Title. The impact of agribusiness crimes on food prices: Evidence from Italy

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Abstract. From the 1990s the Italian agribusiness sector is increasingly threatened by a new and dangerous phenomenon: organized crime in the agribusiness sector. The so-called "Agromafia" imposes its control throughout the whole agricultural supply chain, from production to retail, passing through the processing industry, transports and large-scale distribution. In this paper we examine the relationship between eco-crimes and consumer food and non-alcoholic drinks price index for the 20 Italian regions and 80 Italian provinces in the 1998-2016 period. At regional level, as a proxy for the Agromafia's activities, we build an *ad hoc* eco-criminal index for every region using data annually elaborated from Legambiente. At province level, as a proxy for Agromafia's activities, we use eight specific variables: extortions, counterfeiting, contraband, forest fires, all types of fires, money laundering, suspicious money transfers, and an *ad hoc* eco-criminal index. The analysis shows that the Agromafia can consistently affect the whole agribusiness sector, causing an increase in food prices, especially in south of the country. The ten most affected provinces by phenomenon register a food consumer price index about 12% higher than the least ten affected provinces. By the contrast, in the center-north of Italy money laundering seems to reduce food consumer prices through the reinvestment of illicit proceeds in firms with strong cost advantages.

1 INTRODUCTION
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The Italian agricultural sector with its 1.24 million units of labor (ISTAT 2018b, p. 5) is undoubtedly one of the fundamental foundations of the whole local industrial system and commands the international esteem for excellence. In fact, in December 2016 Italy had the highest number of recognized certifications (DOP[1], IGP[2], and STG[3]) in the UE-28, with 291 top-quality gastronomic specialties and 83,695 certified economic operators (ISTAT 2018a, p. 2). In 2017, the whole agricultural sector generated an added value of about 31.54 billion euros, with a relative weight of 17.11% on the Eu-28 agricultural value added, which places Italy at the top of the European ranking (ISTAT 2018b, p. 13). Nonetheless, since the 1970s, the agri-food sector has suffered from serious structural problems that have limited its potential and a healthy development. These concern the

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[1] Denominazione di Origine Protetta (Protected Designation of Origin).
[2] Indicazione Geografica Protetta (Protected Geographical Indication).
[3] Specialità Tradizionale Garantita (Traditional Specialty Guaranteed).

progressive loss of agricultural ground[4] (Bernetti et al. 2013; Boncinelli et al. 2014) and the rise of the environmental organized crime (Coldiretti-Eurispes 2015, 2017; CIA 2014; Legambiente 1999-2017). The latter issue represents the nucleus of the analysis we propose.

The theme of economic costs produced by the Mafia has been widely developed in the literature[5], but it is not possible to affirm the same for the "Agromafia" business, on which attention has begun to focus only over the last few years and in a piecemeal manner (Canali 2012; Cusatelli and Giacalone 2014).

In fact, these authors have just carried out a qualitative analysis of some issues related to Agromafia, such as counterfeiting[6] and main environmental crimes[7], without thoroughly addressing their economic implications and costs[8].

So, most of the information currently available is due to the annual documents published by public associations for the environmental defense and free market competition, such as CIA (Italian National Confederation of Farmers), Coldiretti-Eurispes, Legambiente and Sos-Impresa. Based on these specific documents, we can define Agromafia as all the economic transactions concerning financial assets, services, and activities linked to the agri-food sector and characterized by Mafia-like methods.

In 2016, about 33,045 administrative offenses and more than 7,000 criminal offenses have occurred within the agri-food sector. Furthermore, the Agromafia's added value would have amounted to 21.8 billion euros[9] and about 25% of the overall investments in Italian agriculture sector were carried out by organized crime (Coldiretti-Eurispes 2017). In the same period, the judiciary authorities decreed the appropriation of 1,038 facilities, 83.64 million kg of foods, and 44,440 packages. And the damage to the sector is very consistent considering that about 350,000 farmers (33% of the total) are victimized every year by organized crime activities (CIA 2014).

Specifically, the eco-criminal activities span a number of categories: i) usury and extortions[10]; ii) exploitation of manual labor[11]; iii) imposition of raw materials and

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[4] The exploitation of natural resources and climate changes are the most important reasons for the structural Italian agribusiness current account deficit of the last 20 years (Carbone and Henke 2012).

[5] See e.g., Arlacchi (1986), Gambetta (1993), Anderson (1995), Gambetta and Reuter (1995), Centorrino et al. (1999), Felli and Tria (2000), Paoli (2002, 2003), Asmundo and Lisciandra (2008), Krkoska and Robeck (2009), Detotto and Vannini (2010), Daniele and Marani (2011), Albanese and Marinelli (2013), Acconcia et al. (2014), Pinotti (2015), Di Gennaro and La Spina (2016), and Blackburn et al. (2017).

[6] In particular, Canali 2012 analyzes different types of counterfeiting in the agri-food sector, and also proposes a simple imitation intensity index.

[7] Cusatelli and Giacalone (2014) concentrate their attention on the illegal activities related to animals, and on crimes against farmers.

[8] A larger body of research has investigated the main determinants of illegal trafficking of wastes and the involvement of organized crime in this specific area of activity (Percoco 2001; Piccolella et al. 2003; Massari and Monzini 2004; Iovino 2010; Ruggiero and South 2010; Corona and Sciarrone 2012; Walters 2013; Martone 2014; Peluso 2015; Germani et al. 2015, 2017).

[9] Coldiretti-Eurispes (2017) estimates an overall damage of 60 billion euros for the "Food Made in Italy".

[10] Extortion strategy is three-dimensional because it's perpetrated against farmers, road haulage firms, and retailers and wholesalers.

[11] According to a study carried out by The European House-Ambrosetti (2016, pp. 39, 43) in the agricultural sector would be about 400,000 illegal workers, with an overall rate of irregularities of 22.3% in 2013 (latest figures), compared with 12,8% of the total economy. The damage to the economy is estimated between 2 and 5 billion euros (FLAI-CGIL 2016, pp. 19).

packaging[12]; iv) transport management throughout the agri-food supply chain[13]; v) damage to crops[14]; vi) livestock rustling and clandestine slaughter[15]; vii) theft of materials and equipment[16]; viii) counterfeiting and contraband of foods; ix) frauds against the European Union for contributions unlawfully received by Mafia's firms[17]; and x) crimes against forests and green areas, such as arson and illegal dumping of toxic wastes (Canali 2012; Coldiretti-Eurispes 2017; DIA 2017; Legambiente 2017a). These illegal activities usually affect the whole agri-food supply chain, from production to retail, and concern all the main Italian Mafias[18] (Coldiretti-Eurispes 2015, p. 53; DNA 2017, p. 805, 865). In particular, Mafias tend to create monopoly situations, distorting "usual" competition and pushing honest business out of the market (Coldirett-Eurispes 2017; Legambiente 2017a). This is a key point because of the crucial nature and weight of the agri-food sector in Italian economy and, in particular, in southern regions (Thomas 2002; Carbone and Henke 2012), which are traditionally more affected by organized crime (Calderoni 2011; Pinotti 2015). In fact, Mafias tend to create monopolies, by distorting "usual" competition and pushing honest firms out of the market (Coldiretti-Eurispes 2017; Legambiente 2017a).

