subtracts part of it by threatening and bribing public officers.

Our main results can be summarized as follows. The relationship between public expenditure and per capita GDP is characterized by parameter heterogeneity. Regions are partitioned in different clusters identified by the initial level of organized crime and the effect of public expenditure on per capita GDP differs across clusters of regions. In particular, in the regions with the higher levels of organized crime public expenditure has a negative effect on per capita GDP. In these regions the estimated share of embezzled public expenditure is higher, amounting to approximately 10% of its book value. Differently, in the regions with lower levels of organized crime the effect of public expenditure on per capita income is positive, and the estimated share of embezzled public expenditure is lower.

The paper is organized as follows. In Section 2, we discuss the literature related to our contribution; in Section 3 we introduce the stylized facts that motivate this article; in Section 4 we describe the data set, while in Section 5 we present the econometric analysis; in Section 6 we present a theoretical model consistent with our empirical findings, while in Section 7 we conclude and discuss the policy implications of our findings.

2 | Related Literature

Our study is related to the literature on corruption, public spending and economic growth. Mauro (1998), Tanzi and Davoodi (1997), among others, show that corruption hinders growth by reducing private investments and worsening the composition of public expenditure (see also Aidt 2003 for an exhaustive survey). In particular, in this literature corruption leads to a diversion of public funds towards the activities in which bribes are easier to collect, implying a bias in the composition of public spending towards low-productivity projects (e.g. large-scale infrastructure investments), at the expenses of growth-promoting sectors (e.g. education and health). Saha and Sen (2021), however, show that the effect of corruption on growth can vary with a key institutional feature of a country, namely the political regime, and in autocratic countries the effect can even be positive.

The present paper differs from the existing literature on corruption by analyzing the case in which the allocation of public spending is affected by a criminal organization of Mafia-type. In particular, in our approach political actors may distort the allocation of public funds on the basis of bribes warranted by the Mafia, under the threat of punishment for noncomplying officers. Our perspective is similar to Dal Bò, Dal Bò, and Di Tella (2006) where pressure groups try to affect public policies using both bribes and the threat of punishment. Dal Bò, Dal Bò and Di Tella (2006), however, do not focus on economic growth but on on the quality of elected public officers. The recent work of Pulejo and Querubin (2023) adopts a similar view and studies the case in which an increase in politicians' salaries makes them less vulnerable to bribes, but increases the use of violence by criminal organizations.

Other recent works addressed the distorsive effects of criminal organizations on the allocation of public funds. For example, Barone and Narciso (2015) show that Mafias are able to embezzle public funds addressed to firms operating in disadvantaged areas by creating fictitious firms that successfully bid for subsidies, while Daniele and Dipoppa (2022) analyze this channel with respect to the appropriation of EU subsidies. Our paper is close in spirit to Di Cataldo and Mastrorocco (2021) showing that Mafias can distort the *composition* of public expenditure towards sectors in which criminal groups are infiltrated, such as Construction and Waste Management, by colluding with local public officials. Di Cataldo and Mastrorocco (2021), however, do not consider the possibility that Mafias can reduce the overall *size* of public funds allocated to productive activities, as we do in this paper. The mentioned works, in addition, do not address the impact of the Mafia-corruption link on economic growth, neither theoretically nor empirically.

The idea to model corruption as subtraction of public funds from productive uses has also been advanced in the seminal contribution of Golden and Picci (2005). Specifically, Golden and Picci (2005) focus on physical public infrastructure and propose a method to compute the size of embezzled funds as the difference between the amount of funds cumulatively allocated by the Government to the infrastructures, and the value of the infrastructures that is actually in place. Although similar in spirit, the method we propose for such an estimation is different, and is based on the assumption that the actual amount of public expenditure is not observable, but can be estimated in an econometric framework that assumes that the book value of public funds represents the actual expenditure (i.e., the share of public funds that is actually allocated to productive uses) with a measurement error. Let us remark that our method, as well as the one of Golden and Picci (2005), however, does not distinguish between active and passive waste as in Bandiera, Prat and Valletti (2009).

The nexus between organized crime, corruption and economic growth is considered in the recent articles of Blackburn, Neanidis and Rana (2017) and Neanidis, Rana and Blackburn (2017). The focus of the proposed theoretical models and the implementation of the empirical analyses, however, are very different from those proposed in this paper. In particular, in Blackburn, Neanidis and Rana (2017) criminals can extort legal firms, thereby affecting economic growth, and corrupt public officers to reduce their law-enforcement efforts. Neanidis, Rana, and Blackburn (2017) explore the theoretical implications of this model in a linear framework, while our empirical analysis suggests the existence of parameter heterogeneity that we argue is consistent with a nonlinear growth model (see Section 6), and includes aspects such as the measurement error bias in the measurement of public expenditure in presence of a Mafia not considered by Neanidis, Rana and Blackburn (2017) or elsewhere. Organized crime and corruption are also jointly studied by Schwuchow (2023), who proposes a theory where inequality fosters organized crime, which may collude or compete with public agencies to extract rents from the population. This view can be seen complementary to ours but differs from our perspective by the focus on inequality, that we do not include in our analysis, and by the lack of consideration for the implications for economic growth.

Other works that study the relationship between organized crime and economic development, with a focus on the Italian case, include Pinotti (2015b), Balletta and Lavezzi (2023), Operti (2018) and Calamunci and Drago (2020). Pinotti (2015b), by adopting a synthetic control approach, estimates the negative effect of organized crime on the Italian regions of Apulia and Basilicata in a cumulated loss of approximately 16 % of per capita GDP. Interestingly, Pinotti (2015b) argues that one possible explanation of such economic slowdown may reside in a reallocation of economic activity from the private sector (as private investment is deterred by the presence of the Mafia), to the public sector, as criminal organizations are able to affect the public process of allocation of public resources. Although this aspect is not explicitly examined by Pinotti (2015b), it is nonetheless consistent with our framework, in which criminal organizations subtract a fraction of existing public funds. Balletta and Lavezzi (2023), differently, focus on extortion imposed by the Sicilian Mafia on legitimate firms. They find that extortion is highly regressive imposing a quasi-fixed cost on firms. This quasi-fixed cost generates a poverty trap, since the presence of organized crime also implies credit rationing (Bonaccorsi di Patti 2009). This result is consistent with the existence of a low-income steady state that we show in our theoretical model is implied by the organized-corruption link, although the channel is different. Finally, works like Operti (2018) and Calamunci and Drago (2020) focus on a specific Italian anti-mafia policy that allows the State to seize properties (real estate, firms, and so on) when they are infiltrated by organized crime. Both papers show that severing the links with organized crime of such assets improve the economic conditions of the segment of the economy affected by the intervention. Specifically, Operti (2018, p. 328), finds that: "financial assets and company confiscation increases [entrepreneurial] entry rates in a province," while Calamunci and Drago (2020) observe that the economic performance of firms operating in the market of the confiscated firms improve along different dimensions. None of these works, however, explore the channel organized crime-corruption-growth as in this paper.[3]

Finally, as mentioned in Section 1, our work is related to the recent literature on the effects that institutions can have at subnational level on local development paths. For example, Gertler (2010) advocates for the incorporation in the economic geography approach of more consideration of how institutions vary at different spatial scales, as: "local circumstances, inherited institutional legacies, and local agency might well influence the course of developmental trajectories." (Gertler 2010, p. 10). In the case of Italy, early sociological work already pointed out that institutional quality varies at subnational (regional) level (Putnam 1992). Rodríguez-Pose (2013, p. 1042), with respect to the index of "civicness" introduced by Putnam (1992), notes that: "[Putnam's] key index of'civicness," which is the result of centuries of evolution, is embedded in what becomes a fixed institutional context" (see also Rodriguez-Pose 2020, for further discussion). Our work, therefore, is consistent with the literature that stresses the need to consider institutional variation at subnational level, in the particular case in which the source of institutional variation is the pervasiveness of organized crime which can interfere with the functioning of formal institutions at local level, an aspect that so far has received scant attention in this literature.

In the next section, we present the empirical stylized facts motivating this article.

3 | Stylized Facts

In this section, we present some stylized facts on the relationship between per capita GDP, corruption and organized crime in Italian regions.

Figures 1 and 2 show, respectively, the relationship between a proxy for the intensity of organized crime, that is, the per capita number of reported extortion crimes, and per capita GDP, and between the per capita corruption crimes and per capita GDP.[4] The relationship is estimated with average values for the period 1996-2013 (extortion) and 1996-2011 (corruption).

Figures 1 and 2 highlight a negative correlation between, respectively, corruption and organized crime on one side and per capita GDP on the other side.[5] Finally, Figure 3 shows that corruption and organized crime are positively correlated, as expected from Figures 1 and 2.[6]

4 | Data

We utilize data from Italian regions for the period 1996–2013. Data on regional GDP and population are from ISTAT; data on public expenditure are from the Italian Ministry of Finance;[7] the measurement of corruption is given by the number of per capita reported corruption crimes;[8] the measurement of Mafia intensity is based on data on Mafia-related crimes (Mafia-related homicides, Homicides, Extortion, Mafia association) from ISTAT, and on data on assets confiscated to the Mafia, from ANBSC, the national

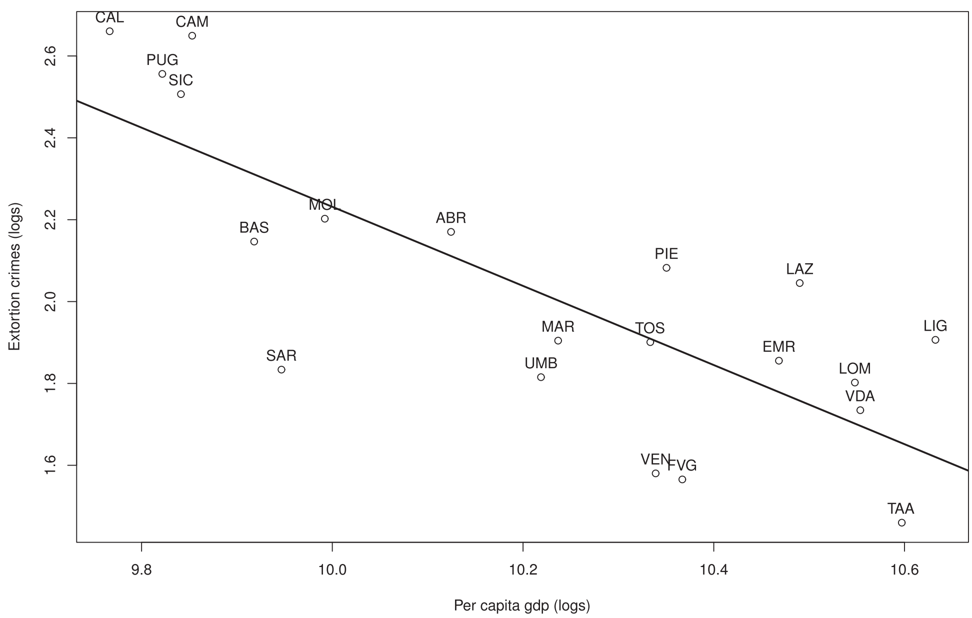

FIGURE 1 | Extortions and GDP per capita (in logs) in Italian regions: average values 1996–2013.

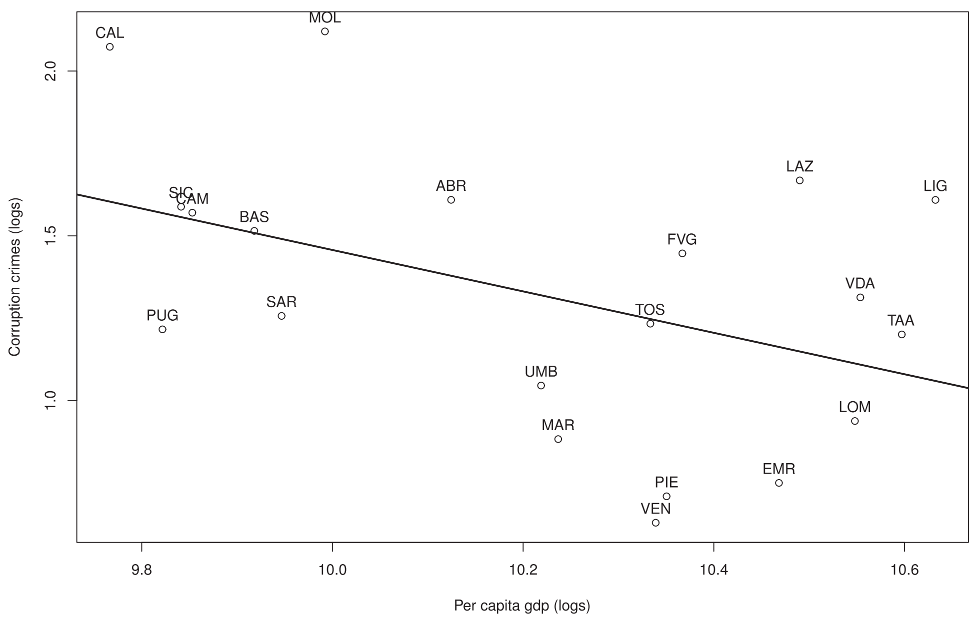

FIGURE 2 | Corruption and GDP per capita (in logs) in Italian regions: average values 1996–2011.

