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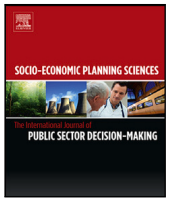

Mafia risk perception: Evaluating the effect of organized crime on firm technical efficiency and investment proclivity

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ABSTRACT

The presence of illegal organizations in economic development settings contributes to the Italian economy's regional heterogeneity by exacerbating other inefficiencies. We aim to investigate how three indicators of awareness of criminal interest in a firm's activities affect the latter's efficiency, as well as examining a potential channel through which illegal activities could hinder firm performance, using a unique set of firm-level data. According to our findings, the presence of criminal network pressure in a firm's environment reduces its technical efficiency and propensity to invest. This phenomenon is particularly strong in Italy's underdeveloped regions, across all illicit considered and risk classes, with inefficiency doubling when the fear of crime becomes significant. A similar pattern emerges in terms of firm investment proclivity. The research findings are relevant for policymakers because they demonstrate that even the perception of a criminal threat has significant effects on a firm's performance; consequently, enhancing legal protection could prevent significant economic and social costs.

1. Introduction

Organized crime poses a significant threat to economic growth, and even high-income countries are not immune to its impact on economic development. Italy is a prime example of this, as the failure of low-income regions to keep pace with the rest of the country can be largely attributed to the presence of organized crime. These criminal groups displace legal private capital, and also infiltrate direct public investment opportunities, thereby creating further opportunities for criminal activity [1]. Since the postwar period, illegal organizations have added to inefficiencies and contributed to regional disparities in the Italian economy. According to Pinotti [1], the economic costs of organized crime in southern Italy alone have led to a decline of at least 16% in GDP *per capita*. Additionally, the significance of criminal activity is considered a risk factor by companies when starting or continuing operations. As highlighted by Mocetti and Rizzica [2], Italy has the second-highest costs related to organized crime imposed on firms among EU countries.

The significance of this study lies in the economic and social implications of the perception of risk posed by criminal organizations. It is well known that the negative externalities of mafia presence on society operate through multiple channels, preventing backward regions from achieving virtuous development. Indeed, numerous studies have highlighted the importance of crime in explaining the shortfall in growth at the macroeconomic level (e.g., [3,4]). Equally, according to the literature on the economics of crime, firms operating within the law incur the burden of the mafia to the point that it conditions their performance [5–8], which can result in the company going out of business [9]. However, we have identified a gap in the existing literature on the economics of crime, since no study has explicitly examined the impact of mafia risk on technical efficiency. This gap likely results from the absence of granular data on crime perception indices. To address this issue, we have leveraged a unique dataset from a highly representative survey conducted by the Bank of Italy, which provides information on the three main crime perception risks faced by nearly 3,000 Italian industrial and service companies at an individual level. We have used a robust methodology (i.e., Stochastic Frontier Analysis — SFA) to relate data from the Bank of Italy on the following types of crimes to which a company is vulnerable: obtaining a loan outside official channels (i.e., usury), receiving an offer to sell the firm under unusual circumstances, and being the target of threats, intimidation, or extortion attempts. As a result, the efficiency of the firm has been directly related to either of these single crime indicators.

For each class of crime risk (not at all likely, unlikely, somewhat likely, very likely), we have identified potential interaction effects with geographical variables. Indeed, fear of organized crime is well known to have a significant impact on firm efficiency, even when the perceived risk is low. Specifically, this further analysis has assess ed whether interacting crime indicators, considered for each individual class, and

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four macro-regional variables allow for a more accurate identification of the effect crime risk has on firm efficiency.

Overall, the methodology enabled us to examine the potential spillover effects of organized crime on a firm's productivity, including impacts such as resource misallocation, higher production costs, issues in the supply chain, and deterioration of social capital.

One of the further aims of our study was to examine whether the negative consequences of crime perception, such as inefficiency, were associated with firms' investment decisions, particularly in relation to innovation and general investments. Prior research has shown that crime-damaged firms are less likely to engage in innovation [10]. Additionally, innovation intensity, as measured by patenting activity, has been found to be closely linked to law enforcement in both Italian provinces [11] and European regions [12], with weaker firms experiencing a stronger effect [13].

This paper contributes to the literature as it is the first to relate a measure of technical efficiency to the crime fear index. Ganau and Rodríguez-Pose [3],Albanese and Marinelli [14] are the closest studies, even if they correlate a raw measure of total factor productivity calculated at the firm level and an aggregate measure of crime index at the provincial level. Therefore, we adopt a more sophisticated measure of productivity as well as the crime fear metric at the individual level, thereby capturing the perception of organized crime more accurately. Our study offers insight into the consistent negative impact on the productivity proxy associated with widespread organized crime, suggesting that firms may be reluctant to invest in environments perceived as polluted by criminal activity. Our study aims to examine the potential negative impact of crime perception on R&D and total investment decisions by utilizing a large number of mafia risk indicators reported by a highly informative sample. According to our knowledge, prior research has not explored the relationship between crime perception and investment decisions.

The remainder of the paper is organized as follows. Section 2 examines the literature on the negative externalities of crime on economic activities. The explicative variables used to investigate the firm's efficiency and investment proclivity are reported in Section 3. The econometric technique applied is described in Section 4. Finally, Section 5 comments on the empirical findings, and Section 6 provides concluding remarks.

2. Background literature

The impact of mafia firms on the economy has been a topic of great interest across various fields of research, including sociology, political science, macroeconomics, and business studies. This section provides a review of the literature on the disruptive effects of organized crime on business productivity, with a particular emphasis on the economic perspective. In this regard, extensive research has demonstrated that crime damages economic activity by increasing costs and decreasing revenues (e.g., [5–8]). For instance, Besley and Mueller [8] modeled the need for firms to defend against criminal activity. Their empirical analysis revealed that bearing protection costs led to significant output loss as a result of misallocation of labor. Likewise, even when the *pizzo* racketeering demands are modest, mafia extortion results in massive resource misallocation for Northern Italian firms [15]. Other sources of distortion can be found in market structure and public resource allocation, as illegal organizations reduce market competition [16] and alter the awarding of public contracts by pursuing abnormal bidding discounts followed by cost overruns (see for instance: [17,18]). As demonstrated by Daniele and Dipoppa [19], criminal organizations employ strategic displacement tactics to evade anti-mafia laws and reduce the state's capacity to identify them. Moreover, mafia-connected firms are more tax aggressive and engage in downward earnings manipulation [20]. It is well known that one form of condition imposed by crime on the profitability and efficiency of a law-abiding firm is the requirement to purchase intermediate inputs at a higher price [14] or of a lower quality. The coercive power can also result in extraordinary trade credit terms that firms with mafia-affiliated top executives negotiate within the supplier relationship contract [21].