Thus, the main research question of the paper is analyzing the economic impact of the organized crime in the agri-food sector. We'll test the statistical significance of the link between the Agromafia's main crimes and food and non-alcoholic drinks consumer price index (CPI) in Italy. Specifically, we'll use a cross-sectional OLS approach for 20 Italian regions and 80 Italian provinces, in the 1998-2016 period. At regional level, as a proxy for Agromafia's activities we'll build an *ad hoc* eco-criminal pressure index, by using aggregated annually data provided from Legambiente; while, at province level we'll adopt a dual strategy. First of all, we'll implement the following eight proxies for Agromafia's activities: extortions, counterfeiting of brands and industrial goods, forest fires, contraband, all types of fire, money laundering, suspicious money transfers, and a synthetic money laundering index obtained by the standardization of the previous two variables; secondly, we'll build a synthetic eco-criminal pressure index for each province by just using the first four types of crime, that we consider the most relevant.

The analysis will show that Mafia's environmental crimes can seriously affect the CPI both at regional and province level, mainly against southern area. In particular, the ten top-ranked provinces for eco-crimes – that belong almost exclusively to the southern regions – have an average food CPI about 12% higher than that of the ten bottom-ranked provinces, that belong entirely to the northern regions. By contrast, in the center-north of Italy money laundering offences seems to reduce food consumer prices through the reinvestment of illicit proceeds in firms with strong cost advantages.

We are cognizant of the potential problems with such a limited sample and with these types of crime, which are usually subject to under-reporting and under-recording bias;

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[12] It is useful to stress that wrappings and packages may affect up to 30% the retail price of foods. In some cases, these costs may exceed those of the agricultural product (Coldiretti 2011).

[13] This is an important point because road transport costs almost account for a third of the final sales price.

[14] Sometimes, Mafias can cut entire plantations (Coldiretti-Eurispes 2016)

[15] In 2016 there have been 4,635 illegal actions against wildlife and farm livestock. And about 490 of these regard rustling.

[16] In 2015 there have been 2,570 thefts of tractors and other farming equipment, geographically distributed as follows: 136 in the North, 414 in the Center, and 2,020 in the Mezzogiorno (Coldiretti-Eurispes 2016).

[17] Just in the 2010-2012 period, 33.1 million euros (out of a total of 52.1 billion euros) of European Agricultural Fund for Rural Development (EAFRD) have been stolen by organized crime.

[18] In particular, we refer to Camorra, 'ndrangheta, and Cosa Nostra.

however, this specific kind of analysis represents the first real attempt in the literature. Furthermore, it provides two original eco-criminal index both at regional and province level, that allow to map Agromafia's infiltration.

The rest of the paper is organized as follows: i) in section 2 we propose a detailed description of the main Agromafia's crimes and their possible link with food and non-alcoholic drinks CPI dynamics in Italian regions; ii) in section 3 we try to take a closer look to the main literature that paper relates; iii) in section 4 we describe data and empirical methodology; iv) in section 5 we build an eco-criminal pressure index for each province; v) in section 6 we present the main empirical findings; and vi) finally, in section 7 we summarize the results and discuss about the policy implications.

2 MAIN ECO-CRIMES AND FOOD CPI

Among the eco-crimes, the most significant are surely extortions against farmers, wholesale and retailers, which represent the most important funding source of the Mafias[19] (Savona 2012); counterfeiting and contraband of foods; illegal transport and sales management; and forest fires (including pastureland). According to Sos Impresa (2012), 160,000 retailers are annually affected by extortions (about 20% of overall retailers), with an annual turnover ranging from 2.76 to 7.74[20] billion euros (Transcrime 2013; Lisciandra 2014). The highest percentages are seen in Sicily (70%), with peaks of 80-90% in Agrigento, Catania, Caltanissetta, Messina, Palermo, and Trapani; Calabria reaches a value of 50% and a maximum of 70% in Reggio Calabria; Campania and Apulia are characterized respectively by a weight of 40% and 30%[21]. Less alarming but still significant data can be inferred from the center-north regions of Italy: there are 10% incidence rates in Lazio, 5% in Lombardy, Piedmont, and Emilia-Romagna, and 4% in Liguria.

According to MiSe-Censis (2018), the counterfeiting of Italian foods steals about 3.1 billion euros from the legal agri-food sector and causes an overall loss of about 19,770 regular jobs. To this it must be added that food counterfeiting represents a criminal "multiplier" because it fosters additional violations linked to the sale of the illicit foods: tax evasion, illegal labor, money laundering, illegal immigration, and abusive trade practices (UVI 2017, p. 22). According to Sos Impresa (2012) and Coldiretti-Eurispes (2017), contraband is a phenomenon directly linked to counterfeiting, and it especially concerns cigarettes, alcoholic drinks, and foods, with a turnover of 1.3 billion euros.

Furthermore, the Agromafia manages all the largest and most important Italian farmers' markets: first Fondi, Giugliano, Rome and Vittoria, but also Catania, Gela, and Palermo (Coldiretti-Eurispes 2017; DNA 2017). And an investigation provided by the Direzione Investigativa Antimafia[22] (called *Gea* investigation) showed that pressure from organized crime can cause a 15% price increase in these markets. In particular, Mafias manipulate prices by imposing extortions to road fruits and vegetables transport, and controlling the market supply, i.e. preventing the "normal and acceptable" bargain among economic

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[19] According to Paoli (2003, p. 165), extortions substantially represent a risk-free activity; they do not require significant initial investment and they are simple to manage and improve. So, they are still the main source of funding for Mafias (Scalia 2010; Savona 2012).

[20] About 5.08 billion euros concern the Mafia's traditional areas of activity (Apulia, Calabria, Campania and Sicily).

[21] Overall, 120,000 retailers are involved in these four regions.

[22] The Direzione Investigativa Antimafia (DIA) was created in 1991 together with the Direzione Nazionale Antimafia (DNA); they are special investigative services specializing in activities against organized crime.

agents and the entry of new and independent market players (DIA 2016, p. 118). Considering the whole supply chain, the monopolistic control exercised by the Mafia can triple the prices from the field to the table[23] (Di Lorenzo 2014; Coldiretti-Eurispes 2017). An evidence also confirmed, e.g., by the changes in the price structure of three specific foods in the 2005-2012 period: fresh vegetables, fresh fruit and milk. About fresh vegetables, in the considered period the incidence of cost production on consumer price has decreased from 34.9% to 27.6%, while the incidence of detail price on consumer price has increased from 34.7% to 45.8%; for fresh fruit the incidence of production cost has decreased from 37.5% to 33.5%, while the incidence of detail price has increased from 25.1% to 38.2%; finally, for milk the incidence of production cost has decreased from 38.5% to 29.5%, while the incidence of detail price has increased from 61.5% to 70.5% (Coldiretti-Eurispes 2013).