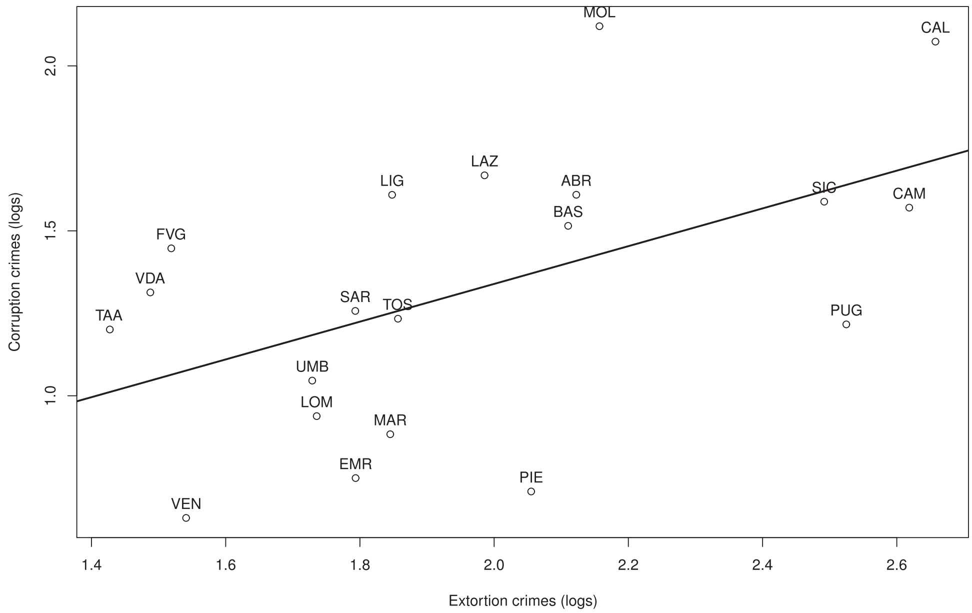

FIGURE 3 | Corruption and extortion (in logs) in Italian regions: average values 1996–2011.

agency managing properties confiscated to criminal organizations. As a measure of public expenditure, we consider the ratio between total regional public expenditure and regional population. Table A1 contains some descriptive statistics.

5 | Empirical Analysis

In this section we propose an econometric model to capture the interplay among organized crime, corruption and economic growth when public expenditure is a productive factor, as in Barro (1990), and a Mafia can divert part of the public expenditure from its productive uses. Such econometric model starts by specifying a simple linear relationship between public expenditure and per capita GDP as the following:

$$\ln(y_{it}) = \alpha + \beta_g \ln(g_{it}) + \epsilon_{it}, \tag{1}$$

where y_{it} denotes per capita GDP of region i at time t, g_{it} denotes (per capita) public expenditure allocated to production, whose effect is captured by the coefficient β_g, and ϵ_{it} is the error term, with $\epsilon \sim \mathcal{N}(\mu, \sigma^2)$. An underlying aspect of this specification is that Mafia intensity can differ across regions, as suggested by Figure 1 and a vast literature (e.g., Calderoni 2011).

Three potential statistical problems, however, can arise in the econometric analysis of Equation (1): (i) an errors-in-variables bias, as the covariate measuring public expenditure at its book value, which can be collected from official datasets, might not capture its true value, as long as a Mafia subtracts part of it; (ii) an omitted variable bias due to the fact Mafia actions are outlaw by definition, and therefore not directly measurable, which implies that the "true level" of Mafia operating in a region is hidden (latent) and difficult to assess; (iii) a possible heterogeneous, region-specific, effect of Mafia on the levels of public expenditure allocated to production (see Griliches and Hausman 1986) and on the relationship between public expenditure and regional per capita GDP, as long as Mafia penetration differs across regions and public expenditure has different levels of efficiency depending on the spread of corruption, as shown by Del Monte and Papagni (2001), and organized crime, as can be conjectured given the correlation in Figure 3.

Each of these problems implies correlation between the residuals and the covariates of regressions such as Equation (1). The higher this correlation, the greater the bias in the magnitude and significance of the estimated coefficients. Several estimators have been proposed to solve these problems, such as Two Stage Least Squares (2SLS), Two Stage Instrumental Variabile (IV-2SLS), dynamic Generalized Method of Moments (GMM) or two-stage GMM with IV. The choice of the instrument is crucial, as bad instruments can conduct to several biases. In particular, Young (2022) shows that, using a comprehensive sample of 1309 instrumental variables regressions in 30 papers published in the journals of the American Economic Association, IV-2SLS models can have little explicative power: non-iid errors distribution persists also after an IV method has been implemented, resulting in increased values of standard errors (see also Huntington-Klein et al. 2021). However, it is well-known that the issue of optimal instruments uncertainty is one the major limitations to all forms of IV approaches, including General Method of Moments (see Bazzi and Clemens 2013). To avoid uncertainty on the instruments and to allow for possible region-specific heterogeneity on the effects of organized crime on GDP, we propose a semi-parametric estimation allowing, on the one hand, to simultaneously obtain groups of regions with a certain level of homogeneity and, on the other hand, to estimate how much of the public expenditure is "subtracted" on average by the Mafia in each region.[9]

A preliminary issue, as noted, is represented by the measurement of organized crime. In the literature the intensity of the presence of the Mafia in a territory, for example, a region or province, is typically accounted for by measures of mafia-related crimes. For example, Ganau and Rodríguez-Pose (2018) consider mafia association, mafia homicides and extortion (see

Calderoni 2011, for thorough discussion of this issue). In this work we employ a factor analysis (FA) based on data on five Mafia-related indicators (see Section 4) to measure the Mafia intensity across Italian regions in 1996, the initial year of our period of observation.[10] Appendix B contains the details of the FA, which shows that a single factor explains approximately 80% of the variance of the set of chosen variables measuring Mafia activity. In the following, therefore, we will consider the first estimated factor as our synthetic Mafia Index, denoted by m_i. Figure 4 shows the relationship between the Mafia Index and regional per capita GDP in 1996.

We can see from Figure 4 that the relationship between the estimated Mafia index and regional per capita GDP is still negative as in Figure 1 (which considered extortion only, and was based on time-averaged values): regions with the highest values of the Mafia Index have the lowest GDP levels. However, Figure 4 shows a more nuanced picture as we move from higher to lower Mafia Index levels. In fact, at lower Mafia Index levels, say around 0.2, we find regions at remarkably different levels of per capita GDP such as Puglia (PUG) and Sardinia (SAR) at low GDP levels, and Piemonte (PIE) or Liguria (LIG) at higher GDP levels.

To better understand the relationship between per capita GDP, public expenditure and organized crime, in the next section we present a covariate measurement error model estimated by finite mixture models (see, among others, Aitkin and Rocci 2002, Rabe-Hesketh, Skrondal and Pickles 2004, Pitt, Rosenzweig and Hassan 2012)), as an econometric approach able to take into account the statistical problems mentioned above. Our assumption, as better specified in the theoretical model of Section (6), is that organized crime can appropriate part of the public expenditure. In other words, the public expenditure allocated to production may be officially measured with error, where the intensity of the "error" is due to the capacity of organized crime to embezzled public funds, that we proxy by the intensity of the organized crime in a region. It is well-known that endogeneity introduced in empirical models as a measurement error bias can be treated within the finite mixture approach (Aitkin and Rocci 2002). In the following, we assume that the observed per capita public expenditure g_{it} is measured with error because its "true" value $\bar{g}_{\text{it}}$ is unobservable or "latent," and depends on region-specific organized crime intensity, measured by the Mafia index m_i at $t = 1996$.

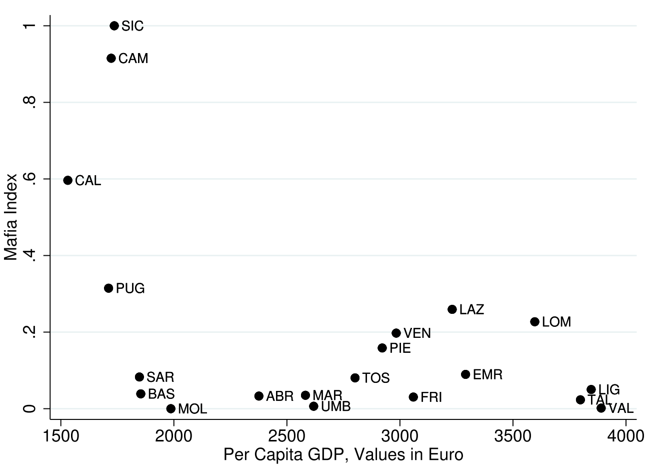

FIGURE 4 | Our estimated Mafia index and per capita GDP in 1996.

5.1 | Finite Mixture Covariate Measurement Error Models

Once we have defined the Mafia Index m_i in 1996, we can use it as a covariate affecting the unobserved level of (per-capita) public expenditure $\bar{g}_{\text{it}}$. As stressed by Abadie, Gu and Shen (2023), however, our empirical analysis may be affected by heterogeneity, as some regions may share common and unmeasured characteristics, that is, an unknown clustering process of the Italian regions may exist, which would affect OLS standard errors. Taking these remarks into account in what follows we consider an empirical model allowing for region-specific effects of organized crime, accounting in this way for unobserved similarity or heterogeneity among regions.

Following, among others, Rabe-Hesketh, Skrondal, and Pickles Skrondal and Pickles (2003, 2004), May, Ibrahim and Chu (2011) and Pichler, Stomper and Zulehner (2008), the empirical estimator we use is based on the discretization of an unspecified random distribution of the region-specific measurement error, which provides a consistent estimate of the *true* distribution of the random effects (see Laird 1978 and Lindsay 1983a, 1983b). Moreover, the discretization of the model likelihoods, by construction, leads to the estimation of marginal error densities through a finite mixture of Gaussian densities, so that the assumption of Gaussian errors is conditional on the mixture component. In this sense, our model specification may help to produce robust estimates of the standard errors giving us more reliable *p*-values.

This empirical strategy allows us, on the one hand, to simultaneously obtain groups of regions with a certain level of homogeneity and, on the other hand, to estimate how much of the public expenditure is "subtracted" on average in each region by the Mafia (Rabe-Hesketh, Skrondal and Pickles 2003), a novel aspect of our analysis.

Our strategy is to define an empirical model in which a key assumption is that what we observe as public expenditure is a realization of a process involving region-specific organized crime hidden actions, on the premise that Italian regions have different socioeconomic structures sharing some common unobserved characteristics, as the level of organized crime.[11] On these grounds, regions can be conceptualized as belonging to "hidden," homogeneous clusters, that is, each region belongs to one of K possible groups of regions sharing some common socioeconomic feature represented, in the empirical model, by cluster-specific latent structures (see, Alfò, Trovato, and Waldmann 2008, Owen, Videras and Davis 2009).

Assuming that the Mafia can capture a portion of observed public expenditure, we can derive the following specification of a system of equations, which represents the complete specification of an empirical approach starting from Equation (1), (Rabe-Hesketh, Skrondal and Pickles 2004):

$$\begin{cases} E(\ln(y_{\text{it}})|\ln(g_{\text{it}}), m_i) = \alpha + \beta_g \ln(\bar{g}_{\text{it}}) & \text{(2a)} \\ E(\ln(g_{\text{it}})|\ln(\bar{g}_{\text{it}})) = \ln(\bar{g}_{\text{it}}) & \text{(2b)} \\ E(\ln(\bar{g}_{\text{it}})|m_{it}) = u_i + \psi m_i. & \text{(2c)} \end{cases}$$

In the system of Equations (2a–2c) only $\ln(y_{it})$, m_i and $\ln(g_{it})$ are observed, while $\ln(\bar{g}_{it})$ and the errors are not.

In Equation (2a) the parameter β_g measures the effect of the actual per capita public expenditure on the regional per capita GDP, while Equation (2b) implies that measurement errors are assumed to be orthogonal to the measurement error variance σ_g. Furthermore, in Equation (2c), we assume that the Mafia actions directly and asymmetrically affect the expected true value of public expenditure, that is, the error term u_i is region-specific with measurement error variance σ_{u_i}.

If we substitute Equation (2c) in Equation (2b) we obtain the reduced form for the measurement equation, denoted as the Measurement Model:

$$E(\ln(g_{\text{it}})|\ln(\bar{g}_{\text{it}}), m_i, u_i) = u_i + \psi m_i, \tag{3}$$

while, by substituting Equation (3) in Equation (2a) we obtain the reduced form of the expected per capita GDP equation, denoted as the Outcome Model:

$$E(\ln(y_{\text{it}})|u_i, \ln(\bar{g}_{\text{it}}), m_i, \epsilon_{\text{it}}) = \alpha + u_i\beta_g + \psi\beta_g m_i. \tag{4}$$

We see that m_i has an indirect effect on per capita GDP though the coefficient $\psi\beta_g$ which represents the effect of the unobserved public expenditure. In this way we can measure the indirect association of GDP and public expenditure through the Mafia Index.

To solve, at least partially, the inconsistency of the model given by Equations (3) and (4), which depends on the fact that the parameters for $\ln(g_{\text{it}})$ and the overall Gaussian errors ϵ_{it} could still be correlated with the measurement error term, we allow for the measurement error term u_i to be distribution-free and region-specific (Rabe-Hesketh, Skrondal and Pickles 2004; Aitkin and Rocci 2002; Pitt, Rosenzweig and Hassan 2012). That is, instead of assuming a normal distribution for u_i, we leave its distribution unspecified (see the seminal work of Laird 1978).

If the estimation process does not find sources of unobserved heterogeneity in the data, the model becomes a classic Measurement Error Model estimated through Maximum Likelihood. In this respect, for $K >> 1$, u_i (for $i = 1, ..., n$) denotes the set of subject and outcome-specific random coefficients. The hypothesis is that the values of $\ln(y_{it})$ represent conditionally independent realization of the potential per capita GDP, given the set of random factors u_i estimated by the EM algorithm (Dempster, Laird and Rubin 1977).[12] From that it follows that since $u_i{*}\beta_g$ measures the random intercept in Equation (4), it could be considered as the estimated average "true" effect of public expenditure on per capita GDP for region i.