Equally, Mirenda et al. [9] analyzed the effects of mafia infiltration in the legal economy. Their study emphasizes that mafia firms entering the legal environment typically pursue an unusual short-term business strategy centered on "exploiting the firm and depleting its assets". Furthermore, Mirenda et al. [9] attributed the better performance of dishonest firms to money laundering or the use of threats, violence, and corruption to dominate the market and secure public contracts, and this is especially evident within the construction industry. Indeed, Ferrante et al. [22] confirmed a strong correlation between the presence of mafia organizations and market concentration within the building sector, which also makes it possible to gain political consensus and social control.

Interestingly, Ganau and Rodríguez-Pose [3] discovered that a significant presence of organized crime dramatically undermines any positive productivity advantages arising from industrial clustering, by infiltrating the supply chain procurement process, and by competing directly, breaks down the collaborative environment of the industrial district. Moreover, this impact is greater for smaller businesses than for larger ones. Conversely, Calamunci and Drago [23] notes that confiscation targeting organized crime firms, which remove unfair competition, have positive spillover effects on the economic environment, resulting in improved performance, turnover, and investments for law-abiding firms, resulting in a more appealing market, which induces firm to enter it [24]. Chircop et al. [25] confirm that anti-mafia police actions against illegal firms not only improve the business conditions of peer firms through the reduction of production costs, leading to an improvement in financial performance and increased investment propensity, but also make peer firms less likely to attempt to avoid tax. Equally, it has been consistently argued that pursuing organized crime by taking action against mafia firms results in a safer and more stable environment, making the local area more appealing to businesses and investors and increasing demand for commercial property ownership [24]. On the basis of these findings, the presence of infiltrated firms, which are managed more in accordance with mafia conventions than with economic equilibrium, may have an effect on the efficiency of competitors.

Overall, this unfavorable environment increases uncertainty and thereby firms' confidence in growth opportunities in the market, and ends up discouraging corporate investment in developed [1,26], as well as underdeveloped countries [4,27] both characterized by a high crime rate.[1]

A consistent stream of literature has underlined that innovation propensity is affected by delinquency. In this regard, fear of criminality has a significant influence on business investment choices.

According to Saridakis et al. [10], firms that have suffered losses as a consequence of crime are less inclined to use innovative strategies. In this vein, Peiró-Palomino and Perugini [11] demonstrate that law enforcement and judicial quality (rule of law) are strong predictors of innovation intensity in the Italian provinces, as measured by patenting activity. Rodríguez-Pose and Di Cataldo [12] found a similar relationship for European regions. According to Agostino et al. [13], the law enforcement index (rule of law) has a negative effect on the productivity and technological advancements of European SMEs, with the effect being stronger for weaker firms and moderate for older and larger companies with a high human capital share.

The theoretical underpinnings for the empirical research on the impact of organized crime can be traced to the theory of community social capital [31]. This theory posits that organized crime not only creates resource misallocation, as it increases the costs of doing business, but when it is widespread, the negative effect is felt on the pillars

[1] Equally, illegal activities reduce forward-direct investment [28–30].

of community social capital, including trust, community identification, social support, and collaboration. Such negative effects can undermine networking, cooperation, and trust among community members. As a result, entrepreneurial initiatives may be hindered, as demonstrated by studies conducted by Barbieri and Rizzo [32],Churchill et al. [33]. We can assume that a similar effect can be seen on a firm's propensity to invest, since crime is a source of uncertainty.

Despite increasing investor and academic awareness of the disruptive effects of organized crime on firm productivity, few studies have addressed the issue, and none have investigated how the fear of organized crime conditions firms' productivity and investment proclivity. Overall, these issues require a better understanding of the economic effects of mafia risk on economic activity, as well as the geographical effect and resulting investment propensity. On the basis of the above literature, we posit the following RQs:

- RQ1: Does the perceived crime risk affect a firm's technical efficiency?
- RQ2: Does the perceived crime risk affect a firm's investment propensity?

3. Data and variable

The present study, utilizing three proxy variables associated with the perceived risk of mafia presence, aims to examine the potential influence of perceived crime risk on a firm's technical efficiency (RQ1) and investment propensity (RQ2), which were gathered by research teams from the Bank of Italy through polling firms about the risk of criminal phenomena spreading.

Specifically, respondents were asked, regardless of their personal experience, how likely it was that the owner of a firm in the same geographic area and economic sector as the respondent had encountered one of the following situations: Obtained a loan outside official channels (e.g. banks or financial companies) — $Crime_1$; Received an offer to sell their business at unusual conditions (e.g. in terms of price, time frame and payment conditions) — $Crime_2$; Been the object of threats, intimidation or extortion attempts — $Crime_3$.[2] The survey respondents could respond in four ways: not at all likely, unlikely, somewhat likely, and very likely.

The survey questions pertain to a range of crimes committed against firms that necessitate a significant level of organization. Furthermore, the presence of all of these factors, both collectively and individually, can contribute to a firm's perception of operating in an unsafe environment. Since the sampled firms have at least 20 employees, it is reasonable to assume that usury and, *a fortiori*, attempts to "buy" firms under unusual circumstances are crimes that occur infrequently at the firm referred to in the survey. Conversely, being the object of threats, intimidation or attempts at extortion is the offense most likely to condition a firm's operativity, possibly even putting its existence at risk in the long run.