A special mention is necessary for forest fires. In fact, usually Mafias use forest fires to establish their military power and control over the territory, as well as to burn and dump illicit toxic wastes[24]. Only in the year 2016, in Italy were recorded 4,635 arson and negligent fires (of which 3,177 in the Mezzogiorno), with an overall loss of more than 27,000 hectares of woodland and green areas, including pastures and pine forests (Legambiente 2017b).

Moreover, southern regions have been characterized by a greater number of environmental crimes than center-north regions; in fact, in 1998-2016 about 60% of all crimes have been perpetrated in the Mezzogiorno[25], while 20% have been committed in the north of Italy (our elaborations on Legambiente data). And if we consider the eco-crimes per 100,000 inhabitants (Figure 1), we notice that the most affected regions have been Campania (30.14), Liguria (23.81), Calabria (21.11), and Lazio (13.85); while, the lower incidence rates of eco-crime have concerned Aosta Valley (1.62), Piedmont (2.81), Trentino (2.86), and Emilia R. (3.68).

Furthermore, during the same period the consumer price index (CPI) for food and non-alcoholic drinks increased significantly more in the south of Italy (+52.04%) than in the north of Italy (+38.42%), with a gap of 13.62% and an annual CPI gap of 0.76% (fig. 2). Considering the difference between Cosenza, i.e., the province with the largest CPI dynamics (+67.58%), and Milan, which we assume as the benchmark in the north, we measure an overall gap of 35.40% and an annual CPI gap of 1.97%. At regional level, the greater CPI dynamics concerns Campania (+58.33%), Calabria (+52.1%), Apulia (+48.15%), and Sardinia (+47.47%), while Tuscany (+34.43%), Lombardy (+37.1%), and Emilia Romagna (137.80) are characterized by the lower increases.

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[23] However, for some goods the increase is even bigger; e.g., the pork chop price per kg can increase by 552.38% from the field to the table, while the price of ham per kg can even grow by 2,194.39%. In particular, for each euro spent by consumers, 15.5% is for the farmer and 48.5% ends in the wholesale distribution (Coldiretti's elaborations on consumers Sms data - Ministry of Agriculture 2009). Generally, farmers earn 15-euro cents for every euro spent in production activities (Coldiretti-Eurispes 2017).

[24] E.g., according to Legambiente (2017), every year in the northern periphery of Naples (the so-called Land of Fires) there would be thousands and thousands of little and mid arsons. Furthermore, from 1991 to 2013 Mafias would dump 10 tons of toxic wastes in the same area, with a 400% increase of pathologies directly related to toxic contamination (Fazzo et al. 2008; Iengo and Armiero 2017). In particular, high incidence and mortality rates have been registered for bladder, laryngeal, liver, and lung cancer, and leukemia (Comba et al. 2014).

[25] In the four traditional mafia regions, they account for 47% of the overall environmental crimes.
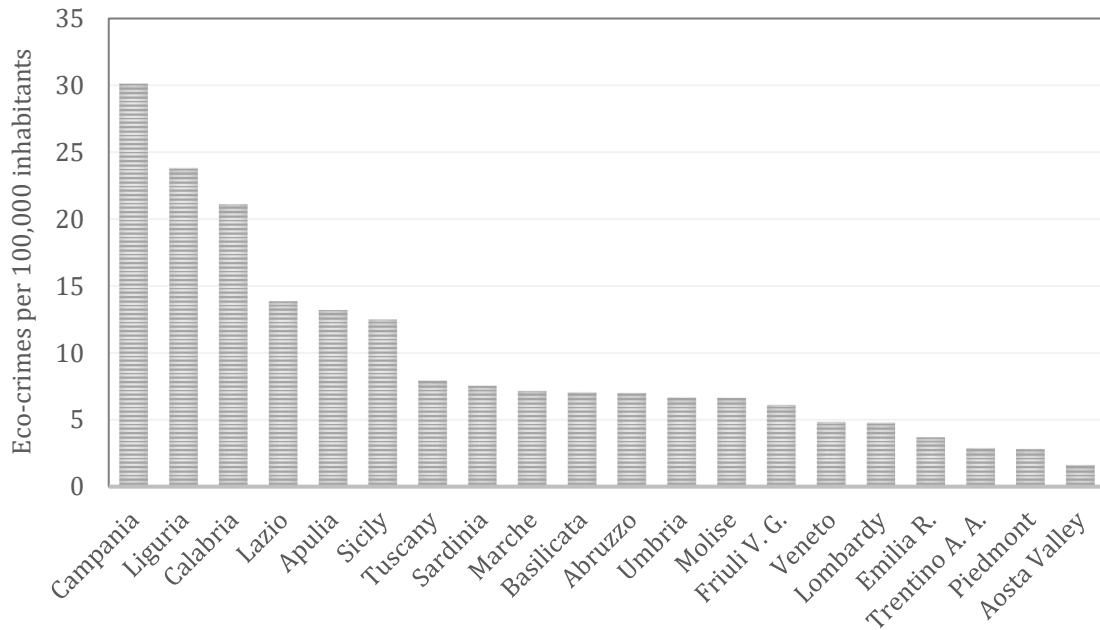
Fig. 1 Average eco-crimes (per 100,000 inhabitants) for Italian regions in 1998-2016 period. Source: own elaborations on Legambiente data (1999-2017). [created with excel]
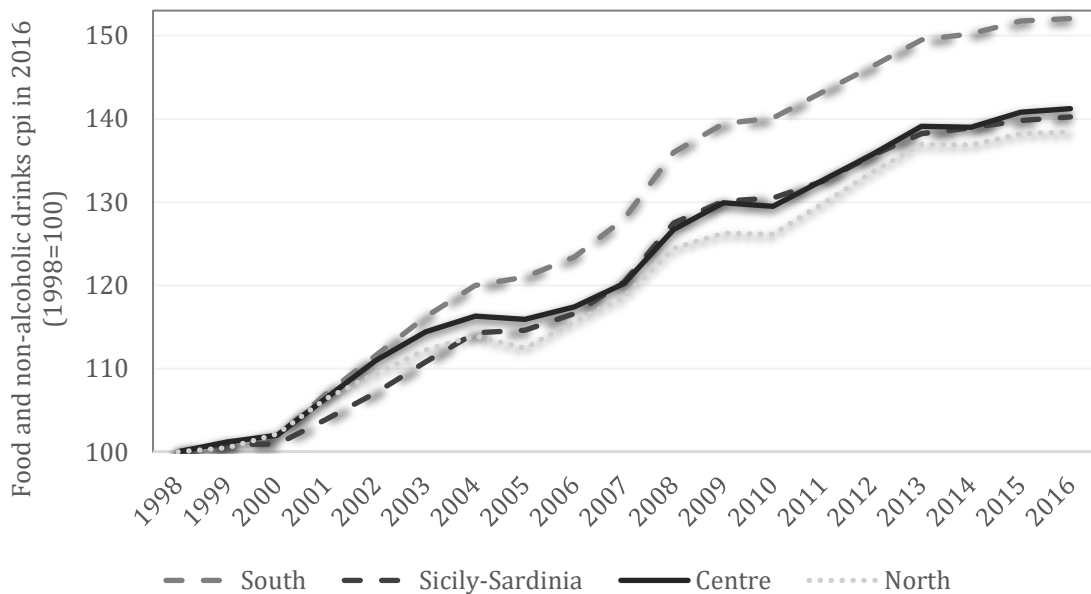
Fig. 2 Food and non-alcoholic drinks CPI in 2016 (1998=100) in the Italian macro-regions. Source: own elaboration on ISTAT data (1998-2016). [created with excel]

3 RELATED LITERATURE

As far as we know, this is the first paper that aims to investigate the specific link between Mafia's crimes and CPI dynamics. So, the closer literature this paper concerns is the interaction between organized crimes and two specific stakeholder of the industry's value chain: firms, and wholesalers and retailers.