Table 1 contains the results of the estimation of the Covariate Measurement Model described by the system of Equations (3) and (4). In Model A organized crime, as proxied by the Mafia Index, affects public expenditure and through this channel, per capita GDP. As a robustness test, we consider as an alternative to the use of the Mafia Index a measure of corruption crimes in region i in 1996 (Model B), denoted by corr_i, given the correlation highlighted in Figure 3.

TABLE 1 | Estimation results: Finite mixture covariate error model.

	MODEL A (True pub. exp. function of Mafia)	MODEL B (True pub. exp. function of corruption)
Outcome model: Fixed part		
Constant	−17.406***	−17.038***
	(0.678)	(5.747)
Outcome model: Random part		
$\ln(\bar{g})(k = 1)$	−0.106***	−0.120***
	(0.020)	(0.030)
$\ln(\bar{g})(k = 2)$	0.047**	0.051**
	(0.020)	(0.0240)
$\ln(\bar{g})(k = 3)$	−0.018	−0.017
	(0.020)	(0.023)
$\ln(\bar{g})(k = 4)$	0.113***	0.116***
	(0.057)	(0.003)
Measurement model		
Constant	8.643***	8.643***
	(0.029)	(0.031)
m_i	−0.048***	
	(0.005)	
corr_i		−0.033***
		(0.008)
n	360	360
K	4	4
Equation errors (standard deviations)		
$\sigma_{\hat{g}}$	0.0659***	0.070***
	(0.0373)	(0.037)
σ_u	0.410***	−0.410***
	(0.0373)	(0.037)
σ_ϵ	0.0776***	
	(0.004)	

Note: Standard errors for locations are obtained by applying the delta method. The last class is estimated by setting the first class. The standard errors for last classes are computed as: $\text{std}(u_k) = \text{sqrt}(u_k^2\hat{\pi}_k)$.
*10%.
**5%.
***1%.

First of all, in both models regions are partitioned into clusters suggesting that there exists unobserved heterogeneity at the regional level. In particular, in Models A and B four clusters of regions are identified.[13] A test on residuals for the estimated models of Table 1 does not allow to reject the hypothesis of Gaussian errors in the different clusters (see Table D1). This result implies that standard errors are free from unobserved heterogeneity and measurement error bias.

Figure 5 shows the partition of Italian regions in the four clusters.

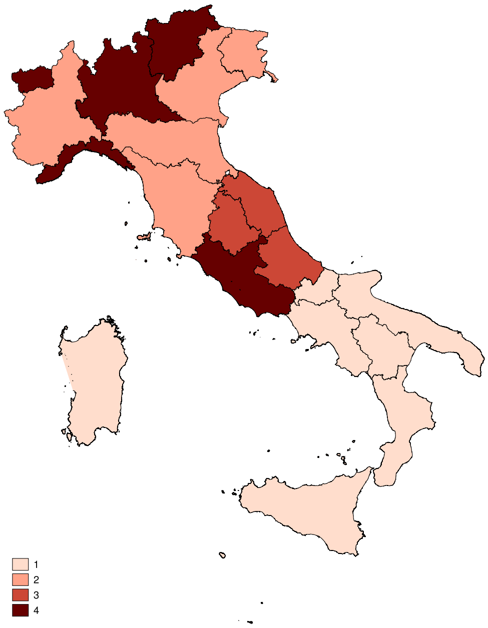

FIGURE 5 | Clusters of regions identified in Table 1. [Color figure can be viewed at wileyonlinelibrary.com]

Cluster 1 includes seven regions, in particular those with the highest levels of the Mafia index (see Figure 4). These are the four regions which witnessed the origins of the most powerful Italian criminal organizations: Apulia (*Sacra Corona Unita*), Calabria (*'Ndrangheta*), Campania (*Camorra*), and Sicily (*Cosa Nostra*). In addition, however, we find other Southern regions such as Sardinia, Molise and Basilicata, which do not feature a historical presence of organized crime, albeit some recent evidence (e.g., Ministero dell'Interno 2019) suggests that Molise and Basilicata are partially plagued by criminal organizations of different origins, also foreign, while Sardinia is characterized by autochthonous delinquent manifestations, although not directly related to the pervasive control of the territory typical of traditional Mafia associations.[14] This result depends on the fact that the random term u_i does not only capture the presence of organized crime but is also likely to capture other unobservable similarities across regions such as cultural traits, family or religious traditions. In fact, all the regions in Cluster 1 are located in the Southern Italy and have very similar low GDP levels (see Figure 4).

Cluster 2 includes five regions from Northern-Central Italy: Piedmont, Emilia-Romagna, Tuscany, Veneto, Friuli-Venezia-Giulia. These regions have similar and low Mafia Index levels, around or lower than 0.2, and a very similar level of per capita GDP in 2006, around 3000 Euros (see Figure 4). Cluster 3 contains three regions from Central Italy (Umbria, Marche and Abruzzo), with a very low level of the Mafia Index and similar per capita GDP around 2500 Euros (see Figure 4), while Cluster 4 contains five regions, four from Northern Italy (Valle d'Aosta, Liguria, Lombardy and Trentino Alto Adige) and the region of Lazio. Regions in Cluster 4 have a low Mafia Index and a very high per capita GDP levels in 2006, although for both variables the values are somewhat dispersed.[15]

A key result in Table 1 is the difference in the estimated coefficients of the Outcome Model, i.e. those identifying the effect of public expenditure on GDP. The estimated coefficients for $\ln(\bar{g})(k = 1, ..,4)$ measure the cluster-specific effects of public expenditure on GDP, once we correct for the measurement error and for the unobserved heterogeneity, in other words they represent the $\hat{u}_k\hat{\beta}_g, (k = 1, ..,4)$ term in Equation (4). In Model A, the coefficient for the effect of the public expenditure in Cluster 1 is negative and significant, while it is positive and significant in Clusters 2 and 4. In Cluster 4, in particular, the coefficient is higher in magnitude and highly significant. In Cluster 3 the coefficient is not statistically different from zero. A negative coefficient of public expenditure suggests that public expenditure may even be detrimental to growth in regions where Mafias are powerful. This represents a further negative effect that Mafias exerts on growth via the public expenditure channel, beyond the subtraction of public funds from productive uses. As we conjectured, the presence of the corruption-Mafia nexus might reduce the efficiency of the part of public expenditure allocated to production. On the contrary, in regions in which Mafias are less powerful the effect of public expenditure on per capita GDP is positive, as predicted by models such as Barro (1990). These results can be seen as complementary to those of Ganau and Rodríguez-Pose (2018), who point out that a pervasive presence of organized crime can reduce firms' productivity (and therefore negatively impact on regional per capita GDP) as a Mafia increases uncertainty in the business environment, alters competition and market structure, increases the firms costs and reduces the revenues (see also Balletta and Lavezzi 2023). Such evidence of parameter heterogeneity is consistent with the existence of different growth regimes, that is with the hypothesis that per capita regional GDP in the different clusters follows different growth models (Durlauf and Johnson 1995; Owen, Videras and Davis 2009; Flachaire, García-Peñalosa and Konte 2014).

As for the Measurement Model, in Model A of Table 1 the coefficient of the Mafia Index is negative and significant, and has value $\hat{\psi} = -0.048$, suggesting a negative effect of the Mafia intensity on actual public expenditure. When we consider in Model B a measure of corruption instead of the Mafia Index we still find a negative coefficient, albeit lower in magnitude. Overall, utilizing corruption crimes instead of the Mafia Index does not affect the main results.

Our empirical approach also allows to estimate the size of the embezzled public expenditure, given its book value. The amount of embezzled public expenditure is the difference between the observed (per capita) public expenditure at book value and the estimated one. Table 2 presents the results, showing the estimated amount of embezzled public expenditure with a lower and upper bound of the estimate (values refer to averages over the period considered).

Table 2 shows that for regions in Cluster 1 the difference between the book value of public expenditure (the "observed" value) and the estimated unobserved value is negative and sizeable, corresponding to approximately 10% of the book value. Overall, therefore, we find that in these regions the public expenditure allocated to productive uses is remarkably lower than what it should be, and is also not effective in stimulating GDP, as the results in Table 1 suggest. The same negative difference is found for regions in Cluster 3, although its impact is much lower (approximately 2% of the book value)

TABLE 2 | Estimation of the embezzled per capita public expenditure.

Clusters	Region	Observed P.E.	Lower bound	Embezzled P.E.	Upper bound
$k == 1$					
	Basilicata	5608.33	−567.03	−566.23	−565.42
	Molise	5571.76	−563.34	−562.54	−561.73
	Calabria	5364.58	−542.42	−541.62	−540.81
	Campania	5149.24	−520.68	−519.88	−519.07
	Puglia	4886.08	−494.11	−493.31	−492.50
	Sardegna	6780.60	−685.39	−684.58	−683.78
	Sicilia	5927.21	−599.23	−598.42	−597.62
$k == 2$					
	Emilia Romagna	5153.53	252.39	253.19	254.00
	Friuli Venezia Giulia	8534.14	405.70	406.50	407.30
	Piemonte	5338.89	253.50	254.30	255.108
	Toscana	5093.32	241.80	242.61	243.411
	Veneto	4050.75	192.14	192.95	193.751
$k == 3$					
	Abruzzo	5319.33	−96.80	−96.00	−95.191
	Marche	4584.21	−83.53	−82.73	−81.92
	Umbria	5260.57	−95.74	−94.94	−94.13
$k == 4$					
	Lazio	8429.94	1009.25	1010.06	1010.86
	Liguria	8114.49	971.46	972.26	973.06
	Lombardia	5885.89	704.43	705.23	706.04
	Trentino Alto Adige	5790.11	692.95	693.76	694.56
	Valle d'Aosta	13,124.06	1571.69	1572.49	1573.30

Note: Observed P.E.: observed per capita public expenditure; Embezzled P.E.: difference between Observed P.E. and the estimated public expenditure from the Measurement Model; Lower bound: lower bound for the estimated embezzled public expenditure, given by: Embezzled P. E. −1. 96 * *s. e.*); Upper bound: upper bound for the estimated embezzled public expenditure, given by: Embezzled P. E. +1.96 * s.e. s.e. refers to the estimate of the effect of m_k in Model A.

For regions in Clusters 2 and 4, differently, the estimated value of the actual public expenditure is predicted to be higher than the observed book value. In particular, the positive difference amounts, respectively, to approximately 5% and 10% for regions in Clusters 2 and 4. We interpret this statistical result as a sign of the efficiency of these regions in utilizing public expenditure for productive uses. Regions in Cluster 2 and 4, as shown in Table 1, are the ones with a positive and significant coefficient on the marginal effect of public expenditure on GDP.

In Appendix D we present some goodness of fit tests of our estimated model and show that, if the identified clusters were known ex-ante, a pooled OLS model with interaction variables would be well-specified in both the estimated coefficients and goodness of fit.

In the next section we introduce a simple growth model which is consistent with the key results of the econometric analysis: the existence of different growth regimes, as the model implies a nonlinear growth path, and a positive relation between the intensity of the Mafia presence (measured by its “strength”) and the size of embezzled public expenditure.[16]

6 | A Growth Model With Organized Crime and Corruption

The economy is populated by workers, bureaucrats (employed by a Government), and a criminal organization (the Mafia). For the sake of simplicity we normalize the number of bureaucrats and members of organized crime to 1, that is, we assume that bureaucrats and the criminal organization behave as an individual agent.[17]

In period t bureaucrats manage the allocation of an amount G_t of public spending. The Mafia aims at grabbing part of the public funds by corrupting and threatening the bureaucrats. For simplicity we assume that diversion of public funds takes the form of a direct transfer to the Mafia. In particular, the Mafia sets up a bargaining process with the bureaucrats to embezzle public funds, in exchange for a bribe and under the threat of punishment. If bargaining is successful and a bribe is defined, corrupted bureaucrats may be detected and punished by an external authority. In what follows we specify the details of the model.

6.1 | Production

Following Barro (1990), production at time t, denoted as Y_t, requires labor L_t, physical capital K_t and public spending $\bar{G}_t$:

$$Y_t = K_t^{\alpha} L_t^{1-\alpha} \bar{G}_t^{1-\alpha}, \tag{5}$$

where $0 < \alpha < 1$. Therefore, we assume that production exhibits constant returns to scale in K_t and $\bar{G}_t$, given L_t (see also Barro and Sala-i Martin 2004, p. 220). For the sake of simplicity we suppose a constant working population L_t.

The amount $\bar{G}_t$ is net of the share subtracted by the Mafia. In particular, following Mauro (2004), we assume that a fraction $0 \leq \phi < 1$ of G_t might not reach the production processes (see also De la Croix and Delavallade 2011 and d'Agostino, Dunne and Pieroni 2016), that is:

$$\bar{G}_t = G_t(1-\phi), \tag{6}$$

where $\phi < 1$ implies that a fraction of public spending is free from corruption.[18] For simplicity we suppose that public spending is financed by a lump-sum tax τ imposed on agents operating in the legal sphere, i.e. bureaucrats and workers. In particular, the Government uses the total revenues to finance public spending and pay the bureaucrats' salaries.

Finally, we assume that the labor market is competitive so that in equilibrium, the wage is given by:

$$w_t = (1-\alpha) k_t^{\alpha} \bar{G}_t^{1-\alpha}, \tag{7}$$

where $k_t = K_t / L_t$ is the capital/labor ratio at time t.