Therefore, we relate a firm's efficiency to all types of mafia risk, whether direct, as in the latter offense, or indirect, as in the preceding two.

$$z_i = \left[Crime_{1,2,3}, \sum_{j=2}^{4} Region_j, \sum_{k=1}^{4} Control \right]$$

As noted by Pinotti [34], the adoption of a subjective measure of crime risk could suffer from measurement errors. This is because the perception of crime risk may be under-reported, due to various factors such as hesitation, fear of revenge, or cultural influences, and leading to a weak correlation with the actual degree and prevalence of organized crime. However, we believe that these potential distortions have been partially addressed by posing the questions indirectly, as participants were required to report on their perceptions of the likelihood that businesses operating in the same sector and geographical area had been exposed to criminal activity, regardless of personal experience. Moreover, in the framework of our analysis, we assume that the risk perception is equally important as objective data on crime, since firms' investment decisions and growth strategies are particularly sensitive to their confidence in the local social-environmental situation. Additionally, objective data captures past situations that have been uncovered and crimes to which businesses have been subjected. We stress test the goodness of our indicators in capturing the real criminal phenomena, by correlating the crime proxies to the typical mafia-style offenses at a macro-regional level.[3] In detail, following Pinotti [34], we have considered a set of eight reported crimes that are considered strictly related to the presence of an organized crime Mafia-type association, as signaled by provincial-level law enforcement authorities (Mafia-type association, Attacks, Smuggling, Arson, Extortion, Homicide, Mafia-style homicide, Money laundering, Attempted mafia–style homicide). Because the three risk perceptions of widespread organized crime are reported within the dataset, the correlations between the variables at the firm level can be calculated, which are: 0.7589, 0.6963, and 0.6848 (see Table 1).

Table 1
Correlations table.

	$Crime_1$	$Crime_2$	$Crime_3$
Mafia–type association	0.8063	−0.3156	0.9285
Attacks	0.3927	−0.3068	0.5379
Smuggling	0.5360	−0.3001	0.6755
Arson	0.5836	−0.2950	0.7055
Extortion	0.4141	−0.2790	0.5434
Homicide	0.4390	−0.2756	0.5450
Mafia–style homicide	0.7059	−0.2868	0.7987
Money laundering	0.2754	−0.3282	0.3565
Attempted mafia style homicide	0.6120	−0.2409	0.6903

The correlations has been calculated using the average value at the macroregional level.
Source: Our elaboration on Bank of Italy, Survey on Industrial and Service Firms and Ministry of Home Affairs data.

While the coefficients reveal a strong and positive correlation between the first and third variables, the second variable – the crime – perceived index – displays a negative albeit weak correlation. This variable captures a less commonly practiced mafia offense, given its implications and premises, such as the need to take on business risks, acquire illiquid assets resulting from extortion, and the risk of high visibility to law enforcement authorities.

The specification includes a set of control variables regarding firm characteristics. In particular, following literature on Italian firm efficiency (see for instance, [35,36]), which find a substantial efficiency disparity between firms operating in Italy's underdeveloped areas (South) and the remainder of the country.

Furthermore, we presume a significant interaction effect between the geographical dummies and mafia risk, because the presence of the mafia is particularly strong in southern Italy, which is likely to be one of the main causes of the lack of development in these areas. Thus, we

[2] Only the survey conducted by the Bank of Italy in 2020 contains the aforementioned questions. The complete questionnaire is available for download at this link: https://www.bancaditalia.it/statistiche/tematiche/indagini-famiglie-imprese/imprese-industriali/distribuzione-microdati/questionario-indagine-imprese/index.html?com.dotmarketing.htmlpage.language=1, while the items have been coded as DFC1B, DFC2B, and DFC3B, respectively.

[3] This robustness check was suggested by an anonymous referee. It is worth noting that the privacy restrictions of the remote system for data processing provided by the Bank of Italy do not allow for the extraction of individual data, nor does the system allow for the introduction of new time series. Specifically, the system only permits the extraction of aggregate statistical information at the macro-regional level.

interact the two multinomial variables, *Crime* and *Regions*, using the first category for each as a benchmark.

$$z_i = \left[Crime_{1,2,3}, \sum_{j=2}^{4} Region_j, \sum_{j=2}^{4}\sum_{h=2}^{4} \gamma_{jh} Region_j \times Crime_h, \sum_{k=1}^{4} Control \right]$$

In particular, the reference categories are firms in the Northwest of Italy that deem the risk of the spread of criminal phenomena to be "not at all likely". Because the estimated coefficients represent the associated variable's inefficiency effect, a negative sign indicates a higher level of efficiency. Size, production sector, export orientation, and pricing market competitiveness are the other control variables. The *Size* variable is proxied by a multinomial control variable using the number of workers (grouped in the BIRD dataset into six categories); the reference category is small firms (with a total number of workers between 20 and 49). We preferred to use a discrete variable rather than a continuous variable to consider possible nonlinear effects of company size on efficiency. *Export* captures the firm's exporting tendency by categorizing it into four groups: enterprises that export less than one-third of their revenue, firms that earn between one and two-thirds of their revenue overseas, and firms that sell more than two-thirds of their revenue in foreign markets. There is clear evidence that export propensity has a beneficial impact on firm efficiency, based on self-selection (e.g., [37,38]) and learning-by-exporting hypotheses (see, for instance [39,40]), but, for small businesses, the effect is reversed [41]. The (in)efficiency equation considers the impact of price competition on the efficiency of a firm. According to the Cournot oligopoly model, a firm's market share is determined by its relative efficiency, so a more competitive environment provides an incentive for firms to improve their efficiency [42]. We included a dummy variable (*Competition*) that controls whether the factor having the greatest influence on a firm's price developments is its main competitors' pricing policies. Our specification further accounts for the heterogeneous nature of sector efficiency using eleven industry dummies.[4]

To address RQ2, we investigate the impact of crime perception on firm investment and R&D expenditure in three separate specifications. To this end, we regress the sum of firm investment with the same set of control variables adopted to explain the variability of the firm's inefficiency in the SFA specifications, as well as other explicative variables commonly used in literature (e.g., [43]), namely firm age (*Age*) and the profitability proxy (*Profit*) included in the survey, which describes the firm's operating result in the year and is an ordinal variable ranging from 1 (large profit) to 5 (large loss).