About the first category, as stated by La Spina and Lo Forte (2006) the pressure of the organized crime can severely affect firm's efficiency and economic performance, by

increasing security and management costs. This is due to the predatory crimes like extortions and robbery, and the restrictions on freedom of initiative and market forces.

On this point, Dabla-Norris and Inchauste (2008) studied the correlation between the constraint posed by organized crime and the real sales growth of more than 9,300 firms in 27 transition countries in Eastern Europe and Central Asia. They estimated that in the period 2002-2005 Mafias negatively and strongly affected sales growth of informal firms, while they had no effect on formal firms. In particular, informal firms experienced a decrease of 2.5% in sales growth.

Centorrino and Ofria (2008) tried to estimate the effect of organized crime on labor productivity in Italian regions mostly affected by organized crime (Apulia, Calabria, Campania, and Sicily) in the period 1983-2005. Though the medium of the "Kaldor-Verdoorn" approach, they found that crimes negatively affect labor productivity, especially in non-tradable sectors.

Instead, Albanese and Marinelli (2013) analyzed the interaction between total factor productivity and Mafias. In particular, by using a production function for a sample of small and large Italian industrial and services firms, they find that organized crime has a negative impact on total factor productivity of all types of firm, without significative distinctions.

Similarly, Ganau and Rodrìguez-Pose (2018) by analyzing the link between 26,812 Italian SMEs'[26] (up to 250 employees) total factor productivity and quartile distribution of organized crime in Italy in the 2009-2013 period, estimated that when the value of organized crime increases from 1st percentile to 99th percentile of its distribution, the productivity growth – determined by a higher level of industrial clustering – drops from 4.4% to 1.1%. This is mainly due to three complementary dynamics: i) first of all, when Mafias establish their control over the territory by imposing *pizzo* or other illegal payments, they produce an increase in market transaction costs, neutralizing positive externalities derived from the interaction within firms and with local stakeholders; ii) secondly, Mafias can impose recruitment of unnecessary staff, and very expensive transport services and suppliers, that contribute to increase management costs and to reduce overall efficiency; iii) finally, Mafias can significantly distort "usual" competition by investing in apparently legal activities that have strong cost and price advantages, with negative effects on the profits of the firms that respect the law.

Furthermore, according to Caglayn et al. (2017), the presence of Mafia can also reduce innovation propensity of the firms: specifically, in the north of Italy a 1% positive change in the organized crime index is associated with a 1.3% drop in the number of patents, that are considered as a proxy for technology level. In fact, on the one hand the presence of Mafia causes a loss of competitiveness for incumbent firms, that results in a decrease of innovation and productivity[27]; and on the other hand, the possibility of using cheaper illegal services allows low productive firms to keep costs down and to stay in the market for longer.

About second category, we examine the link between agri-food sector and two specific crimes: extortions and money laundering. About extortions, Asmundo and Lisciandra (2008) – by analyzing court judgements and procedural documents about a sample of 2,286 firms – estimated that nearly 30% of Sicilian firms would have been forced to pay

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[26] About 9.72% of these firms belong to food and beverage industry.
[27] According to the authors, when Mafias are well-established in the socio-economic substratum, firms tend to interact with organized crime rather than pursue innovation strategy. Obviously, this leads to a decrease in innovation and competition.

pizzo monthly or periodically in the 1987-2007 period. Specifically, the *pizzo* averages 300 euros per month, and for 60% of Sicilian firms the extortions may not exceed 500 euros. Clearly, this phenomenon may have some effects on CPI. In fact, DNA (2008) stressed that in Palermo the extortion racket forces food and beverage retailers and wholesalers to be part of a cartel, in order to keep the sales price particularly high and to lighten the payment of *pizzo.*

Similarly, Di Gennaro and La Spina (2010), by analyzing 1,124 judicial documents, and 2,248 audio surveillance and telephone tapping, have estimated in 950 million euros the average annual withdrawal of monetary amount from the firms victimized by Camorra in the provinces of Napoli and Caserta, i.e. about 2% of their GDP.

According to Lisciandra (2014), who has analyzed both judicial and crime investigations survey about 1,117 Italian firms in the period 1988-2009, the most affected sectors are the following: retail and wholesale trade, and building construction, with a revenue of about 1.93 billion euros in the lower estimated scenario.

About retail and wholesale trade, the percentage of estimated extorted business in regions with traditional Mafia structure ranges from 39.67% of Apulia to 100% of Calabria, with Campania and Sicily that reach 82.69% and 55.15%, respectively. While, about non-traditional areas the higher values belong to Veneto (23.19%), Piedmont (19.04%), and Tuscany (18.07%)[28]. Furthermore, this large amount of money is usually moved to illegal or legal market through the medium of laundering. According to Beatrice (2009) and Di Gennaro (2018) extortions are often instrumental to impose Mafia's control of the legitimate systems.

In fact, in the final stages of the money laundering crimes, the so-called "integration", Mafia creates a veneer of legality by investing in apparently legitimate business activities, such as real estates, firms, and retailers (Bernasconi and Giunta 2011, p. 97; Alberti 2016; Fabrizi et al. 2017).

Moreover, a recent paper by Ardizzi (2014) estimated that overall money laundering is equal to 7.5% of GDP in the center-north of Italy and 5.1% of GDP in Mezzogiorno[29]. And according to Transcrime (2013), in 2000-2011 about 29.4% of organized crime's total investment was addressed to wholesale and retail distribution, with possible positive effects on price competitiveness of the Mafia's firms or that have strong links with organized crime[30]. In particular, as confirmed by Coldiretti-Eurispes (2013, 2015, 2017), Mafias tend to invest large fractions of their money in agri-food related activities. In fact, this sector has shown a great ability to address the crisis and to develop in an unfavorable cyclical climate[31].

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[28] As stated by the authors the percentage of extorted businesses should be only read with respect to businesses belonging to the weak economic subcategories.

[29] This evidence is confirmed by DNA (2016, p. 453), which attests that 45.91% of the 182,038 suspected monetary transactions recorded in 2015 concerned the north of Italy, while 26.49% and 27.60% stemmed from the center of Italy and Mezzogiorno, respectively.

[30] Mafia's firms are able to rely on huge competitive advantages, which we can sum up by cheap labor, tax evasion, unlimited financial resources available, extensive deregulation, and ability to attract public funding (Ravenda et al. 2015a, 2015b).