6.2 | Preferences

Agents live for two periods: in the first period they work and save part of their income, s_t, for consumption in the second period, in which they retire. Assuming that workers and bureaucrats have the same preferences, they choose consumption and saving to maximize the following utility function:

$$U = u(c_t) + \beta u(c_{t+1}), \tag{8}$$

subject to:

$$c_t = w_t - \tau - s_t, \tag{9}$$

and:

$$c_{t+1} = r_{t+1} s_t, \tag{10}$$

where τ is the lump-sum tax levied by the Government and r_{t+1} is the interest rate. Assuming a logarithmic utility function, optimal saving is given by:

$$s_t^* = \frac{\beta y_t}{1+\beta}. \tag{11}$$

6.3 | Bureaucrats

Following Blackburn, Bose and Emranul Haque (2006, 2011) and Varvarigos and Arsenis (2015) we assume that that bureaucrats receive a wage equal to the wage paid to workers, that is, to w_t in Equation (6). The assumption is justified as follows. Bureaucrats can work for the private sector and receive a salary equal to that paid to workers. Therefore, if bureaucrats were paid a lower salary than that paid by the private sector, they would seek additional compensation through bribes and thus would always be corrupt (see Gorodnichenko and Sabirianova Peter 2007). On the other hand, the Government has no incentive to pay a salary higher than that paid by firms to minimize its labor costs.[19]

Bureaucrats supervise the allocation of public spending G_t. Following Dal Bò, Dal Bò and Di Tella (2006) we assume that the Mafia tries to force bureaucrats to distort the allocation of public funds by using two instruments: a bribe and a threat of punishment, assumed to be credible.[20] As in Dal Bò, Dal Bò and Di Tella (2006) we assume that if bureaucrats refuse the "offer" by the Mafia, and do not distort the allocation of public funds, that is, if $\phi = 0$, they receive the legal income w_t but are subjected to a punishment by the Mafia of intensity z.[21] In particular, the parameter z can depend on the strength of organized crime: the higher the strength, the higher z. Assuming linear utility with respect to income, the payoff of a bureaucrat who is not corrupted is therefore given by:

$$y_t^{B_{nc}} = \hat{w}_t - z - \tau. \tag{12}$$

where, from Equation (7), $\hat{w}_t = (1-\alpha) k_t^{\alpha} G_t^{1-\alpha}$.

If bureaucrats accept corruption, then with probability p corruption is not detected by the Authorities and bureaucrats receive the wage w_t and a bribe from the Mafia. The bribe is assumed to be a fraction θ of ϕG_t, the share of embezzled public spending (see Mohtadi and Roe 2003). With probability $1-p$, corruption is detected and bureaucrats are left with nothing (see Acemoglu and Verdier 1998).[22] The expected payoff of corrupted bureaucrats is therefore given by:

$$y_t^{B_c} = p(w_t + \theta \phi G_t) - \tau. \tag{13}$$

Note that $y_t^{B_c}$ is nonlinear in ϕ. In fact, an increase in ϕ has two opposite effects on $y_t^{B_c}$. On the one hand, for a given w_t a higher ϕ increases the expected income of bureaucrats. On the other hand, a higher ϕ decreases aggregate output and therefore w_t declines. It is possible to show that when ϕ is below a certain threshold the first effect dominates the second, so that $y_t^{B_c}$ increases with ϕ.[23]

6.4 | The Mafia

The payoff of the Mafia is given by the expected income from corruption which depends on the bargaining process with the bureaucrats. If the bureaucrats are not corrupted, the Mafia payoff is normalized to zero.[24] On the other hand, if the bargaining process is successful the Mafia obtains a fraction of public spending ϕG_t with probability p, and pays a bribe to the bureaucrats.

If corruption is detected, criminals are left with nothing and have to pay a fine $-P$.[25] The expected utility of organized crime when corruption takes place, therefore, is given by:

$$y_t^{M_c} = p\phi G_t(1-\theta) - (1-p)P, \tag{14}$$

otherwise, $y_t^{M_{nc}} = 0$.

6.5 | The Equilibrium

In this section we characterize the equilibrium for the economy. We model the bargaining process between bureaucrats and the Mafia as a standard bilateral contracting problem. We assume that contracting parties are rational individuals who aim to achieve the highest possible payoff, and therefore choose the most efficient solution (see Bolton and Dewatripont 2005). We consider this setting as more realistic than the one of Dal Bò, Dal Bò and Di Tella (2006), in which organized crime makes a take-it-or-leave-it offer to politicians.[26]

Specifically, we model the bargaining process between bureaucrats and the Mafia consistently with the existing literature on the interaction between organized crime and public functionaries, civil servants, politicians, and various kinds of consultants in public tendering (see in particular Canonico et al. 2017). That is, we refer to the dealings taking place between the Mafia and the so-called "gray area," that is, a trading zone in which exchanges take place: "between different types of players [e.g. politicians] requiring reciprocal recognition and mutual favors assuming the same profit-making objective." (Canonico et al. 2017, p.158).

For example, from the second half of the eighties, the Sicilian Mafia entered and managed a system of pre-determined divisions of public tenders that was previously the exclusive competence of entrepreneurs and politicians (see Della Porta and Vannucci 2016).[27] In those years, the so-called "Siino method" was established.[28] This was a system of planning and allocation of public tenders in which all the relevant subjects have a part: the competing companies form a cartel to adjudicate the tenders in rotation, the politicians and bureaucrats earn bribes in exchange of permissions and information, the Mafia gets a share of the income generated off the back of the public purse (e.g., Della Porta and Vannucci 2016).[29]

Therefore, we assume that the amount of public funds diverted from productive uses can be defined as the solution of a joint surplus maximization process. That is, the optimal amount ϕ^* is chosen to maximize the total surplus from trade, denoted as $\mathrm{TS}(k_t)$. Specifically, from Equations (7), (13), and (14) the amount of ϕ^* is obtained as the solution of:

$$\phi^* = \operatorname{argmax}\{\mathrm{TS}(k_t)\}, \tag{15}$$

that is,

$$\phi^* = \operatorname{argmax}\Big\{p\big(1-\alpha\big)k_t^\alpha[G_t(1-\phi)]^{1-\alpha} + p\phi G_t - \big(1-p\big)P - \tau\Big\}, \tag{16}$$

from which we obtain:

$$\phi^* = 1 - \frac{k_t(1-\alpha)^{2/\alpha}}{G_t}. \tag{17}$$

Equation (17) shows that ϕ^* decreases with the capital-labor ratio and becomes equal to zero when k_t is sufficiently high, that is, when $k_t > k^H$, a threshold value given by:

$$k^H = \frac{G_t}{(1-\alpha)^{2/\alpha}}. \tag{18}$$

Figure 6 represents the negative relationship between ϕ^* and k_t, highlighting the threshold k^H.

The intuition behind this result is that, ceteris paribus, a higher capital-labor ratio makes the optimal amount of embezzled public expenditure lower as it implies higher salaries of public officers, which can therefore find corruption less attractive.[30]

On the other hand, from Figure 6 and Equation (17) we also see that, given k_t, an increase in public spending G_t increases ϕ^* for any level of k_t, (see the blue line in Figure 6) and shifts to the right the level of k^H. This suggests that, for given k_t, an increase in public expenditure increases the incentives of bureaucrats and the Mafia to embezzle public funds, and increases the threshold level of development after which $\phi^* = 0$.[31]

Bureaucrats and the Mafia have an incentive to negotiate a bribe if the total surplus evaluated at ϕ^*, denoted as $TS^*(k_t)$, is greater than the sum of the outside options evaluated at ϕ^*, denoted by $OP^*(k_t)$. That is, the condition for corruption to occur is:

$$TS^*(k_t) > OP^*(k_t) \tag{19}$$

which, by plugging in the terms from Equations (12–14), becomes the following inequality:

$$p(1-\alpha)k_t^\alpha[G_t(1-\phi^*)]^{1-\alpha} + p\phi^* G_t - (1-p)P > (1-\alpha)k_t^\alpha G_t^{1-\alpha} - z. \tag{20}$$

To identify the conditions for the inequality in Equation (19) to be satisfied, notice first of all that $TS^*(k_t)$, i.e. the left-hand side of Equation (19), is a linear function of k_t for a given G_t. That is, considering the value of ϕ^* from Equation (16), $TS^*(k_t)$ can be rewritten as:

$$\mathrm{TS}^*(k_t) = [pG_t - (1-p)P] + p\alpha(1-\alpha)^{(2-\alpha)/\alpha}k_t. \tag{21}$$

Differently, $\mathrm{OP}^*(k_t)$, that is, the right-hand side of Equation (20), is concave in k_t, for the concavity of the production function, and can be rewritten as:

$$\mathrm{OP}^*(k_t) = -z + (1-\alpha)G_t^{1-\alpha}k_t^\alpha. \tag{22}$$

In particular, the function $\mathrm{OP}^*(k_t)$ has a negative intercept that depends on the level of Mafia punishment z. Figure 7 provides a

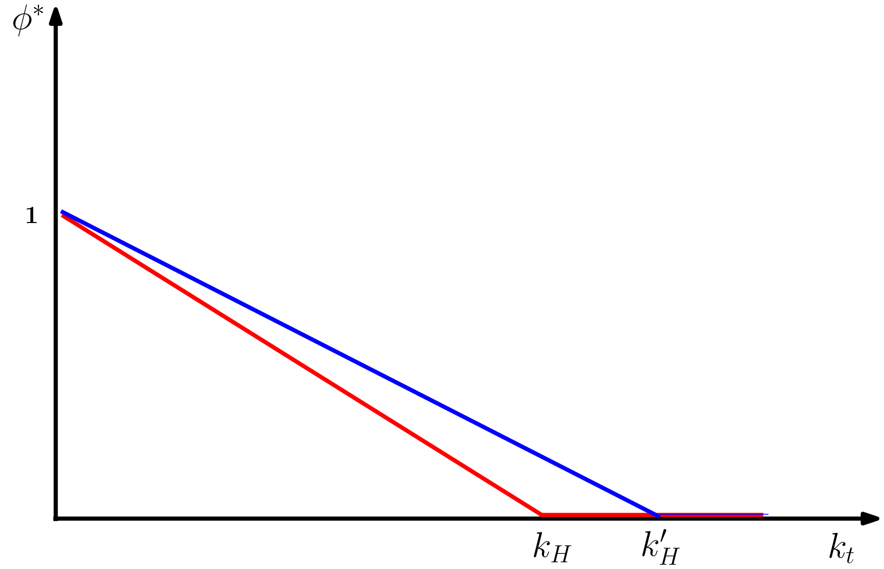

FIGURE 6 | The relation between the optimal level of ϕ and the capital/labor ratio k_t. The blue line represents the case of higher G_t. [Color figure can be viewed at wileyonlinelibrary.com]

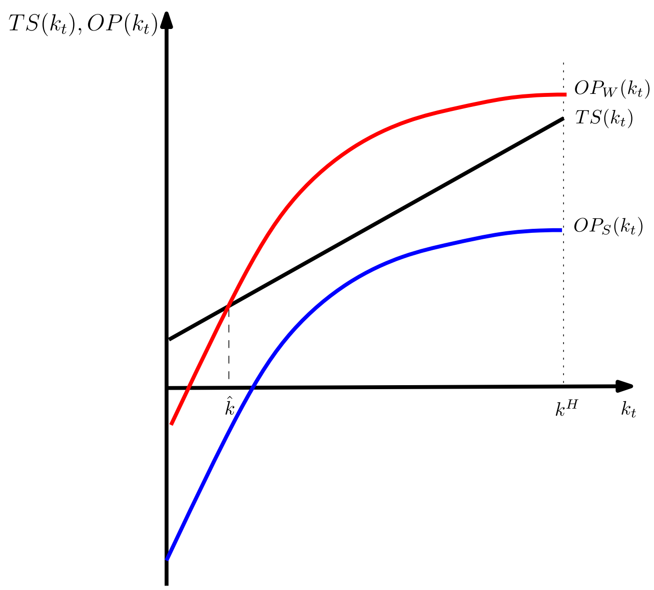

FIGURE 7 | Equilibrium corruption. Red: case of "weak Mafia"; Blue: case of "strong Mafia." [Color figure can be viewed at wileyonlinelibrary.com]

graphical representation of the relationship between $TS^*(k_t)$ and $OP^*(k_t)$, considering two possible positions of the function $OP^*(k_t)$ that depend on the value of z.

To illustrate Figure 7 it is possible to show, first of all, that $TS(0) < OP(0)$ if:

$$z < z_L \equiv (1 - p)P - pG_t,$$

and that $TS(k^H) < OP(k^H)$ if:

$$z < z_1 \equiv (1 - p)\left(\frac{G}{1 - \alpha} + P\right). \qquad (23)$$

Given that $z_L < z_1$ by construction, if $z < z_L$ corruption never takes place i.e. $TS(k_t) < OP(k_t)$ for each k_t. This is the case in which $TS(k_t)$ always lies below $OP(k_t)$, and corresponds to the case in which the Mafia is very weak, as measured by a particularly low value of z. This case would make the problem uninteresting and therefore, for simplicity, we do not represent it in Figure 7.

On the other hand, if $z_L < z < z_1$ then corruption occurs only when k_t is sufficiently low, that is, $TS(k_t) > OP(k_t)$ only if k_t is below a certain threshold $\hat{k}$. This case corresponds to the crossing between $TS(k_t)$ and the red $OP(k_t)$ curve in Figure 7, denoted as $OP_W(k_t)$.

Finally, if $z > z_1$ then corruption takes place for each level of k_t, that is, $TS(k_t) > OP(k_t)$ for each k_t. This corresponds to the case in which the $TS(k_t)$ line is always above the $OP(k_t)$ curve, as it happens in a comparison between the $TS(k_t)$ line and the blue $OP(k_t)$ curve in Figure 7, denoted as $OP_S(k_t)$.[32]

To rule out the uninteresting case in which corruption never takes place, in what follows we assume that:

Assumption 1

$$z > z_L.$$

Proposition 1 summarizes the theoretical results presented so far, highlighting the conditions under which corruption takes place.