The estimates are based on the use of the Bank of Italy's Remote Execution system (REX), which allows for the remote processing of data collected in the survey of industrial and service firms (INVIND Bank of Italy, Survey on Industrial and Service Firms, [2009–2020]). However, to safeguard the confidentiality of firm-specific information, the Bank of Italy restricts access to its microdata solely through a remote processing system, which permits external researchers to perform econometric analyses without direct access to the microdata. Furthermore, the outcomes of the analysis conducted by the remote process are solely provided subsequent to a manual verification to ensure compliance with confidentiality standards. This measure guarantees that the findings do not disclose any data that could be linked to specific organizations. Therefore, the remote processing system of the Bank of Italy enables researchers to obtain access to microdata while ensuring the confidentiality of individual firm data.[5] The Bank of Italy conducts this survey every year, gathering data on specific firms and some fundamental economic indicators, but unfortunately the crime data has only been collected for one year. Therefore, the investment equations are based on a cross-sectional analysis. The reference population is that of companies with registered headquarters in Italy, at least 20 employees, and belonging to a variety of industrial and private non-financial service sectors. The sample is based on a stratified design with a non–proportional probability of selection according to the firm's activity sector (listed in Table 2 of the survey's methodological note), size, and location. Table 2 lists the variables pertinent to the investigation, while Table 3 reports the summary statistics.

4. Methodology

The methodology used to evaluate the technical efficiency of a firm establishes a hypothetical production frontier that links the maximum output feasible with a given set of inputs to the firm's actual product [44].[6] Specifically, our efficiency analysis is based on a one-step SFA that enables us to relate the effectiveness of production value added to a set of firm inefficiency drivers.[7] Actually, having established the production frontier, the estimated frontier represents the optimum in terms of achievable firm output (value-added) in the absence of inefficiency $y_i = f(x_i, \beta)$, where y_i represents the firm output, x_i represents the vector of inputs. The technique includes both an inefficiency component (u_i) and potential random shocks (v_i) to account for possible causes that prevent optimum production levels being achieved, so the equation can be expressed as follows: $y_i = f(x_i, \beta) \cdot \xi_i \cdot exp(v_i)$. The inefficiency term is bound to be non-negative and i.i.d. $N^+(0, \sigma_u^2)$, whereas v_i is a random variable i.i.d. $N(0, \sigma_v^2)$. Applying the logarithmic transformation and let be $u_i = -ln(\xi_i)$, the equation becomes:

$$lny_i = lnf(x_i, \beta) + u_i + v_i$$

Finally, the inefficiency can be estimated as follows:

$$\xi_i = \frac{f(x_i, \beta) \cdot exp(v_i - u_i)}{f(x_i, \beta) \cdot exp(v_i)} = exp(-u_i)$$

Our SFA analysis uses the trans-logarithmic function, that presents several advantages with respect to the standard Cobb–Douglas function. We perform the technical efficiency investigation using a trans-logarithmic function, since it is a Taylor series expansion up to the second order of a generic production function which does not require definition of the elasticity of substitutions between input production, making it more appealing than the linear specification, such as the Cobb–Douglas equation.[8] Specifically, it relates production function (i.e., capital and labor) to firm output, proxied by value added.

$$ln[Q_i] = \beta_0 + \beta_1 ln[L_i] + \beta_2 ln[K_i] + \frac{1}{2}\beta_3 (ln[L_i])^2 + \frac{1}{2}\beta_4 (ln[K_i])^2 + \frac{1}{2}\beta_5 (ln[L_i]) \cdot (ln[K_i]) + \epsilon_i$$

where Q is the firm output, that we proxied to total value added and L and K are the input variables (i.e. average number of employees and capital stock, respectively). Actually, due to privacy restrictions, the capital stock K is not included in the dataset, and we are unable to combine the data from the survey with other data sources. As a

[4] The survey follows the NACE 2007 taxonomy of economic sectors, according to the NACE rev. 2 classification, which includes Sections B, C, D, E, G, I, H, J, L, M, and N, but excludes construction.

[5] These limitations hinder scholars from integrating additional firms' information, such as further balance sheet value or its geographic location, into the sample.

[6] For a recent review of the literature regarding the development and the applications of stochastic frontier analysis, see Aigner [45].

[7] The Appendix section contains a comprehensive description of the SFA methodology.

[8] Furthermore, we used the likelihood ratio test to evaluate the two equations above, and the test results show that the specification we use is preferable $\chi^2(3)=71.27$, p–value = 0.00%.

Table 2
Variables description.

Variable name	Type	Description
Macro Regions	Multinomial variable	
Northwest		Firm headquarter in the Northwest of Italy
Northeast		Firm headquarter in the Northeast of Italy
Centre		Firm headquarter in the Centre of Italy
South		Firm headquarter in the South of Italy
$Crime_{1\,2\,3}$	Multinomial variable	How likely is Usury, Dispossession and Extortion?[1]
Class 1		Not at all likely
Class 2		Unlikely
Class 3		Somewhat likely
Class 4		Very likely
Value added	Continuous variable	Firm value added (thousand of €)
Labor	Continuous variable	Total gross annual wage (thousand of €)
Capital	Continuous variable	Expenditure on fixed asset (thousand of €)
$Size^2$	Multinomial variable	Six categories
Export	Multinomial variable	
Category 0		Non–exporting firms
Category 1		Firm exporting less than 1/3 of their turnover
Category 2		Firm exporting between 1/3 and 2/3 of their turnover
Category 3		Firm exporting less than 2/3 of their turnover
$Profit^4$	Multinomial variable	Five categories
Competition	Dummy variable	Does your price setting depend mainly on competitors' pricing policies?

[1] See the paper for more details.
[2] 0=20–49; 1=50–99; 2=100–199; 3=200–499; 4=500–999; 5=1000 worker or more.
[3] 1 = Large profit; 2 = Small profit; 3 =Broad balance; 4 = Small loss; 5 =Large loss.
[4] Source: Bank of Italy, Survey on Industrial and Service Firms, [2009–2020].

Table 3
Summary statistics.