[31] In recent years there has also been a rapid increase of a mirror phenomenon, called "money dirtying". In other words, clean money is progressively invested in profitable criminal activities, especially related to agri-food sector. Mafias accept this kind of relationship because it allows to establish direct contact with institutional players, politicians, successful entrepreneurs, and to hide the drug money (Coldiretti 2013, 2015, 2017).

4 DATA AND EMPIRICAL METHODOLOGY

The main goal of the paper is to estimate the incidence of main Mafia illegal activities on food and non-alcoholic drinks CPI for the collectivity in 20 Italian regions and 80[32] Italian provinces. To achieve this goal, we use simple and multivariate cross-sectional OLS for the 1998-2016 period. The choice of cross-sectional data instead of a panel approach is justified by two different reasons: a) firs of all, the perception and the measurement of the Mafia system may considerable change in the short term because of its complexity (Calderoni 2011) and under-reporting bias due to *omerta*[33] (Pinotti 2015); b) secondly, the control and explanatory variables chosen for the analysis don't cover exactly the same time period. So, in order to have a more accurate and likely estimation of the phenomenon, we just implement the average values for each variable.

The choice of CPI as a measure of inflation could produce some bias connected to the combination of weighting and measurement, such as commodity substitution bias, quality adjustment bias, outlet substitution bias, and introduction of new goods (Bryan and Cecchetti 1993; Hausman 2003). In some cases, the differences between CPI and inflation may even reach 2% (Briscoe e Reckless 1994); in others, it does not exceed 0.5% (Sabourin 2012). However, even if the CPI tends to overstate the general rate of inflation, the first is the only and best measure available[34] (Boskin et al. 1998; Patel and Villar 2016).

At regional level, we just use an independent variable. Using data provided by Legambiente (1999-2017), we create an ad hoc eco-criminal pressure index for each region. The eco-crimes encompass four main categories: illicit waste trafficking, building speculation, crimes against forests, green areas and farmland, and offenses to the agri-food sector, animals and fauna[35]. It's important to stress that Legambiente doesn't provide data declined specifically for the agribusiness sector at regional level but just at national level, and just for the recent years. Since it's not possible to obtain the associated data, we jointly use all the four considered macro categories annually reported by Legambiente as a proxy for agribusiness crimes. So, each crime has the same weight[36].

Specifically, the index is compiled according to the following analytical method: i) we calculate the average of eco-crimes for every Italian region in the 1998-2016 period; ii) we standardize the data according to surface area (crimes per 100 sq. km.) and by population (crimes per 100,000 inhabitants); and 3) the respective outputs are switched to fixed-base indexes (with average=100), from whose arithmetic mean we achieve the

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[32] This limited sample is due to lack of observations for the considered period. In fact, according to ISTAT (2017) not all provinces periodically communicate the data on CPI. Wherever possible, we have reconstructed the partially missing historical series by using the regional data.

[33] This refers both to tacit and opportunistic support to the Mafia system (Mete 2011; Di Gennaro 2016), and to the fact that victims are usually afraid to report crimes to the police because of the Mafia's retaliations.

[34] In fact, ISTAT just provides data on CPI (https://www.istat.it/it/archivio/16333#1).

[35] In every case, it means all infringements found by the law enforcement. However, further details about these criminal offenses are specifically provided in the Appendix (Table 5).

[36] This is coherent with our analysis. In fact, toxic and hazardous wastes are usually buried in quarries, vast plains and arable land, with a subsequent damage to agriculture such as serious pollution, occupation of the land, and spread of animal infection and disease (Greyl et al. 2009; Legambiente 2017a). Moreover, building speculation and fires against forests and farmland can cause important soil erosion processes, hydrogeological instability, and loss of biodiversity (Legambiente 2017a, 2017b, 2017c). And according to Panagos et al. (2018), in Italy the soil erosion annually reduces agricultural productivity by 619 million euros.

eco-criminal pressure index (Table 6 in the Appendix). The structure of the index is represented by the following equation:

$$\text{Eco\_crime}_{region} = \text{Illicit Waste}_{trafficking} + \text{Building speculation} + \text{Forest}_{fires} + \text{Agri\_food}_{crimes} \quad [1]$$

First of all, in order justify the use of proxy variables for provinces[37], we begin to verify the link between environmental crimes and CPI at regional level. Specifically, we estimate the following simple regression equation (figure 3):

$$y = \beta_0 + \beta_1(\text{Ecocrime}) + \varepsilon \quad [2]$$

Where β_0 is the constant, Ecocrime represents the eco-criminal pressure index, and ε is the random error term. Model 1 is well specified, in fact Whyte (1980) and Shapiro-Wilk (1965) tests allow to accept null hypothesis: homoscedasticity and normality assumption of the residuals are both met. Moreover, the model is statistically significant; in fact, the Fisher-Snedecor distribution is equal to 29.2, far higher than the tabulated critical values at 1% level of significance (5.85).

Fig. 3 shows that data are not scattered at all but very well distributed around the regression straight line, except for Liguria, Tuscany, and Sicily, which are more below the regression line. In fact, the independent variable and regressor have a high positive correlation coefficient of 0.79 and a R-square of 0.62. Furthermore, the eco-criminal pressure index coefficient of 0.073 – which has a standard error of 0.014 – is statistically significant at a 1% level as well as the constant, which has a standard error of 1.58 (Table 1). Even if it is not possible to establish the direction of causality, the regression equation shows that each 10-points increase in the eco-criminal pressure index is correlated with a 0.73% increase in the food and non-alcoholic drinks CPI.

And the effect seems more pronounced for the southern regions, which appear graphically spread at the top right corner of the scatterplot. Among them, Campania and Calabria have the highest values, while Lombardy and Emilia Romagna are characterized by a lower dynamic both for the food and non-alcoholic drinks CPI and for environmental crimes. So, the evidence of a good biunivocal relationship between the two variables allows to deepen the analysis.

Variables	Coefficients	Student's T	p-value
Constant	135.248 (1.5817)	85.51	6.03e-025
Eco-crimes	.0733 (.0136)	5.404	3.91e-05
F-value		.0000	
Whyte (p-value)		.1141	
Shapiro-W. (p-value)		.1682	
Adjusted R^2		.6187	

Table 1 OLS regression between food CPI and eco-crimes for 20 Italian regions. Notes: Error standards in brackets.