Proposition 1. Under Assumption 1, two scenarios can arise, depending on the strength of the Mafia, proxied by the value of z:

i. A "Weak Mafia" scenario: if $z_L < z < z_1$, corruption occurs if k_t is lower than the threshold level $\hat{k}$.

ii. A "Strong Mafia" scenario: if $z > z_1$, corruption occurs for each $k_t \in (0, k^H]$.

The $OP_W^*(k_t)$ and $OP_S^*(k_t)$ curves in Figure 7 respectively represent the cases of "Weak Mafia" and "Strong Mafia."

The intuition of Proposition 1 is the following. When the strength of organized crime is low, which we proxy by a low level of z, then corruption takes place at low levels of capital (and income), whereas at high levels of capital (and income) corruption does not take place. This occurs because when the economy is poor the wages of the bureaucrats are low, and therefore bureaucrats have a higher incentive to negotiate and accept a bribe. On the contrary, if the economy is rich (i.e., if k_t is sufficiently high), the bureaucrats' wage is higher and therefore the incentive to accept a bribe is lower.

Differently, when the power of organized crime is high, that is, z is high, corruption occurs at all capital levels. The intuition in this case is that the punishment by the Mafia is so high that it drastically reduce the outside options of the bureaucrats, for whom in this case earning an income with or without a bribe becomes less important than the organized crime punishment.

In the next section we describe the growth path for this economy for the two cases of strong and weak Mafia.

6.6 | Economic Growth

In this section we analyze the growth dynamics of income per worker implied by our model. Let us define first of all the Government budget constraint.

Government's total revenues are obtained from a lump-sum tax on agents operating in the legal sphere (bureaucrats of mass 1 and workers), so that total revenues amount to $\tau(L_t + 1)$. We assume that no taxes are paid by members of the Mafia, under the hypothesis that their illegal income goes completely undocumented. The Government uses total revenues to finance public spending and bureaucrats' salaries. Assuming that income from bribes is hidden and therefore does not contribute to total revenues, the Government budget constraint is given by:

$$\begin{cases} (L_t + 1)\tau = G_t + w_t \text{ if } \phi^* = 0 \\ (L_t + 1)\tau = G_t + pw_t \text{ if } 0 < \phi^* < 1 \end{cases}. \tag{24}$$

Assuming that only the income from the formal sector contributes to the savings available for capital accumulation, aggregate physical capital is accumulated from the sum of the savings of the workers, $\frac{\beta(w_t - \tau)L_t}{1+\beta}$, and of the bureaucrats, i.e. $\frac{\beta(w_t - \tau)}{1+\beta}$ if $\phi^* = 0$, or $\frac{\beta(pw_t - \tau)}{1+\beta}$ if $0 < \phi^* < 1$. From Equation (24) it follows that physical capital accumulation follows the dynamic process:

$$K_{t+1} = \frac{\beta(w_t L_t - G_t)}{1 + \beta}, \tag{25}$$

where we assume that physical capital fully depreciates after one period. In per worker terms:

$$k_{t+1} = \frac{\beta[w_t - G_t/L_t]}{1 + \beta}, \tag{26}$$

where $k_{t+1} = K_{t+1}/L_{t+1}$.

Now we can derive the accumulation equations for the cases of weak and strong Mafia. In particular, from Equations (7), (17) and (26), when $z_L < z < z_1$, that is, in the case of Weak Mafia, the dynamics of physical capital accumulation is given by:

$$k_{t+1} = \frac{\beta}{1+\beta}\begin{cases} -g_t + (1-\alpha)^{(2-\alpha)/\alpha}k_t \text{ if } k_t \le \hat{k} \\ -g_t + (1-\alpha)k_t^{\alpha}G_t^{1-\alpha} \text{ if } k_t > \hat{k} \end{cases}, \tag{27}$$

where $g_t = \frac{G_t}{L_t}$ and $\hat{k}$ is represented in Figure 7. Differently, in the case of Strong Mafia, that is, when $z_1 < z < z^H$, the dynamics of capital accumulation is given by:

$$k_{t+1} = \frac{\beta}{1+\beta}\begin{cases} -g_t + (1-\alpha)^{(2-\alpha)/\alpha}k_t \text{ if } k_t \le k^H \\ -g_t + (1-\alpha)k_t^{\alpha}G_t^{1-\alpha} \text{ if } k_t > k^H \end{cases}, \tag{28}$$

where k^H is represented in Figure 6.

In both cases it can be observed that the capital accumulation equation is linear when k_t is below a threshold given by, respectively, $\hat{k}$ (Weak Mafia) and k^H (Strong Mafia), and concave when k_t is above the threshold. In this framework corruption occurs when k_t is below the threshold, and does not occur when it is above (see Figures 6 and 7).

Figures 8 and 9 represent the accumulation paths in the two cases. These figures are drawn for given values of $\hat{k}$ and k^H.

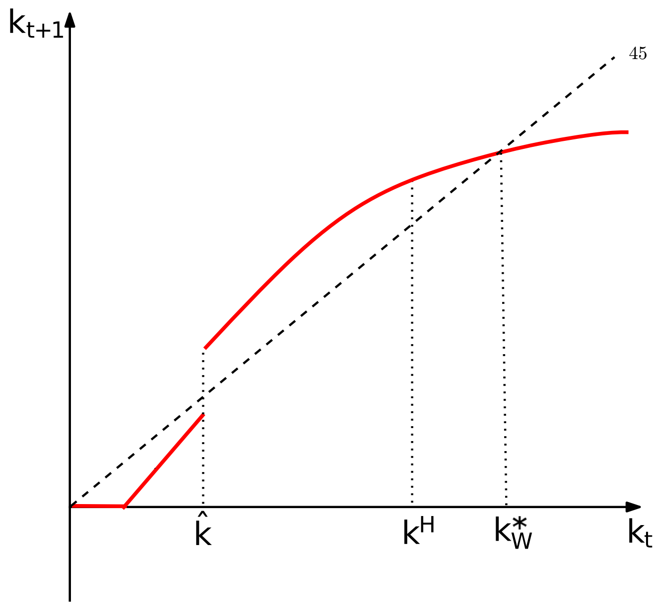

FIGURE 8 | Capital accumulation: Weak Mafia: $z < z_1$. [Color figure can be viewed at wileyonlinelibrary.com]

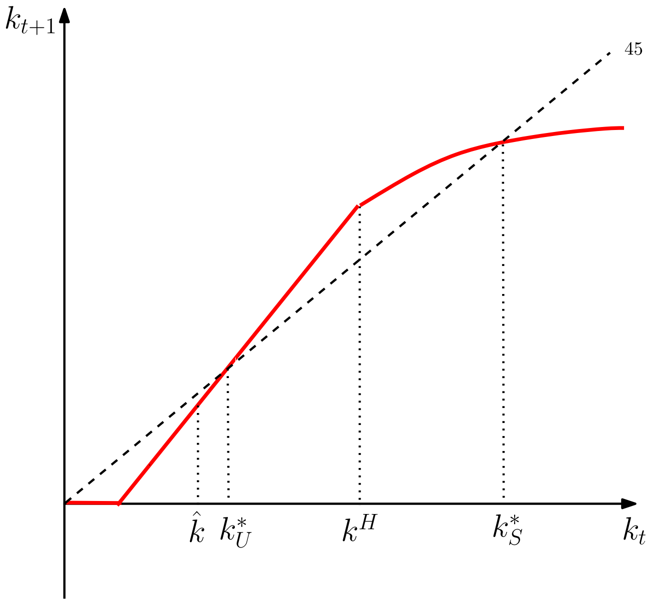

FIGURE 9 | Capital accumulation: Strong Mafia: $z > z_1$. [Color figure can be viewed at wileyonlinelibrary.com]

Figures 8 and 9 highlight that the accumulation process is characterized by multiple steady-state levels of k_t (and, therefore, of y_t): a low-income steady state at $k^*_L = 0$, and a high-income steady state level at k^*_W and k^*_S for the cases, respectively, of Weak Mafia and Strong Mafia. Figure 8 shows that the shift between basins of attraction occurs at a discontinuity in the accumulation path at $\hat{k}$, while Figure 9 shows that the shift occurs at the unstable equilibrium k^*_U given by the intersection of the 45° line and the accumulation path. An important implication of the growth dynamics represented in Figures 8 and 9 is that, *ceteris paribus*, an increase in the strength of the Mafia, proxied by z, increases the size of the basin of attraction of the low-income steady state from $(0, \hat{k}]$ to $(0, k^*_U]$.[33]

To sum up, the empirical implications of the theoretical model presented in this section are: (i) in economies where organized crime is strong (weak), corruption is more (less) likely. Figure 7, in fact, shows that with a strong (weak) Mafia, corruption takes place at any capital level (only at low capital levels); (ii) in presence of corruption orchestrated by organized crime, the growth dynamics is nonlinear and characterized by multiple steady states, with regions clustering at low/high GDP steady-states (see Figures 8 and 9); (iii) in economies where organized crime is strong (weak), the basin of attraction of the low-income equilibrium is larger (smaller). This implies that in such economies it is more likely that income persists at low levels (see Figures 8 and 9); and (iv) in economies where organized crime is strong (weak) the share of embezzled public expenditure is high (low). In such economies, in fact, capital is likely to be low (high) and, according to Equation (17), this implies that ϕ^* is high (low).

Our key empirical results, together with the stylized facts that motivated our analysis, are consistent with the theoretical model. In fact, Figure 3 in Section 3 is consistent with the empirical implication (i) by showing the correlation of corruption and extortion. The existence of different growth regimes identified by the empirical analysis of Section 5, namely by the different effect that public expenditure has on per capita GDP across regional clusters, are consistent with the empirical implication (ii). The empirical analysis even suggests that the marginal effect of public expenditure on per capita GDP can be negative where the Mafia is stronger, reinforcing the tendency for such economies to stay poor. As pointed out by Durlauf and Johnson (1995) we cannot, however, claim that the regimes identified in the empirical analysis are also identifying different steady-state levels, but just that they are consistent with their existence.[34] Figure 1 and the FA analysis of Section 5 are consistent with empirical prediction (iii), with the caveat mentioned for empirical prediction ii). Finally, the results in Table 2 are in line with prediction (iv). In the next section we draw some concluding remarks.

7 | Conclusions

We studied the case in which a criminal organization corrupts public officials by using threats and bribes to embezzle public funds, reducing in this way the growth potential of an economy. We proposed an econometric investigation of this hypothesis on a data set from Italian regions for the period 1996-2013. Our results suggest that the effect of public expenditure on per capita GDP differs across regions, and that the different levels of Mafia intensity at regional level are a key driver of this result.

The striking result, which represents a novelty with respect to the existing literature, is that in the regions where the Mafia is stronger the estimated effect of public expenditure on GDP is negative, suggesting that a strong presence of organized crime is associated to a lower efficiency in the use of the public resources allocated to productive uses. In addition, in those regions the estimated share of public expenditure embezzled by the Mafia is the highest, measuring approximately 10 % of the public expenditure book value. Differently, in regions characterized by lower levels of organized crime public expenditure appears to be utilized in a more efficient way, as the estimated coefficient of the effect of public expenditure on GDP is positive, and the size of the embezzled public money is estimated to be positive as well: a statistical implication of the estimation suggesting that in those regions the amount of public expenditure allocated to productive uses appears higher than its book value. As such, these results provide a novel perspective on the complex interactions that, over time, characterized organized crime, corruption and economic growth at regional level in Italy. In fact, the vast literature that explored the nexus between organized crime and corruption (e.g., Della Porta and Vannucci 2016) did not identify a relationship among these factors as in this work. For example, previous results such as Del Monte and Papagni (2001) identified an average positive effect of public expenditure on GDP growth in Italian regions and an average negative effect of corruption. Our results allow to clarify that, behind averages, there exist significant region-specific effects, driven by the different regional pervasiveness of organized crime.

Finally, we showed that the empirical results are consistent with a simple theoretical model that predicts a nonlinear growth dynamics that depends on the strength of the criminal organization, proxied by the intensity of the level of punishment the Mafia can impose on noncomplying bureaucrats. In this way we provided a theoretical support to the empirical findings.

Our results have important policy implications. First of all, in line with the literature of the effects of institutions at subnational level, our results suggest that the pervasive presence of organized crime and the corruption activities that thereby spread out, may represent a cause of the different efficiency of the formal institutions at subnational level in implementing policies aimed at promoting economic growth (Rodriguez-Pose 2013, 2020).

We argue that where mafias are strong, in particular, public policies based on public outlays can have little or no effect on economic growth. Previous research already criticized economic policies applied in the past in Italy aiming at reducing the gap in regional economic development, especially those based on the mobilization of public resources, for being ineffective (e.g. Alesina, Danninger and Rostagno 2001; Auricchio et al. 2020). Our results shed new light on these criticisms. In addition, our results raise concern on the effectiveness of the vast public expenditure program launched by the EU to assist countries to boost the recovery of their economies after the severe economic downturn induced by the the COVID pandemic (see Fabbrini 2022, for a detailed analysis of the recovery plan for Italy, denoted as *Piano Nazionale di Ripresa e Resilienza* (PNRR), and Aresu, Marrocu and Paci 2023, for similar conclusions of an analysis of the effect of public capital on value added in Italian regions). Specialized anti-mafia authorities already drew their attention to the fact that criminal organizations might actually try to divert part of this huge amount of funds from its productive uses (see Ministero dell'Interno 2023; Europol 2023).