Variable	Mean	Std. Dev.	Min	Max
Value Added	27,742.70	109,423	27	2,451,524
L	212.27	584.42	...	...
K	16,632.99	123,451	11	4,041,36
Investim	4.909306	.0585821	...	...
Profit	2.468376	.0227185	1	5
Size	1.578462	.0277397	1	6
Exporter	1.198632	.0200599	1	4
$Crime_1$	1.458803	.0134547	1	4
$Crime_2$	1.473504	.0135107	1	4
$Crime_3$	1.340855	.0114596	1	4
Competition	0.2981197	0.0084594	0	1
Age	39.54701	.4650477	...	...

Source: Bank of Italy, Survey on Industrial and Service Firms, [2009–2020].
Missing values due to privacy constraints.

consequence, and following Forgione and Migliardo [36], we adhere to the perpetual inventory method as described below [46]:

$$k_{\alpha,t} = \sum_{i=0}^{\infty}(1-\delta_\alpha)^i I_{\alpha,t-(i+1)} \qquad k_{\beta,t} = \sum_{i=0}^{\infty}(1-\delta_\beta)^i I_{\beta,t-(i+1)}$$

$$k_{\gamma,t} = \sum_{i=0}^{\infty}(1-\delta_\gamma)^i I_{\gamma,t-(i+1)} \qquad k_{\zeta,t} = \sum_{i=0}^{\infty}(1-\delta_\zeta)^i I_{\zeta,t-(i+1)}$$

$$k_{\eta,t} = \sum_{i=0}^{\infty}(1-\delta_\eta)^i I_{\eta,t-(i+1)}$$

where α denotes the firm's investment in building, β in plants, machinery, and equipment, γ in means of transport, ζ denotes the total amount spent on software and databases, and η denotes the amount spent on research and development. The corresponding depreciation rates match the relevant coefficients as specified under the fiscal rule. In conclusion, k_i represents a weighted sum of the history of tangible and intangible asset capital stock investments, where the weights are depreciation rates, and the sum of the sub-capital stocks reflects the total capital stock K for company i which is utilized in the SFA.

Finally, the following formula is used to obtain a firm technical efficiency score:

$$\xi_i = E\{exp - (u_i)\,|\epsilon_i\}$$

where ϵ_i represents the sum of v_i and u_i.

The stochastic frontier's parameters are as follows, and the approach for estimating the inefficiency effects is simultaneous and one step:

$$\sigma_{ui}^2 = exp\,(\delta_u, z_{ui})$$

δ, where is a vector of parameters that need to be estimated and z_{ui} is a vector of environmental factors that affects company *i's* inefficiency, as detailed in the section below.

Finally, to address the potential endogeneity of the efficiency determinants, we employed endogenous panel stochastic frontier models as proposed by Karakaplan [47], but the results of the relative endogeneity tests strongly confirm that correction for endogeneity is not necessary.[9]

5. Results

It is critical to note that the SFA is based on a one-step procedure in which the coefficients of each environmental element indicate the inefficiency associated with variance (σ_u). As a result, a negative coefficient indicates that the environmental variable lowers inefficiency, whereas a positive effect indicates that the environmental variable increases technical inefficiency.

The empirical findings of the SFA specification reported in Table 4 show that, when the crime parameters are considered – regardless of the macroregions – as a discrete variable, there is a significant and negative effect of firm efficiency only for $Crime_3$, indicating that firms operating in an environment where being the target of threats, intimidation, or extortion attempts is a possibility, are more inefficient. In contrast, neither of the other two factors threatening a firm's activities hinders efficiency. Indeed, the latter kind of offense seems to be a more direct threat to economic and entrepreneurial freedom, whereas the other two criminal phenomena, while increasing the perception of operating in a context of wide-spread crime, do not directly affect the surveyed firms.

In this regard, the specifications relating a firm's geographical location to all classes of crime variables (Table 5) provide intriguing clues,

[9] The estimation was run using as instrument variable the geographical area of the firm location, ($\chi^2(1) = 0.01$ p–value > $\chi^2 = 0.9346$). An anonymous referee provided valuable feedback by suggesting that we stress test our specification to identify any potential endogeneity bias.

Table 4
One-step Stochastic Frontier estimates.

	(I)	(II)	(III)
$\ln[L_i]$	0.876***(0.09)	0.876***(0.09)	0.873***(0.09)
$\ln[K_i]$	−0.152***(0.03)	−0.151***(0.03)	−0.155***(0.03)
$1/2(\ln[L_i])^2$	−0.042*(0.02)	−0.042*(0.02)	−0.043*(0.02)
$1/2(\ln[K_i])^2$	0.026***(0)	0.026***(0)	0.026***(0)
$1/2(\ln[L_i])\times(\ln[K_i])$	0.019(0.02)	0.019(0.02)	0.021(0.02)
Intercept	5.567***(0.27)	5.566***(0.27)	5.588***(0.26)
σ_u			
Firm dimension	−0.142*(0.07)	−0.150*(0.07)	−0.145*(0.07)
Export	−0.093(0.07)	−0.094(0.07)	−0.102(0.07)
$Sector_1$	−1.130***(0.31)	−1.128***(0.32)	−1.131***(0.32)
$Sector_2$	−1.568***(0.28)	−1.555***(0.29)	−1.550***(0.29)
$Sector_3$	−0.791*(0.32)	−0.789*(0.32)	−0.807***(0.32)
$Sector_4$	−0.740**(0.28)	−0.723**(0.28)	−0.724**(0.28)
$Sector_5$	−1.762***(0.37)	−1.753***(0.37)	−1.756***(0.37)
$Sector_6$	−1.578***(0.37)	−1.582***(0.37)	−1.597***(0.36)
$Sector_7$	−1.296***(0.25)	−1.286***(0.26)	−1.279***(0.25)
$Sector_8$	−1.017***(0.31)	−1.006(0.31)	−1.015***(0.32)
$Sector_9$	−1.497***(0.46)	−1.503(0.47)	−1.536***(0.47)
$Sector_{10}$	−1.910***(0.35)	−1.890***(0.35)	−1.921***(0.36)
$Sector_{11}$		benchmark	
North East	−0.197(0.22)	−0.191(0.22)	−0.198(0.23)
Centre	0.352(0.21)	0.351(0.21)	0.359(0.21)
South	0.502*(0.2)	0.519**(0.2)	0.465*(0.2)
Competition	−0.357*(0.15)	−0.358*(0.15)	−0.360*(0.15)
$Crime_1$	0.100(0.08)		
$Crime_2$		0.125(0.08)	
$Crime_3$			0.253**(0.09)
Intercept	0.213(0.34)	0.176(0.34)	0.025(0.34)
$E(\sigma_u)$	0.5731	0.5712	0.5709
σ_v	0.646***(0.02)	0.644***(0.02)	0.647***(0.02)