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[37] Legambiente doesn't provide data for environmental crimes at the province level. Only in recent years, Legambiente has started to report data for a small sample of provinces.
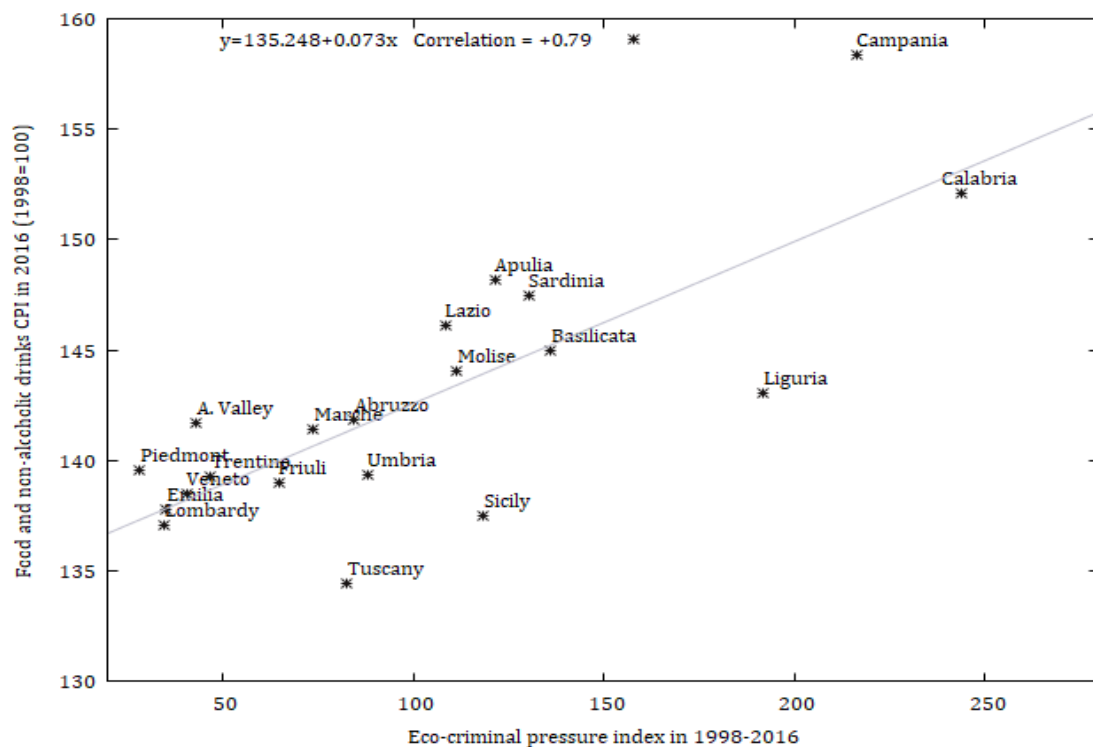
Fig. 3 OLS regression for 20 Italian regions in 1998-2016. Dependent variable: food and non-alcoholic drinks CPI in 2016. Source: own elaboration on ISTAT data (1998-2016) and Legambiente data (1999-2017). [created with gretl]

At province level, we use a set of control variables and a set of explanatory variables (Table 2). The control variables, which have been included to prevent endogeneity problems, are the following: the change in GDP per capita in the 2000-2016 period, the change in unemployment rates in the period 2004-2016, the average population density in the period 1998-2016, the average Gini index in the 2003-2015 period, the change in the agriculture, forest and fish value added per worker in the 2000-2014 period, the average uncultivated land in the 2000-2010, the farm size in 2000-2010, the farms/mass market retailers (MMR)[38] ratio in 2000-2016, and an institutional quality index for the so-called "rule of law". To this we add two dummies to control for regional and provincial specific features.

In particular, according to the so-called Engel's law (Engel 1857; Houthakker 1957; Kubicová and Kádeková, 2011), an increase in GDP per capita is associated with a less than proportional increase in the expenditures for food products; this should lead to a growth of food demand and to higher sales price. Consistently with the previous statement, a decrease in unemployment should increase GDP per capita and sales price.

About population density, Yegorov (2009) found that high population density is correlated with non-cooperative behavior; so, it can influence the demand for monopolistic products, with a possible positive effect on sales price. However, for other authors like Ricker-Gilbert et al. (2014), when markets are fully integrated, supply and demand factors don't significantly affect sales prices; the other way around, higher rural

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[38] Specifically, we mean minimarkets with sales surface area between 200 and 400 square meters, supermarkets with sales surface area of almost 400 square meters, and hypermarkets with sales surface area of almost 2,500 square meters (Ministry of Economic Development - Directorate General of Trade, Insurance and Services). About hypermarkets, we just refer to sales space devoted to food.

population density can have positive effects on food commodities prices, like maize. Cirera and Masset (2010) showed that elasticity of food consumption to the world Gini coefficient is equivalent to -1, so when world Gini coefficient decreases by 1%, food consumption per capita increases by the same percentage; so, this could lead to an increase in food prices via demand growth. About agricultural value added, an increase in the real value added per worker should cause an increase in competitiveness and productivity, by allowing to reduce prices at source. Instead, an increase in uncultivated lands should lead to a decrease of the supply of food, by increasing the associated sales price. About farm size, a large body of literature converge on the hypothesis of an inverse correlation between farm size and land productivity (Sen 1975; Van Zyl et al. 1995; Masterson 2007; Li et al. 2013). E.g., this may be due to the abundance of family labor force with very low opportunity cost, diminishing returns to scale, market imperfections, and a better process of selection of the farmers, that could lead to lower prices at source. Since the monopsony could affect prices more than crime, we consider also a variable describing the ratio between farms and sellers. Indeed, the ratio between farms and the whole number of MMR has the objective to measure the degree of monopsony power in the market; a higher index means a greater imbalance relation between farms and MMR, to the advantage of the latter, with a subsequent increase of sales price.

The inclusion of the rule of law is due the fact that a complete model on crime should have three dimensions: crimes, consequences, and policing. So, the rule of law allows to cover the latter dimension and control for under-reporting bias of crimes[39]. Finally, we control for the regions with traditional presence of mafia-type groups (dummy takes 1 for Apulia, Calabria, Campania and Sicily's provinces) and for the size of the provinces (dummy takes 1 if the provinces are the regional capitals). The regional/provincial dummies are useful to capture the idiosyncratic features that characterize Italian regions/provinces.

Specifically, as explanatory variables we implement the following indexes: the change in MMR in the 2001-2016 period, the average density of MMR in the 2001-2016 period, the average extortions rates in the 2000-2016 period, the average counterfeiting rates of brands and industrial goods in the 2004-2016 period, the average forest fires rates in the 2004-2016 period, the average contraband rates in the 2000-2016 period, the average all types of fire rates in the 2004-2016 period, the average money laundering rates in the 2004-2016 period, the average suspicious money transfers in the 2009-2016 period, a money laundering synthetic index obtained by considering the standardized mean of the previous two[40], and a synthetic eco-criminal pressure index built by using the most relevant Agromafia's crimes[41].

For the dependent variable, as usual, we implement the change in food and non-alcoholic drinks CPI for the collectivity in the 1998-2016 period. Additional descriptive statistics of the variables used in our analysis are presented in Table 7 in the Appendix.

Variables	Definitions	Sources
Independent variable		
CPI	Food and non-alcoholic drinks consumer price index in 2016 (1998 = 100)	ISTAT

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[39] Speaking of which, I'd like to thank an anonymous referee for the valuable suggestion.

[40] In fact, money laundering is usually one of the most under-reported crime. By using two different sources, we may partially correct this bias and obtain a more efficient index.

[41] The specific methodology and other details will be explained in Sect. 4.