In light of the results of this article, on the one hand, controls on the allocation of public funds in regions in which criminal organizations are strong should be all the more intense. Recent developments of the Italian law on the adjudication of public contracts seem to go in the right direction, for example with the introduction of centralized regional bodies (*Stazione pubblica appaltante*) for the the adjudication processes, or with the requirement of more transparency of the contractor with respect to its financial transactions (see Lavezzi 2014 for more details). On the other hand, however, our results suggest that one of the main tools of improving the efficiency of the public sector in implementing pro-growth policies based on public outlays in Italian backward regions is the contrast to organized crime, which still remains a key policy intervention to favor the transition of such regions towards a virtuous development path and increase regional resilience.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available in Mario Lavezzi Homepage at https://sites.unipa.it/mario.lavezzi/. These data were derived from the following resources available in the public domain: - istat, https://www.istat.it/ - Italian Ministry of Finance (MEF), https://www.rgs.mef.gov.it/ - National Agency of Confiscated Goods (ANBSC), https://benisequestraticonfiscati.it/

Endnotes

[1] In this article, we use the terms organized crime and Mafia as synonyms.

[2] The Sicilian Mafia (*Cosa Nostra*) is a prominent case of this type of criminal organizations. See Gambetta (1993) for details and for an account of its origins.

[3] Other works show that organized crime may have another negative economic effect, namely a depressive effect on real estate values and rents. See Battisti et al. (2022); Calamunci et al. Ferrante and Scebba (2022, 2023); Boeri et al. (2023).

[4] The number of reported extortion crimes and corruption crimes are expressed per 100,000 inhabitants. Data are from ISTAT, the Italian National Statistical Institute. See Section 4 for details.

[5] The estimated elasticities from the bivariate regressions in Figures 1 and 2 are, respectively, −0.97 (p-value 0) and −0.62 (p-value: 0.054). The relationship between other proxies for organized crime (per capita number of mafia homicides, mafia association, confiscated estates, voluntary homicides) and per capita GDP is still negative and significant. In our econometric analysis we will utilize an indicator that takes into account all of these crimes. We defer the reader to Sections 4 and 5 for details on data and methods for the estimation of Mafia intensity across regions.

[6] The estimated elasticity from the bivariate regression represented in Figure 3 is 0.57 (p-value 0.02). The remark in Footnote 5 on the use of other proxies of organized crime applies here: the correlation is positive and significant for all measures of crimes, with the exception of confiscated goods.

[7] GDP, investment and public expenditure are evaluated at year 2000 prices. The source of data on public expenditure is: "La spesa statale regionalizzata" (various years). The selection of the time period is dictated by the availability of homogenous data on public expenditure, as after 2013 the criteria for their collection changed.

[8] Specifically, we utilize the number of corrupt activities reported to the police per 100,000 inhabitants, utilized in Del Monte and Papagni (2007) and Lisciandra and Millemaci (2017).

[9] In Appendix C we present the results from an alternative approach that could be developed starting from Equation (1). Namely, we consider a panel estimation of a classic error-in-variable model, in which different types of IV are utilized. One key difference with respect to the results presented here is that the Mafia is assumed to have an effect on public expenditure that is not region-specific. The results show that, in fact, residual heterogeneity still persists even with the use of different instrumental variables, making the approach presented in the main text preferable.

[10] For each mafia-related indicators we considered the number of these indicators per 100.000 individuals, and then normalized each value to have zero mean and unit variance.

[11] See Putnam (1992) on the differences in social capital or Calderoni (2011) on the different levels of Mafia penetration across Italian regions and provinces.

[12]For the computational details see Aitkin and Rocci (2002), and Alfò, Trovato, and Waldmann (2008).

[13]The number of clusters has been identified according to the BIC criterium, which implied a minimum value of clusters between 4 and 5. We considered four clusters as the fifth was only a division of a cluster of three regions in two, with one cluster containing only one region (Abruzzo).

[14]The work of Pinotti (2015b) estimates the effect of organized crime on GDP by focusing on the regions of Apulia and Basilicata.

[15]Our analysis at regional level may overlook the fact that, in Italy, there exists heterogeneity in the presence of organized crime at provincial level that might be missed by an analysis at regional level (Dugato, Calderoni, and Campedelli 2020, even provide a measurement of organized crime at municipal level). In addition, our analysis might suffer from over-reliance on a specific way of measuring organized crime. In Appendix E we presente the results of a different clustering approach based on provincial data, encompassing in particular a different way of measuring organized crime. We show that the clustering obtained in this way is highly consistent with the one based on regional data in our main empirical analysis.

[16]The implementation of the empirical model presented in this paper could be expanded in two ways: i) by considering a dynamic model, to considers the evolving nature of organized crime and its adaptability to anticorruption measures; ii) by employing spatial econometric techniques to take into account interregional influences and spillovers effects. These aspects are left for future research.

[17]Indeed, the members of Mafia groups typically act as a monopolistic power over a territory, rather than independently (Schelling 1984).

[18]That is, we assume that a fraction of public spending is predetermined, for example teachers' wages, and cannot be embezzled.

[19]The aim of this assumption is to define the wages of the bureaucrats in a relatively simple manner, avoiding the need to make additional assumptions about the structure of the labor market and consequently about the wage structure in the public and private sectors (see Pagani 2003).

[20]A well-known characteristic of the "Mafia trademark" is, in fact, the use of violence and intimidation (see Gambetta 2009 and Dal Bò, Dal Bò, and Di Tella 2006).

[21]For simplicity we assume that punishment is inflicted with certainty to noncompliant bureaucrats.

[22]Taken together, this assumption and the one on certainty of Mafia punishment for bureaucrats refusing corruption implies that Mafia is more efficient than the State in inflicting a punishment, which corresponds to the perception that most citizens have in territories in which Mafias operate (see Lavezzi 2014, for a discussion of this point).

[23]In fact, simple calculations show that $\partial y_t^B/\partial\phi > 0$ if $\phi < 1 - [(1-\alpha)^2/\theta G_t]^{1/\alpha} k_t/G_t)$.

[24]In actual circumstances organized crime revenues come from various activities such as drug trafficking, money laundering, extortion of legitimate firms, exploitation of prostitution, etc. (see Calderoni 2014, for a discussion). For simplicity, we abstract from this aspect.

[25]This assumption aims at capturing a feature of the Italian Penal Code (art. 416bis), according to which membership of a criminal organization of Mafia type is a crime in itself. We are assuming that Mafia membership is detected if a corruption deal is detected.

[26]Balletta and Lavezzi (2023) argue that the take-it-or-leave offer from the Mafia better represents the case in which the Mafia extorts individual firms.

[27]In previous arrangements, entrepreneurs autonomously put in place collusive agreements to regulate access to resources that were allocated through public tenders, often shielded by political or bureaucratic protection. In practice corruption and collusion mutually supported each other: if the cartel of companies asked for protection services to corrupt politicians and bureaucrats, the latter, having as sole interlocutor the referents of the cartel, could share with them the highest income that its presence ensured. On the other hand, the interaction between organized crime and firms simply implied the latter had to pay the "pizzo" (i.e., protection money) to the Mafia, but the role of the Mafia extended neither to other services nor to the regulation of award mechanisms (see Della Porta and Vannucci 2016; Fazekas, Sberna, and Vannucci 2022).

[28]Angelo Siino was known in the eighties as the "minister of public works" of *Cosa Nostra*, and was in charge of maintaining relations with the public administrations for the definition of bribes on public procurement. In the 1990s Mr Siino became one of the main State witnesses in anti-mafia investigations.

[29]For simplicity, in this work we abstract from the role played by a cartel of firms in this bargaining process, which certainly represents an interesting direction for further research (see Gambetta and Reuter 1995, for more discussion on firms' cartels and organized crime).

[30]If we assumed a more complex labor market structure, characterized, for example, by wage inequality in the public sector, then we could have a different scenario in which higher salaries in the public sector might be associated with greater corruption (see Demirgüç-Kunt, Lokshin, and Kolchin 2023; Foltz and Opoku-Agyemang 2015). This is an interesting aspect that, however, goes beyond the scope of the paper and we leave it for future research.

[31]The literature pointed out that an economy with a large public sector is fertile ground for the spread of organized crime (Lavezzi 2008).

[32]In Appendix F we show that the case characterized by $\mathrm{TS}(0) > \mathrm{OP}(0)$ and $\mathrm{TS}(k_H) > \mathrm{OP}(k_H)$, i.e. with two intersections between the $TS(k_t)$ and $OP(k_t)$ curves cannot occur.

[33]This is the case as, from Equation (28), we see that the vertical intercepts of both the linear and the concave parts of the growth path are identical and equal to $-g_t$. Given that k^H is greater than $\hat{k}$ by construction, the linear part must necessarily cross the 45° line to the right of $\hat{k}$, which implies an increase of the basin of attraction of $k_L^* = 0$.

[34]Lavezzi (2008) and Balletta and Lavezzi (2023) provide evidence and theoretical insights that, in the case of Sicily, organized crime might actually be responsible of pushing the region into a poverty trap, i.e. a low-income stable steady state. Further research is however needed to prove that this can be the case of other regions by exploring the relevant channels, as the corruption-organized crime nexus that we highlight in this work.

[35]See Lavezzi (2014) for details on Mafia activities and on its social embeddedness.

[36]FA methods are statistical tools able to summarize information from a multiplicity of indicators into a few weighted indicators (factors), capable of preserving the useful information of the original set of indicators. The new estimated variables are composite orthogonal indices, uncorrelated with one another, but representative of the indicators that the coefficients represent, i.e. they explain the total variance of the original variables. In sum, starting from a set of indicators that measure a certain phenomenon, FA obtains a single variable (or more, but in any case, a strictly lower number than the original number of indicators) that describes the common information contained in the set of the original variables.

[37]We consider the overall number of homicides as exact imputation of an homicide to criminal organizations cannot be always guaranteed. Indeed, Pinotti (2015b, p. F209) shows that the overall number of homicides can be a good proxy for the intensity of Mafia activities. See also Brancaccio (2019, p. 73) for a similar remarks on the homicides by the *Camorra*, the Neapolitan mafia.

[38]Lewbel (2012) shows that the model parameters could be identified also when heteroscedasticity is present, or when v_{it} and e_{it} are correlated.

[39]The models in Table A4 are estimated with robust standard errors. We also estimated an error-in-variable model without a direct effect of Mafia on per capita GDP, results are consistent with those presented here and are available upon request.

[40]In the estimation we drop the intercept to avoid the aliasing effect between dummies and the constant, and consider Cluster 3 as the reference cluster.

[41]The GMM is a probabilistic model that assumes all the data points are generated from a mixture of several Gaussian distributions with unknown parameters. This approach allows us to model the presence of subpopulations within our overall population without requiring prior knowledge of the subpopulation to which an observation belongs (for a review on Mixture models and GMM see McLachlan and Peel 2000).

[42]See www.transcrime.it.

[43]Our data set on public expenditure does not contain a breakdown of data at provincial level, so that we cannot use such data in this clustering exercise.

[44]Cluster 5 also contains Latina, a province from Lazio with high levels of organized crime activities, (see Table 2 in Ministero dell'Interno 2013, for details).

[45]In this comparison, a region is assigned to a cluster in Table A9 if it has a relatively high number of provinces in that cluster. For example, Lombardia is assigned to Cluster 2, and so on.

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Appendix A

Descriptive Statistics

Table A1 contains average regional values of the relevant variables utilized in the empirical analysis, and the values of the indicators of Mafia activity (four crimes and an indicator of confiscated goods) utilized to build the Mafia index in 1996.

TABLE A1 | Descriptive statistics.

Region	GDP	Publ. Exp./Pop.	Mafia Hom.	Vol. Hom.	Extort.	416bis	Confisc. Goods
Abruzzo	2494.634	5319.334	0	0.022	0.003	0.004	0
Basilicata	2029.332	5608.33	0.003	0.015	0.014	0.014	0.01
Calabria	1744.024	5364.581	0.154	0.257	0.327	0.198	0.33
Campania	1901.603	5149.245	0.485	0.507	0.072	0.279	0.07
Emilia Romagna	3518.279	5153.53	0.001	0.106	0.004	0.019	0
Friuli Ven. Giu.	3179.326	8534.143	0.001	0.024	0.001	0.006	0
Lazio	3595.865	8429.942	0.004	0.164	0.035	0.043	0.03
Liguria	4145.817	8114.495	0.001	0.047	0.008	0.006	0.01
Lombardia	3809.978	5885.889	0.004	0.273	0.025	0.023	0.02
Marche	2791.106	4584.213	0.002	0.025	0.001	0.004	0
Molise	2185.364	5571.764	0.000	0.007	0.001	0.002	0
Piemonte	3127.11	5338.888	0.004	0.123	0.011	0.009	0.01
Puglia	1843.014	4886.079	0.084	0.204	0.105	0.117	0.1
Sardegna	2088.239	6780.603	0.001	0.105	0.007	0.001	0.01
Sicilia	1879.332	5927.205	0.137	0.322	0.256	0.417	0.26
Toscana	3074.376	5093.325	0.002	0.088	0.001	0.016	0
Trentino Alto Adig.	4002.127	5790.114	0.000	0.015	0.000	0.002	0
Umbria	2741.42	5260.567	0.000	0.020	0.000	0.002	0
Valle DAosta	3831.536	13124.06	0.000	0.005	0.000	0.001	0
Veneto	3091.69	4050.749	0.001	0.095	0.014	0.012	0.01

Note: GDP = Per Capita GDP, (ISTAT, average values, 1996:2013). Publ. Exp./Pop. = Total Expenditure/Population, (Ministry of Interior, ISTAT, average values, 1996:2013). Mafia Hom. = Homicides due to Mafia activities (Values per 100,000 inhabitants, ISTAT, year 1996). Vol Hom. = Voluntary homicide (Values per 100,000 inhabitants, ISTAT, year 1996). Extort. = Extortions (Values per 100,000 inhabitants, ISTAT, year 1996). 416Bis = Mafia association, Article 416 − bis of the Penal Code (Values per 100,000 inhabitants, ISTAT, year 1996). Confisc. Goods = Goods confiscated to the Mafia (Values per 100,000 inhabitants, Ministry of Interior, year 1996).