Bank of Italy, Survey on Industrial and Service Firms, [2009–2020].
Number of observations: 2,397.
Standard errors in parentheses, *p < 0.05, **p < 0.01, ***p < 0.001.

since all types of offenses considered become an important factor for firms in southern Italy, even those with low ("unlikely") perceived risk. This finding confirms the results of literature, which have demonstrated that productivity losses are more pronounced among firms situated in underdeveloped regions of Italy [3], irrespective of their size and sector across all municipalities [14]. Indeed, interaction effects for southern firms increase as crime risk increases, even doubling for the highest perceived crime risk in the $Crime_1$ and $Crime_3$ models. These results indicate that firms in the underdeveloped regions of Italy are heavily conditioned for as long as the social environment is perceived to be more unfavorable, which likely induces multiple spillover effects identified in the literature cited in Section 2 and resulting in decreased investment and innovation propensity.

For example, it is reasonable to hypothesize that organized crime activities insinuate into firm supply chains, forcing legally established firms to accept higher prices [25] and lower-quality subcontracting [14], which in turn reduces firm effectiveness. Similarly, law-abiding firms may face negative externalities of this adverse economic environment, such as security costs to defend against potential offenses [8] or decreased confidence among businesses. The misallocation of resources may occur as a result of the abnormal trade credit conditions that firms must concede to dishonest counterparts [21]. This can lead to unforeseen payment delays in trade credit, which are closely linked to financial distress among Italian firms [48]. Equally, unfair competition in private goods [23] and public procurement markets [17,18] can lead to a lack of productivity.

Our findings support the assumption that criminal financial interests in a local area can disrupt the market equilibrium to the point that they alter the demand for commercial property ownership [24].

On the contrary, even when the risk is perceived as "very likely", the spread of criminal phenomena has no effect on the firm's technical productivity in the rest of Italy. We cannot identify with certainty the reasons for this evidence, but the evidence suggests that organized crime in the those areas has less of an impact on firm productivity due to a more solid social context in terms of institution quality, legal culture, etc.

Therefore, our findings appear consistent with each channel identified in the empirical literature regarding the effect of crime on firm productivity, but many of these factors are not observable in our sample and would require further researches, thereby we can only stress test whether firm investments and R&D expenses are related with the spread of criminal phenomena as reported in Table 6.

Indeed, our estimate corroborates Pinotti's [1] and Chircop et al.'s [25] the hypothesis that organized crime discourages capital investments by private enterprises, and that removing the state of fear induced by mafia from the local territory encourages firms to pursue new growth opportunities by implementing investment plans in property, plants, and equipment. A possible explanation for this findings is the lower propensity of banks to grant loans or their application of higher interest rates in areas and economic sectors with high levels of criminal infiltration [49]. Even if not reported, R&D investment is weakly correlated to crime.

With regard the other the control variables, they take the expected signs in all the specifications we run. Specifically, empirical estimates support the hypothesis that firms exposed to price competition are less inefficient and more likely to invest, whereas export propensity implies a large flow of investment but has no effect on firm efficiency. Intriguingly, economies of scale are validated by both empirical models, whereas firm age is not a significant factor in explaining productivity and investments.[10]

[10] In particular, we confirmed that age coefficient and its square were never significant in the SFA model and investment analysis in an unreported estimate.

Table 5
One-step Stochastic Frontier estimates interacting Crimes and regional variables.

	(I)	(II)	(III)
$\ln\left[L_i\right]$	0.871***(0.08)	0.878***(0.09)	0.877***(0.09)
$\ln\left[K_i\right]$	−0.154***(0.03)	−0.15***(0.03)	−0.155***(0.03)
$1/2\left(\ln\left[L_i\right]\right)^2$	−0.043*(0.02)	−0.043*(0.02)	−0.044*(0.02)
$1/2\left(\ln\left[K_i\right]\right)^2$	0.025***(0)	0.025***(0)	0.025***(0)
$1/2\left(\ln\left[L_i\right]\right)\times\left(\ln\left[K_i\right]\right)$	0.021(0.02)	0.02(0.02)	0.021(0.02)
Intercept	5.581***(0.26)	5.551***(0.27)	5.571***(0.27)
σ_u			
Firm dimension	−0.14*(0.07)	−0.146*(0.07)	−0.145*(0.07)
Export	−0.085(0.07)	−0.086(0.07)	−0.103(0.07)
$Sector_1$	−1.231***(0.32)	−1.161***(0.31)	−1.168***(0.32)
$Sector_2$	−1.635***(0.3)	−1.564***(0.28)	−1.573***(0.29)
$Sector_3$	−0.846**(0.33)	−0.828**(0.31)	−0.848**(0.31)
$Sector_4$	−0.829**(0.28)	−0.76**(0.27)	−0.756**(0.28)
$Sector_5$	−1.845***(0.37)	−1.82***(0.35)	−1.814***(0.36)
$Sector_6$	−1.686***(0.39)	−1.588***(0.37)	−1.658***(0.37)
$Sector_7$	−1.405***(0.26)	−1.327***(0.25)	−1.31***(0.26)
$Sector_8$	−1.095***(0.32)	−1.04***(0.31)	−1.062***(0.32)
$Sector_9$	−1.602***(0.48)	−1.554***(0.46)	−1.636***(0.47)
$Sector_{10}$	−1.969***(0.36)	−1.908***(0.35)	−1.958***(0.36)
$Sector_{11}$		benchmark	
Competition	−0.37*(0.15)	−0.371*(0.15)	−0.383*(0.15)
Northwest × not at all likely		benchmark	
Northwest × unlikely	0.232(0.39)	0.235(0.40)	0.485(0.40)
Northwest × somewhat likely	0.320(0.49)	0.426(0.42)	0.210(0.59)
Northwest × very likely	−0.484(0.7)	−0.452(0.59)	−2.448(1.45)
Northeast × not at all likely	0.077(0.28)	−0.077(0.29)	−0.037(0.27)
Northeast × unlikely	−0.957*(0.41)	−0.007(0.34)	−0.544(0.41)
Northeast × somewhat likely	0.026(0.68)	−0.138(0.76)	0.942(0.76)
Northeast × very likely	−0.425(0.7)	−1.221(0.66)	−1.045(0.69)
Centre × not at all likely	0.460(0.26)	0.335(0.26)	0.450(0.25)
Centre × unlikely	0.522(0.34)	0.815*(0.34)	0.673*(0.33)
Centre × somewhat likely	0.100(0.36)	0.277(0.4)	0.049(0.47)
Centre × very likely	0.288(0.69)	−0.027(0.72)	−0.127(0.49)
South × not at all likely	0.475(0.25)	0.448(0.25)	0.432(0.23)
South × unlikely	0.59*(0.3)	0.957***(0.29)	0.765*(0.3)
South × somewhat likely	0.906**(0.33)	0.945**(0.34)	1.412***(0.38)
South × very likely	1.857***(0.49)	0.319(0.69)	1.574*(0.64)
Intercept	0.320(0.34)	0.269(0.33)	0.262(0.33)
$E\left(\sigma_u\right)$	−0.8667	−0.8784	0.5637
σ_v	0.648***(0.02)	0.645***(0.02)	0.649***(0.02)