Control variables		
GDP per capita	Change in GDP per capita (constant prices, PPP) in 2000-2016 (2000 = 100)	Eurostat
Unemployment	Absolute difference in unemployment rates in 2004-2016	ISTAT
Population density	Change in population density (inhabitants per square kilometer) in 1998-2016 (1998 = 100)	Eurostat
Gini index	Average Gini index in 2003-2015 (declined at regional level)	ISTAT
Agriculture V. A.	Change in Agriculture, forest and fish value added (constant prices) per worker in 2000-2015 (2000 = 100)	OECD
Uncultivated land	Average uncultivated land in % of total utilized agricultural area in 2000-2010	ISTAT (Agricultural Census 2000, 2010)
Farm size	Average farm size (hectares of UUA per farm) in 2000-2010	ISTAT (Agricultural Census 2000, 2010)
Farms/MMR	The ratio between the number of farms and the number of mass market retailers (minimarkets, supermarkets, and hypermarkets) in 2000-2016	ISTAT (Agricultural Census 2000, 2010), National observatory of Commerce
Rule of Law	An index that measures average provinces' rule of law performance[42] in 2004-2012	Nifo and Vecchione (2014)
Explanatory variables		
Mass Market Retailers (Change)	Change in the number of minimarkets, supermarkets and hypermarkets per 100,000 inhabitants in 2001-2016 (2001 = 100)	ISTAT, National observatory of Commerce
Mass Market Retailers (Density)	Average density (square meters) of minimarkets, supermarkets and hypermarkets per 1,000 inhabitants in 2000-2016	ISTAT, National observatory of Commerce
Extortions	Extortion rates per 100,000 inhabitants in 2000-2016	ISTAT
Counterfeiting	Counterfeiting rates of brands and industrial goods per 100,000 inhabitants in 2004-2016	ISTAT, Ministry of the Interior
Forest fires	Forest fires rates per 100,000 inhabitants in 2004-2016	ISTAT
All types of fire	All types of fire per 100,000 inhabitants in 2004-2016	ISTAT
Contraband	Contraband rates per 100,000 inhabitants in 2000-2016	ISTAT
Money laundering	Money laundering rates per 100,000 inhabitants in 2004-2016	ISTAT, Ministry of the Interior
Suspicious transactions	Average suspicious money transfers per 100,000 inhabitants in 2009-2016.	ISTAT, UIC (Italian Foreign Exchange Office)
Synthetic M. L.	A fixed-base index derived from the mean between standardized money laundering rates and suspicious transactions (mean = 100)	ISTAT, Ministry of the Interior, UIC
Eco-criminal Index		ISTAT and Ministry of the Interior

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[42] The rule of law is calculated by using the following variables: crimes against property, crimes reported, trial times, magistrate productivity, submerged economy, and tax evasion (Nifo and Vecchione 2014, p. 1633).

	An index built by using extortions, counterfeiting, forest fires, and contraband rates (Sect. 4)

Table 2 Definitions of variables used in OLS models.

5 An eco-crime ranking by provinces

In recent years an increasing number of official and academic actors have attempted to build synthetic measurement of the presence of the Mafias at regional and provincial level to quantify their economic costs (Daniele and Marani 2008; Censis 2009; Calderoni and Caneppele 2009; Calderoni 2011; Transcrime 2013; Coldiretti-Eurispes 2015, 2017). Among these, Coldiretti-Eurispes (2017) has estimated a detailed Agromafia pressure index at provincial level, which include many types of crimes, such as extortions, usury, money laundering, rustling, theft of agricultural products and machineries, damages to crop, and illegal grazing of livestock. However, this particular index refers only to 2016 and focus almost exclusively on crimes against farmers.

So, we propose an index that aim to capture the Agromafia's long term development and consider as far as possible the whole agri-food supply chain. Specifically, we use Agromafia's proxies to build a synthetic index at the province level and draw up a national ranking. We consider the most significant and consistent variables to eco-crimes: extortions, counterfeiting, forest fires, and contraband, each of which weighted by population (rates per 100,000 inhabitants). Since we can't discriminate between agri-food and other sectors, we use the overall data for each variable. And we set the following weights to the variables: 6/20 for extortions and forest fires; and 4/20 for counterfeiting and contraband. In fact, as previously showed, extortions to the agri-food supply chain actors and fires against forest and green areas are widely spread from many years (Dalla Chiesa 2013; Legambiente 1999-2017); so, probably they have a greater impact on food prices than counterfeiting and contraband, that have increased especially in the last few years (MiSe-Censis 2018). Furthermore, as previously stressed, extortions and forest fires can have a strong and direct impact on food prices. In fact, if the imposition of *pizzo* can lead to the formation of an economic cartel that contributes to increase food prices (DNA 2008), forest fires can significantly improve soil erosion (Legambiente 2017a, 207b), with consequent negative effects on agricultural productivity (Panagos et al. 2018).

Specifically, the values of the variables are switched to fixed based indexes (with average = 1), from whose weighted mean we achieve the eco-criminal pressure index. The structure of the index is represented by the following equation:

$$\text{Eco\_crime}_{\text{province}} = 0.3E_X + 0.3F_{\text{fires}} + 0.2C_{\text{ount}} + 0.2C_{\text{ontr}} \qquad [3]$$

Where E_x are the extortion rates per 100,000 inhabitants, F_{fires} are the forest fires rates per 100,000 inhabitants, C_{ount} means the counterfeiting rates of brands and industrial goods per 100,000 inhabitants, and C_{ontr} are the contraband rates per 100,000 inhabitants. As we can see from Table 3, the leading ten provinces for eco-crimes in Italy in the 1998-2016 period belong almost exclusively to southern regions, with the only exceptions of Latina and Genova. In particular, at the top of the ranking we find Naples (6.35) that has even a double value compared to the second ranked province, Cosenza (3.47). Furthermore, four provinces of Campania (Naples, Avellino, Benevento, and Caserta) are included in the top ten; so, as also stated by Coldiretti-Eurispes (2017), DNA (2017), and Legambiente (2017a), Agromafia crimes seem to be highly concentrated in this specific area.

While, if we consider the last ten provinces of the ranking, we notice that they all belong to northern regions. And in the second part of the ranking, from 41th to 80th position, we just find four southern provinces (Chieti, L'Aquila, Sassari, and Cagliari). Specifically, the ten top-ranked provinces have an average food CPI about 12% higher than that of the ten bottom-ranked provinces. Overall, southern provinces have an average eco-crime index of 1.8 and a CPI of 147.39, respectively 1.05 points and 8.19% above center-north provinces.

However, it's necessary to stress that Agromafia's crimes also concern some provinces of center-north regions, such as Lazio, Tuscany, and Liguria. As shown in the previous paragraph, this output is also consistent with the food and non-alcoholic drinks CPI dynamics of the most of their provinces. E.g., La Spezia, Latina, and Pisa, which belong respectively to Liguria, Lazio, and Tuscany, have an average CPI of +48.31%, i.e., about 7.2 percentage points above the average for Italian provinces (41.14%); and an average eco-crime index of 1.89, i.e., 0.89 points above the mean.