Appendix B

The Measurement of the Mafia

In this article, we assume that a Mafia can distort public decisions on public expenditure. However, although we have some concepts of what a "Mafia" is, and we can theoretically define its consequences on economic activities, we cannot directly measure its "level." We know that a Mafia combines some violent and "social" activities,[35] but a true measure of Mafia remains latent and unobservable. Our choice, in line with the literature (e.g., Calderoni 2011) is to measure the Mafia level in a region through an index obtained from a Factor Analysis (FA) based on official data on Mafia-related offenses and activities, as recorded by police forces and the judiciary. This choice has been made to avoid specific empirical conjectures on what a Mafia really is.

The main advantage of FA is that a (potentially) single estimated scale measurement index allows measuring a complex or latent phenomena, such as the strength of a Mafia over a territory. Here we assume that the presence of Mafia in the Italian regions is an unobservable factor (i.e. a "latent variable") which can be explained by a set of observable variables such as those related to the Mafia-related offenses.[36]

Tables B1 and B2 contain the results from the FA on a set of indicators of organized crimes activity: homicides directly imputable to organized crime, overall number of homicides, extortion, Mafia association (art. 416bis of the Italian penal code),[37] confiscated goods. Tables B1 and B2 show that the FA identifies one Factor, that will be used as a synthetic Mafia Index at regional level, to be utilized in the econometric analysis of Section 5.

Tables B1 and B2 show that the first factor explains approximately 80% of the variance of the set of chosen variables measuring Mafia crimes, while the other factors have only a marginal correlation with the measures. For this reason we keep the first Factor as representing Mafia intensity in each region in 1996.

TABLE B1 | FA: Factor loadings.

Variable	Factor 1	Factor 2	Factor 3
Mafia homicides	0.8671	−0.2052	0.0327
Homicides	0.8397	−0.2029	−0.0494
Extortion	0.6679	0.0762	0.0852
Mafia association	0.8475	0.1566	−0.0156
Confiscated goods	0.8255	0.1996	−0.0369

TABLE B2 | FA: Correlation matrix, unrotated factors.

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor 1	3.88	3.27	0.777	0.777
Factor 2	0.611	0.296	0.122	0.899
Factor 3	0.315	0.201	0.063	0.962
Factor 4	0.114	0.038	0.023	0.985
Factor 5	0.0758	.	0.015	1.00

Appendix C

Estimation of an Error-In-Variable Model

In this section we present an alternative econometric approach, starting from Equation (1). Specifically, we abstract from the possibility that the Mafia has region-specific effects, i.e. we assume that the latent variable capturing the effects of the Mafia symmetrically affects regional public expenditure levels.

Therefore, we consider the following system of equations, corresponding to a classic error-in-variable model:

$$\ln(y_{\text{it}}) = \alpha + \beta_g \ln(\bar{g}_{\text{it}}) + v_{it} \tag{29a}$$

$$\ln(g_{it}) = \ln(\bar{g}_{\text{it}}) + \psi m_i + e_{\text{it}} + u \tag{29b}$$

where y_{it} denotes per capita GDP, $\bar{g}_{it}$ the actual public expenditure allocated to production after Mafia embezzlement. In the system of Equations (29a) and (29b) only $\ln(y_{it})$, $\ln(g)_{it}$ and m_i are known. In particular, the observed public expenditure $\ln(g_{it})$ is composed of the true, but unobserved, component $\ln(\bar{g})_{it}$ plus the measurement error term u that in this specification directly and symmetrically influences the different regional public expenditure levels. To take into account that a share of public expenditure is subtracted by the Mafia, in Equation (29b), we introduce the term ψm_i, expecting that $\hat{\psi} < 0$.

From Equations (29a) and (29b), it is possible to obtain the following specification:

$$\ln(y_{it}) = \beta_0 + \beta_g \ln(g_{it}) + \beta_m m_i + \epsilon_{it} \tag{30}$$

where $\beta_0 = \alpha - u^*\beta_g$, $\beta_m = -\beta_g{}^*\psi$ while the overall error term $\epsilon_{it} = v_{it} - \beta_g{}^* e_{it}$ is assumed to be distributed as $N(0, \sigma)$.[38] Notice that in Equation (30) Mafia directly affects GDP. As a matter of fact, there might be multiple channels though which organized crime affects output (Pinotti 2015a) and, therefore, assuming a direct effect of Mafia on GDP could also represent a way to take this into account.

Table C1 reports the results of the panel FE-IV and GMM estimations of Equation (30), in which we follow Lewbel (1997, 2012) to construct instruments based on data transformations. The Lewbell's method uses instruments orthogonal to the response variable when no additional information is available from the data, or it is difficult to implement a model to correlate instruments with an unobserved variable, as the level of a Mafia could be.[39]

Table C1 contains the results of two specifications of a Panel FE-IV model and of a GMM model with Continuously Updated Estimates (which is more robust to heteroscedasticity, see Kleibergen 2005, and Caner 2009), in which the choice of the instruments differ (see the bottom part of Table C1). Results in Table C1 are not univocal. In particular, in Models (1), (2) and (3) the coefficient for public expenditure, the estimated β_g in Equation (30), does not have a statistically significant influence on per capita GDP, while in Model (4) public expenditure appears positively correlated with the level of per capita GDP.

The parameter $\hat{\beta}_m$, related to the Mafia Index, is significant and negative in all models. This would suggest that the Mafia has a direct, negative effect on GDP, a result that could be in general expected from the stylized fact in Figure 1, from Figure 4, and from the existing literature on this topic (Pinotti 2015a). However, from the specification of Equation (30), β_m measures the combined effect of "true" public spending on GDP and of Mafia activity. In addition, the direct effect of β_g on GDP is also partially captured by the intercept, as β_0 includes both the homogeneously distributed measurement error u and β_g itself.

Overall, results in Tables C1 suggest that we are facing a model uncertainty problem: almost all the implemented tests for the orthogonality and the endogeneity of instruments (the Sargan-Hansen test for panel IV and the Jensens test for GMM) for all the estimated model specification do not have power to reject the null assumptions, while the under-identification test suggests that we may reject the null assumption of a non-identified model. Looking at the Kleibergen-Paap weak instrument test, we can reject the assumption of a low correlation between instruments and covariates.

TABLE C1 | Panel Instrumental variable results.

Dep. var. log of per capita GDP	Panel FE-IV 1 (1)	Panel FE-IV 2 (2)	Panel GMM-CUE 1 (3)	Panel GMM-CUE 2 (4)
$\ln(g)_{it}$	0.0479	0.1052	−0.0171	0.0315**
	(0.0456)	(0.0641)	(0.0115)	(0.0140)
m_i	−0.5352***	−0.5251***	−0.6700***	−0.6211***
	(0.1096)	(0.1070)	(0.1180)	(0.1086)
Constant	7.6139***	7.1322***	8.2556***	7.7798***
	(0.4050)	(0.5606)	(0.1195)	(0.1278)
Year and region FE	YES	YES	YES	YES
Exogeneity test				
Davidson–Wu–MacKinnon test for $\ln(g)_{it}$ and m_i				
	1.992	0.280	1.992	0.280
$(P - value)$	(0.3694)	(0.8692)	(0.3694)	(0.8692)
Underidentification tests				
Kleibergen–Paap LM $\chi^2(3)$	18.658	18.992	18.658	18.992
$P - value$	(0.000)	(0.000)	(0.000)	(0.000)
Weak-instrument-robust inference				
Kleibergen–Paap Wald F	39.113	189.149	39.113	189.149
Stock-Yogo critical values				
5% maximal relative bias	13.91	16.85		
10% maximal size	9.08	10.27		
LIML maximum critical value			4.36	5.44
Overidentification test				
Sargan–Hansen–Jensen	4.952	189.149	3.979	5.622
$(p -$ value$)$	(0.084)	(0.172)	(0.137)	(0.131)
Orthogonality Statistics for m_i				
Hansen J statistics	1.089	4.812	1.069	4.986
$(p -$ value$)$	(0.297)	(0.090)	(0.301)	(0.083)
Sargan C Statistic	3.864	0.184	2.910	0.636
$(p -$ value$)$	(0.0493)	(0.668)	(0.088)	(0.188)
Test for Normal Residuals				
Pagan–Hall(p-value)	(0.006)	(0.004)	(0.007)	(0.004)
Shapiro–Wilk(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
R-squared	0.9986	0.9986	0.9986	0.1840
Regions	20	20	20	20
Observations	360	320	360	320
Sig. levels: *0.10, **0.05, ***0.001, robust s.e. in parentheses.				
Instruments	m_i, q vector as in Lewbel (1997, 2012).	m_i, q vector as in Lewbel (1997, 2012) and second-order differences of covariates.	m_i, q vector as in Lewbel (1997, 2012).	m_i, q vector as in Lewbel (1997, 2012) and second-order differences of covariates.

Although the implemented models to some extent might represent a good representation of the effects of interest, the estimated parameters (both in magnitude and sign) are not stable across specifications with different instruments (in particular from from Model (1) to Model (2) for FE-IV estimations). In other words, these results do not help us to discriminate among models.

In addition, for all the models implemented in Table C1, the Shapiro-Wilk and Pagan-Hall tests (robust for heteroscedasticity) reject the null hypothesis of Gaussian residuals at 5% significance level. The main consequence of the results of these tests is that, in addition to model uncertainty, the significance of the estimated parameters is also uncertain, as the standard errors might be biased.

Appendix D

Goodness-of-Fit of the Finite Mixture Model

Table D1 contains the Shapiro test on residuals for the Finite Mixture Model (FMM) model showing that for all implemented model we cannot reject the assumption of normally distributed residuals.

Furthermore, Figure D1 allows to assess the goodness of fit of the covariate measurement model estimation. The rootograms compare the empirical frequencies with the estimated frequencies of units to belong in a cluster. As we can see, the observations in the sample have been clustered in a satisfactory way. This is also confirmed by looking at the top right panel of Figure D1 reporting the observed and fitted values. This panel highlights that the regions in the clusters are well identified. In addition, by looking at the cumulative distributions functions in the bottom left panel, we can see that the predicted values of our model can well replicate the observed values of the dependent variable, differently from a simple linear model estimated by OLS-FE. Finally, the histogram of residuals confirms that the results of the Shapiro tests of normally distributed residuals in Table D1.

To further assess whether the information obtained from the partition of the Italian regions into clusters is effective in reducing heteroscedasticity and unobserved heterogeneity, we estimate a simple pooled OLS regression of log GDP on public expenditure, interacting public expenditure with cluster dummies and the Mafia Index variable (with robust standard errors).[40]

Table D2 contains the results, providing support to the following intuition: covariates and clusters are significant, while the effect of public expenditure once corrected for the "Mafia effect" is negatively related to per capita GDP, the same for the effect of public expenditure. The OLS results confirm that public expenditure in Cluster 1 has a negative influence on GDP, while for the others the effect is positive. Moreover, the average effect of the public expenditure is not significant. The effect of Mafia via public expenditure ($\ln(g)_{it} * m_i$) is negative as in the estimated models of Section 5.

Finally, Figure D2 shows the high capacity of the estimation to predict the values of per capita GDP, by comparing fitted and actual per capita GDP values, and the distribution of the residuals, showing that we cannot reject the assumption of normally distributed residual as the Shapiro–Wilk test in Table D2 suggests.

TABLE D1 | Shapiro–Wilk Test on Residuals (p − value).

Models		$K == 1$	$K == 2$	$K == 3$	$K == 4$
A	Output model Residuals	0.63538	0.33615	0.34445	0.83298
	Measurement Model Residuals	0.1227	0.19456	0.74194	0.8433
B	Output model Residuals	0.94752	0.92331	0.30938	0.94679
	Measurement Model Residuals	0.10068	0.20269	0.74421	0.84509

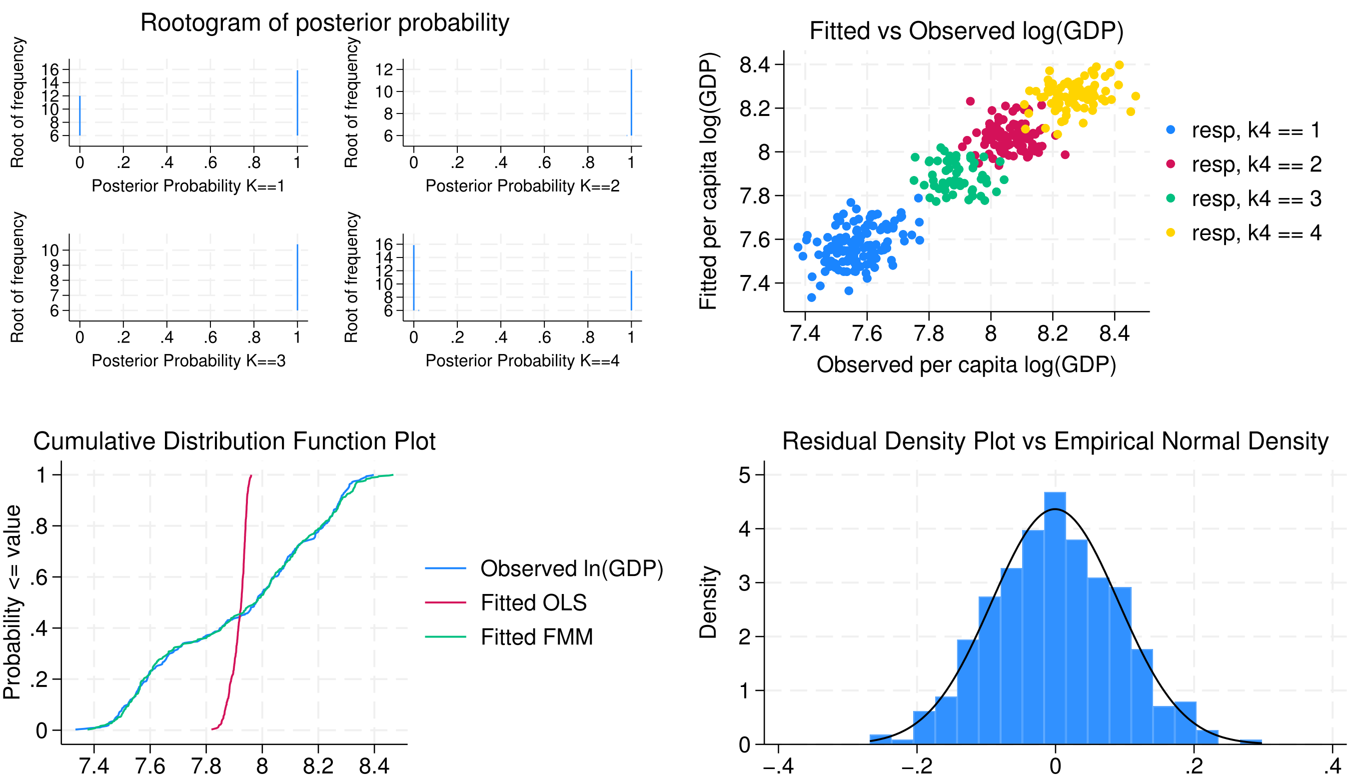

FIGURE D1 | Goodness-of-fit: Finite mixture model (FMM), Model A.