Source: Bank of Italy, Survey on Industrial and Service Firms, [2009–2020].
Number of observations: 2,397.
Standard errors in parentheses, *p< 0.05, **p < 0.01, ***p < 0.001.

6. Concluding remarks

While the literature on the economics of crime is vast, it fails to examine whether the negative externality of the mafia hampers the technical efficiency of firms. This study aims to fill this gap by utilizing a suitable technique to determine how the fear of illicit actions affects firm production efficiency measures. Additionally, our analysis identifies a possible reason for a scarce propensity to invest. The findings corroborate the assumption that organized crime is a cancer that erodes the community's social capital. Indeed, the present study provides evidence that the perception of being exposed to criminal threats is a risk factor that tends to lower both firms' efficiency and investments. Furthermore, the interaction specification confirms that criminality exacerbates regional disparities in terms of inefficiency and investment propensity, even at low levels of perceived risk. In other words, we demonstrate the mafia's role in preventing backward regions from catching up with the rest of Italy in terms of productivity. In this regard, literature has linked lower private investment levels in regions with high crime rates to higher credit costs [50] as well as to rising corruption and bribery in the public procurement system [1]. The poor credit market conditions persist even when anti-mafia law enforcement targets detected organized crime firms because they lead banks to restrict credit to seized firms without improving the credit conditions of legal firms operating in the same business area [51]. The research findings will be especially relevant for policy makers, practitioners, and academics worldwide, as organized crime affects both developing and developed countries. In fact, the potential economic and social consequences of crime-related externalities could point to the best path for increasing legal protection and avoiding, for instance, recourse to unofficial credit providers, thereby combating economic and social costs at the firm and country levels. Similarly, considering the hidden damage that organized crime causes to the production system, civil society may be led to reject any possible, even indirect, connection with criminal organizations, thereby weakening their power. The initiative taken by trade associations, such as those in the industrial, artisanal, agricultural, and trading sectors, to establish networks against mafia-style organizations – exemplified by groups like "*addio pizzo*" – is commendable. By working together to combat criminal influence, these associations act as an antibody to the erosion of social capital, and can help promote the reputation of their industries and firms by demonstrating their commitment to anti-crime initiatives. The use of anti-mafia labels on their products is an effective way to further advertise this commitment and encourage others to follow suit.

This research contains few limitations that should be taken into account. First, while the poll collects some financial data, many balance-sheet data are not available, and it is not possible to bridge this gap by combining survey data with publicly available firm data due to confidentiality constraints that prevent survey participants from being identified. This study is also based on cross-sectional data, which

Table 6
Linear regression for Investment.

	(I)	(II)	(III)
$Profit$	−0.192***(0.04)	−0.194***(0.04)	−0.188***(0.04)
$Firm\ dimension$	1.200***(0.03)	1.200***(0.03)	1.200***(0.03)
$Export$	0.406***(0.05)	0.405***(0.05)	0.404***(0.05)
$Sector_1$	1.418***(0.38)	1.460***(0.38)	1.429***(0.38)
$Sector_2$	−0.095(0.38)	−0.053(0.38)	−0.045(0.38)
$Sector_3$	−0.788(0.41)	−0.736(0.41)	−0.752(0.41)
$Sector_4$	0.628(0.38)	0.668(0.38)	0.659(0.38)
$Sector_5$	1.768***(0.38)	1.826***(0.38)	1.820***(0.38)
$Sector_6$	0.907*(0.41)	0.947*(0.41)	0.963*(0.41)
$Sector_7$	1.138**(0.36)	1.187***(0.36)	1.188***(0.36)
$Sector_8$	1.203**(0.39)	1.245***(0.39)	1.247***(0.39)
$Sector_9$	2.233***(0.41)	2.314***(0.41)	2.276***(0.41)
$Sector_{10}$	−0.366(0.38)	−0.300(0.37)	−0.323(0.37)
$Sector_{11}$		benchmark	
$Competition$	0.201*(0.09)	0.204*(0.09)	0.209*(0.09)
$Firm\ age$	0.000(0.00)	0.001(0.00)	0.000(0.00)
$Northwest \times not\ at\ all\ likely$		benchmark	
$Northwest \times unlikely$	0.160(0.19)	0.054(0.20)	−0.055(0.21)
$Northwest \times somewhat\ likely$	0.033(0.34)	0.112(0.29)	−0.031(0.36)
$Northwest \times very\ likely$	−0.521(1.46)	1.307(1.09)	2.184(1.37)
$Northeast \times not\ at\ all\ likely$	0.234(0.15)	0.196(0.16)	0.257(0.14)
$Northeast \times unlikely$	0.373(0.19)	0.439*(0.19)	0.095(0.22)
$Northeast \times somewhat\ likely$	−0.019(0.36)	0.007(0.31)	0.038(0.51)
$Northeast \times very\ likely$	0.376(0.91)	0.704(0.80)	0.311(1.63)
$Centre \times not\ at\ all\ likely$	0.106(0.15)	0.104(0.15)	0.057(0.14)
$Centre \times unlikely$	0.048(0.21)	0.085(0.20)	0.108(0.19)
$Centre \times somewhat\ likely$	0.376(0.28)	0.384(0.25)	0.488(0.45)
$Centre \times very\ likely$	0.771(0.62)	0.077(0.79)	−0.371(1.10)
$South \times not\ at\ all\ likely$	−0.466**(0.15)	−0.473**(0.15)	−0.568***(0.15)
$South \times unlikely$	−0.481*(0.20)	−0.514*(0.20)	−0.461*(0.20)
$South \times somewhat\ likely$	−0.530*(0.25)	−0.540*(0.26)	−0.190(0.29)
$South \times very\ likely$	−0.659(0.50)	−0.110(0.65)	−1.035*(0.52)
$Intercept$	2.200***(0.40)	2.155***(0.40)	2.200***(0.40)