TABLE D2 | OLS estimation of the effect of public expenditure on GDP with cluster dummies.

Dep. var. log of per capita GDP	$\hat{\beta}$
	−0.029***
	(0.005)
	0.023***
	(0.005)
	0.046***
	(0.005)
	−0.055
	(0.065)
	−0.017**
	(0.005)
	8.360***
	(0.548)
N	360
Shapiro Wilk	0.994
Pvalue	0.211
R^2	0.96

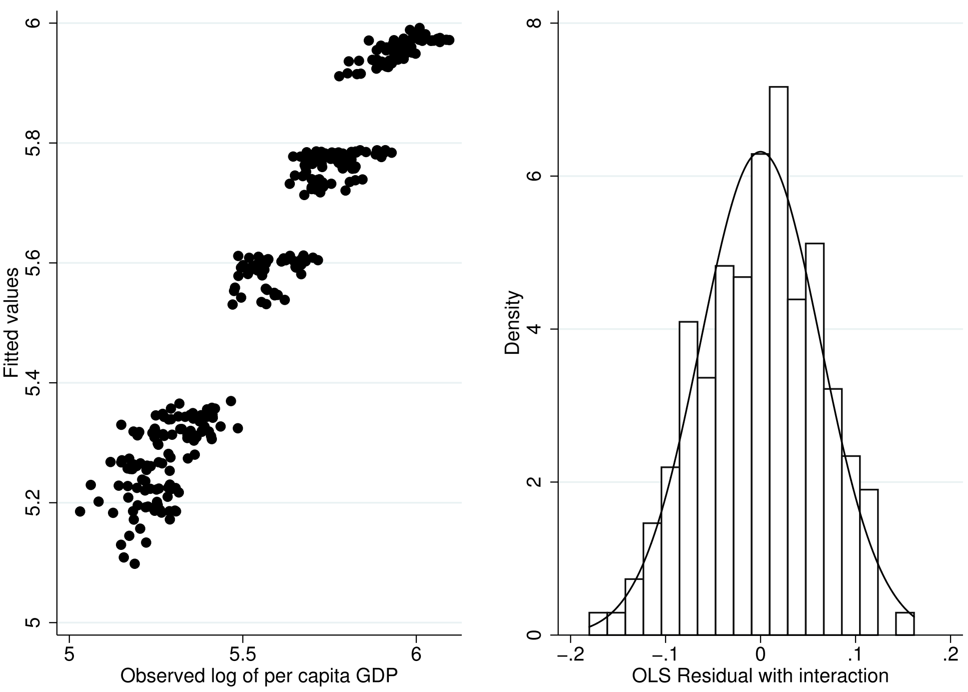

FIGURE D2 | Goodness-of-fit: OLS with Interaction.

Appendix E

Clustering at Provincial Level

Our approach can have two important limitations. Since we use data at the regional level, some doubts could arise due to the intra-regional heterogeneity in the presence of organized crime. Our NUTS-2 level data, in fact, may obscure the fact that organized crime is a heterogeneous phenomenon within the same region. For example, regions in the South of Italy include provinces where the incidence of Mafia is relatively low, while at the same time organized crime infiltration is also present in some areas of Northern Italy (e.g. Calderoni 2011). In addition, the measurement of the Mafia intensity can depend on the specific indicators we chose to perform the FA analysis.

To address these aspects, in this appendix we present the results of a different clustering procedure in which we consider data at provincial level and a different indicator of Mafia intensity. Specifically, we perform an unsupervised clustering of Italian provinces using a Gaussian Mixture Model (GMM).[41] In this exercise we consider the variable *MI* as a Mafia indicator, from Ministero dell'Interno (2013). The variable MI is based on a methodology developed by the research center *Transcrime*[42] and represents an updated version of the index proposed by Calderoni (2011). MI is a cross-section index built from the following indicators: Mafia homicides (2004–2011, from Italian Minister of the Interior); Mafia association crimes (2004–2011, from Italian Minister of the Interior); municipalities dissolved for Mafia infiltration (2000-2012, from ANBSC; number of active Mafia groups as from DIA reports) (see Ministero dell'Interno 2013, p. 26, for details). Given that, therefore, the period covered by *MI* is 2004–2012, we consider a posterior measure of economic activity to minimize potential endogeneity in the relationship, as we did in the main text by selecting the value of the Mafia index in 1996. Specifically, we consider data on Provincial value added in 2021 (the most recent available data from ISTAT), where provinces are indexed by $i = 1, ..., 95$ (NACE 3).[43] Applying the GMM clustering procedure to these data, returns five clusters of provinces, listed in Table E1.

Figure E1 shows that the relationship between provincial Value Added and the Mafia Index mirrors the pattern observed between regional per capita GDP and our measure of Organized Crime (see Figure 4).

In Figure E1 we see that provinces with the highest Mafia Index values tend to have the lowest GDP levels. However, a more nuanced picture emerges as we examine provinces with lower Mafia levels. To gain a clearer understanding, let us note that Clusters 1 and 5 include provinces with the lowest levels of Value Added. Cluster 1 contains provinces from the Southern regions of Sicily, Campania and Calabria (plus Bari, from Puglia) and exhibits the highest average Mafia Index value (40.84), while Cluster 5 shows the third-highest Mafia Index value 8.22. (see Table E2). Interestingly, Cluster 5 contains the Sicilian and Campanian provinces with a relatively lower level of MI, respectively: Enna, Ragusa and Siracusa, and Avellino and Benevento. Still, these levels of MI are higher than in most of the remaining provinces.[44]

Clusters 2 and 3 contains provinces from Central-Northern regions, and show the lowest levels of the mafia index and relatively high (average) levels of value added. Provinces in Cluster 4, have the highest value of (average) value added, as they include for example Rome and Milan. On the other hand, the Mafia index is somewhat higher than in provinces with lower value added. This is consistent with the position of the regions of Lazio and Lombardy in Figure 4. In summary, the GMM clustering technique appears to confirm that low levels of Value Added are more closely associated with high levels of Mafia activity. However, low Mafia levels alone are not sufficient to guarantee higher economic activity, as in Figure 4.

Table E3 highlights how provinces are grouped across different clusters for the different regions.

TABLE E1 | GMM provincial level clusters.

Cluster 1	
	Agrigento Bari Caltanissetta Caserta Catania Catanzaro Crotone Foggia
	Messina Napoli Palermo Reggio Calabria Salerno Trapani Vibo Valentia
Cluster 2	
	Alessandria Ancona Aosta Arezzo Asti Belluno Bergamo Biella Cagliari
	Campobasso Chieti Cremona Cuneo Ferrara Forli'-Cesena Gorizia Grosseto
	Isernia Livorno Lodi Lucca Macerata Mantova Nuoro Oristano Padova
	Pavia Pescara Pisa Pistoia Pordenone Ravenna Rieti Rovigo Sassari Siena
	Sondrio Teramo Terni Trento Treviso Udine Venezia Vercelli Verona
	Vicenza Viterbo
Cluster 3	
	Bologna Brescia Como Frosinone Lecco Modena Parma Perugia Piacenza
	Prato Rimini Savona Trieste Varese
Cluster 4	
	Firenze Genova Imperia Milano Novara Roma Torino
Cluster 5	
	Avellino Benevento Brindisi Cosenza Enna Latina Lecce Matera Potenza
	Ragusa Siracusa Taranto

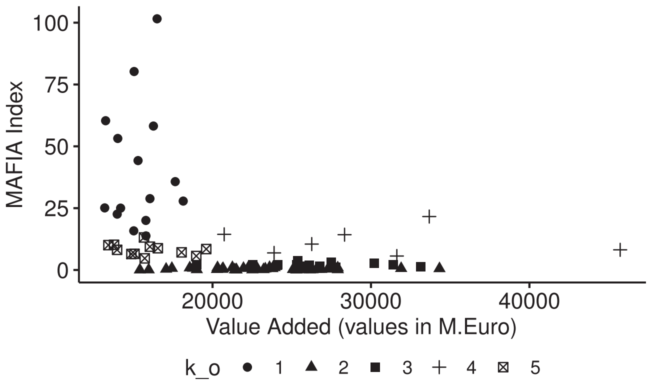

FIGURE E1 | GMM Clusters: Value added versus Mafia Index.

Calabria and Sicily show a significant presence in the Cluster 1, with Calabria having 4 occurrences and Sicily having 6. Lombardia and Toscana appear most frequently in the Cluster 2, with 6 and 7 occurrences, respectively. Emilia Romagna and Lombardia also show a strong presence in Cluster 3, while Lazio and Liguria have more scattered occurrences across different Clusters, indicating a more diverse or balanced representation across Value Added and Mafia index distributions. Finally, some regions such as Basilicata and Puglia, have provinces only in Cluster 1 or Cluster 5. Overall, the table suggests that provinces in certain regions have strong, distinct patterns, while others are more evenly distributed across different clusters.

TABLE E2 | Value added and mafia index: Clusters specific mean values.

Clusters	1	2	3	4	5
Value added	15,348.63	23,488.71	26,352.34	30,036.17	15,979.52
Mafia index	40.84	0.445	2.13	11.64	8.22

TABLE E3 | GMM Provincial Level Clusters: aggregate for Italian regions.

Region	$K==1$	$K==2$	$K==3$	$K==4$	$K==5$
Abruzzo	0	3	0	0	0
Basilicata	0	0	0	0	2
Calabria	4	0	0	0	1
Campania	3	0	0	0	2
Emilia Romagna	0	3	5	0	0
Friuli Venezia Giulia	0	3	1	0	0
Lazio	0	2	1	1	1
Liguria	0	0	1	2	0
Lombardia	0	6	4	1	0
Marche	0	2	0	0	0
Molise	0	2	0	0	0
Piemonte	0	5	0	2	0
Puglia	2	0	0	0	3
Sardegna	0	4	0	0	0
Sicilia	6	0	0	0	3
Toscana	0	7	1	1	0
Trentino Alto Adige	0	1	0	0	0
Umbria	0	1	1	0	0
Valle dAosta	0	1	0	0	0
Veneto	0	7	0	0	0

To compare the classification based on regional data with the one based on provincial data, we conducted a synthetic test of similarities between clusters. Specifically, we used the Rand Index (Rand 1971), which measures the similarity between two clusterings by evaluating all pairs of samples and counting those that are consistently assigned to the same or different clusters in both the predicted and true clusterings. The test ranges from 0 (no similarity) to 1 (maximum similarity).

In our case we compare the classification based on Regional level using the Finite Mixture Covariate Measurement Error Models presented in Section 5.1 against the one based on provincial data using the Gaussian Mixture Model.[45] The test scores 0.68, which is a reasonably good result considering that: (1) The data involve different observational units (provincial vs. regional level); (2) the time horizons differ, with the provincial test using a cross-sectional approach (2004-2012 for the Mafia Index and 2021 for Value Added), while the regional model employs a longitudinal data for the period 1996–2013; (3) the provincial data lacks information on public expenditure, a crucial variable in the regional analysis for understanding the impact of mafia presence on GDP; and (4) the GMM clustering is unsupervised, while the clustering in the main text is based on the specification and estimation of some functional forms connecting the variables.

We conclude, therefore, that a different clustering exercise based on provincial data provides results that are largely consistent with the clustering of regions presented in the main text.

Appendix F

Proof of Proposition 1

From Equations (21) and (22) define k^{MIN} the level of k_t such that the two functions have the same slope, that is:

$$k^{\text{MIN}} = \frac{G}{p^{1/(1-\alpha)}(1-\alpha)^{2/\alpha}}. \tag{31}$$

Then the scenario characterized by two threshold levels of k_t such that if $k_t < k_1$ and $k_t > k_2$ then $\text{TS}(k_t) > \text{OP}(k_t)$ arises if $\text{TS}(k^{\text{MIN}}) - \text{OP}(k^{\text{MIN}})$. Given that $k^{\text{MIN}} > k^H$, this scenario never occurs in the range $k_t \in [0, k^H]$.