Source: Bank of Italy, Survey on Industrial and Service Firms, [2009–2020].
Number of observation: 2,942; R^2 0.4980.
Standard errors in parentheses, *p < 0.05, **p < 0.01, ***p < 0.001.

precludes a causality inference as well as making it impossible to investigate long-term relationships regarding crime and firms' investment propensity. Although, it is reasonable to assume that the causality direction should be straightforward and the perception of crime risk is persistent over time.

Future avenues could be explored in greater depth, most likely using geographical dummies at more disaggregated level, such as at the municipal level (we failed to take advantage of this opportunity, but Bank of Italy researchers may be better placed to investigate this aspect), to highlight areas that require more vigilant monitoring and stricter legislation. Identification of this spillover effect could, to a large extent, trigger better policy actions to be implemented toward several strategies to mitigate the negative externalities of poor institutional quality, which end up creating a productive field for organized crime associations. In a similar vein, further analysis could create a composite organized crime index based on three main illicit activities perceived at firm level, thanks to which we may identify possible multiplier effects of mafia as a whole on firm performance a composite indicator of crime based on three profiles of how illegal activity affects firm efficiency.

CRediT authorship contribution statement

Antonio Fabio Forgione: Conception and design of study, Acquisition of data, Analysis and/or interpretation of data, Writing – original draft, Writing – review & editing. **Carlo Migliardo:** Conception and design of study, Acquisition of data, Analysis and/or interpretation of data, Writing – original draft, Writing – review & editing.

Data availability

The data that has been used is confidential.

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Appendix

As well clarified in Belotti et al. [52], the stochastic frontier models are based on the idea that, given a set of inputs and outputs, no economic actor can outperform an optimal frontier, and deviations from this benchmark represent individual inefficiency. From a statistical standpoint, this insight has been implemented by defining a regression model with a composite error term that incorporates the classical idiosyncratic disturbance to capture measurement error and any other standard sources of noise, as well as a one-sided disturbance that represents inefficiency. In detail, given the general equation:

$$y_i = \alpha + \mathbf{x_i}\beta + \epsilon_i,\ i = 1, \ldots, N$$

where y_i and x_i are the logarithmic representation of the output produced by the i_{th} unit and the set of inputs, respectively, whereas β are the coefficients associated with the independent variables vector x_i. The term ϵ_i is the sum $v_i \sim N\left(0, \sigma_v^2\right)$, which represents measurement and specification error, and a one-sided disturbance, $u_i \sim F$, which represents inefficiency. In addition, it is expected that u_i and v_i are independent of one another and i.i.d. across observations. To make the model estimable, the assumption regarding the distribution of the inefficiency factor is required and we modeled it with the exponential

function $u_i \sim \mathcal{E}(\sigma_u)$ as proposed by Meeusen and van Den Broeck [53],Aigner et al. [54].

In this equation, the value of y_i denotes the logarithmic representation of the output produced by the i_{th} productive unit. x_i refers to a set of inputs (capital and labor). Given the assumption regarding the exponential distribution of the inefficiency factor, we estimated the parameter using the maximum likelihood method of the function $\ell(\theta)$, where the $\theta = (\alpha, \beta', \sigma_u^2, \sigma_v^2)$. The estimates of inefficiency is finally obtained through the mean of the conditional distribution $f(u_i|\hat{\epsilon}_i)$, being $\hat{\epsilon}_i = y_i - \hat{\alpha} - x_i'$. To be derived, the likelihood function requires the assumption of independence between u_i and v_i. The composite error term, ϵ, arises as a result of the convolution of the probability density functions of the two individual random variables, v and u, which jointly form the relationship $\epsilon = v - u$.

$$f_\epsilon(\epsilon_i) = \int_0^{+\infty} f_u(u_i)\, f_v(\epsilon_i + u_i)\, du_i$$

Therefore, the log-likelihood function for n productive entities can be expressed as:

$$\ell(\theta) = \sum_{i=1}^{n} \log f_\epsilon(\epsilon_i|\theta)$$

Battese and Coelli [55] proposed an approach for assessing technical efficiency by separating the unobserved component from the compounding error, by exploiting the conditional distribution of u given ϵ and thereby $E[e|\hat{\epsilon}]$ allows inefficiency to be estimated.

$$lnL = \sum_{i=1}^{N} \left\{ -ln\sigma_u + \frac{\sigma_v^2}{2\sigma_u^2} - ln\Phi\left(-\frac{\epsilon_i - \frac{\sigma_v^2}{\sigma_u}}{\sigma_v} \right) - \frac{\epsilon_i}{\sigma_u} \right\}$$

where $\sigma_S = (\sigma_u^2 + \sigma_v^2)^{1/2}$, $\epsilon_i = y_i - \mathbf{x_i}\beta$ and $\Phi()$ is the cumulative distribution function of the standard normal distribution. To obtain estimation for u_i, the mean of the conditional distribution $f(u|\epsilon)$ can be used.

$$E(u_i|\epsilon) = \mu_{*i} + \sigma_* \left\{ \frac{\phi(-\mu_{*i}/\sigma_*)}{\Phi(\mu_{*i}/\sigma_*)} \right\}$$

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