Provinces	Index	Provinces	Index
1 - Naples	6.3487	41 - Chieti	0.7697
2 - Cosenza	3.4730	42 - Trieste	0.7536
3 - Latina	2.8060	43 - Perugia	0.7449
4 - Brindisi	2.6924	44 - Siena	0.7186
5 - Avellino	2.6246	45 - Alessandria	0.6962
6 - Benevento	2.4119	46 - Macerata	0.6492
7 - Reggio Calabria	2.1289	47 - Bergamo	0.6391
8 - Caserta	2.1285	48 - Forlì-Cesena	0.6223
9 - Genova	2.0817	49 - L'Aquila	0.6223
10 - Bari	1.9788	50 - Vercelli	0.6184
11 - La Spezia	1.6792	51 - Varese	0.6043
12 - Sondrio	1.6725	52 - Parma	0.5975
13 - Foggia	1.6636	53 - Novara	0.5973
14 - Savona	1.6562	54 - Sassari	0.5463
15 - Matera	1.4644	55 - Asti	0.5318
16 - Rome	1.2824	56 - Milano	0.5233
17 - Pisa	1.1983	57 - Torino	0.5212
18 - Campobasso	1.1695	58 - Gorizia	0.5186
19 - Lucca	1.1688	59 - Verona	0.5031
20 - Grosseto	1.1639	60 - Cuneo	0.4853
21 - Massa	1.1046	61 - Pesaro Urbino	0.4664
22 - Potenza	1.0996	62 - Cagliari	0.4549
23 - Livorno	1.0708	63 - Piacenza	0.4501
24 - Palermo	1.0320	64 - Lecco	0.4364
25 - Viterbo	0.9612	65 - Rovigo	0.4031
26 - Ancona	0.9219	66 - Ferrara	0.3978
27 - Pistoia	0.9038	67 - Bolzano	0.3697
28 - Arezzo	0.8786	68 - Padua	0.3643
29 - Ravenna	0.8645	69 - Belluno	0.3573
30 - Bologna	0.8573	70 - Aosta Valley	0.3534
31 - Como	0.8400	71 - Udine	0.3516

32 - Syracuse	0.8384	72 - Mantua	0.3381
33 - Ascoli	0.8379	73 - Pavia	0.3278
34 - Florence	0.8349	74 - Modena	0.3153
35 - Biella	0.8221	75 - Trento	0.3114
36 - Venice	0.8206	76 - Cremona	0.3094
37 - Brescia	0.8117	77 - Reggio Emilia	0.2971
38 - Rimini	0.8106	78 - Vicenza	0.2682
39 - Trapani	0.7931	79 - Pordenone	0.2469
40 - Terni	0.7866	80 - Lodi	0.2342

Table 3 Eco-crimes ranking for 80 Italian provinces in the 1998-2016 period. Source: own elaborations on ISTAT data (2000-2016) and Ministry of the Interior data (2004-2010).

6 Empirical results

At the province level, we estimate four OLS models using the following variables:

$$y = \beta_0 + \beta_1(\text{GDP}) + \beta_2(\text{U}) + \beta_3(\text{P}_d) + \beta_4(\text{Gini}) + \beta_5(\text{A}_{va}) + \beta_6(\text{U}_{land}) + \beta_7(\text{Size}) + \beta_8\left(\frac{\text{Farms}}{\text{MMR}}\right) + \beta_9(\text{Law}) + \beta_{10}(\text{MA}_c) + \beta_{11}(\text{MA}_d) + \beta_{12}(\text{E}_x) + \beta_{13}(\text{C}_{ount}) + \beta_{14}(\text{F}_{fires}) + \beta_{15}(\text{C}_{ontr}) + \beta_{16}(\text{A}_{fires}) + \beta_{17}(\text{M}_l) + \beta_{18}(\text{S}_t) + \beta_{19}(\text{S}_{ml}) + \beta_{20}(\text{E}_{crime}) + \beta_{21}(\text{dummy}) + \varepsilon$$
[4]

Where β_0 is the constant, GDP is the change in GDP per capita, U is the absolute difference in unemployment rates, P_d is the population density, Gini is the average Gini index, A_{va} is the change in agriculture, forest and fish value added per worker, U_{land} is the average uncultivated land, Size is the average farm size, Farms/MMR means the degree of monopsony power in the market, Law means the rule of law, MA_c is the change in MMR, MA_d is the change in MMR density, E_x are the extortion rates per 100,000 inhabitants, C_{ount} means the counterfeiting rates of brands and industrial goods per 100,000 inhabitants, F_{fires} are the forest fires rates per 100,000 inhabitants, C_{ontr} are the contraband rates per 100,000 inhabitants, A_{fires} are all types of fire reported per 100,000 inhabitants, M_L are the money laundering rates per 100,000 inhabitants, S_T are the suspicious money transfers per 100,000 inhabitants, S_{ML} is a synthetic index obtained from the normalization of the previous two, E_{crime} is the eco-criminal pressure index for each province, dummy is the control for regional/provincial features, and finally ε is the random error term.

Variable	Model 1	Model 2	Model 3	Model 4
Constant	5.0367***	5.0187***	5.0083***	4.9168***
	(.1378)	(.1376)	(.1391)	(0.1339)
GDP per capita	-.0007	-.0005	-.0007	-.0008
	(.0005)	(.0005)	(.0005)	(.0005)
Unemployment	.0002	.0000	.0007	-.0002
	(.0019)	(.0019)	(.0019)	(.0019)
Pop. Density	.0000	-.0000	.0000	-.0000
	(.0000)	(.0000)	(.0000)	(.0000)
Gini index	-.1848	-.0829	-.1736	.2335
	(.3568)	(.3546)	(.3626)	(.3512)
Agricultural V.A.	.0003**	.0003*	.0003*	.0002*
	(.0001)	(.0001)	(.0001)	(.0001)
Uncultivated land	.0013	.0008	.0010	.0007

	(1)	(2)	(3)	(4)
	(.0011)	(.0011)	(.0011)	(.0012)
Farms size	.0012	.0007	.0011	.001
	(.0007)	(.0007)	(.0007)	(.0007)
Farms/MMR	.0000	-.0000	.0000	.0000
	(.0000)	(.0000)	(.0000)	(.0000)
Rule of Law	-.078***	-.0902***	-.0692**	-.0686**
	(.028)	(.0287)	(.028)	(.0285)
Mass M. R. (Change)	.0000	.0000	.0000	.0000
	(.0000)	(.0000)	(.0000)	(.0000)
Mass M. R. (Density)	-.0000	-.0000	.0001	.0000
	.0001	(.0000)	(.0000)	(.0000)
Extortions	.0069***	.0063***	.0061***	
	(.0019)	(.0019)	(.0018)	
Counterfeiting	.0025***		.0027***	
	(.0008)		(.0008)	
Forest fires	.0011**		.001**	
	(.0005)		(.0005)	
Contraband		.0029***		
		(.0010)		
All types of fire		.0012***		
		(.0004)		
Money Laund.	-.0063**	-.0053*		
	(.0031)	(.0031)		
Suspicious Trans.	-.0005***	-.0004**		
	(.0002)	(.0002)		
Synthetic M. L.			-.0004***	
			(.0001)	
Eco-crime index				.0343***
				(.0075)
Dummies	Yes	Yes	Yes	Yes
N.	80	80	80	80
F-value	.0000	.0000	.0000	.0000
Whyte (p-val.)	.5455	.5528	.4472	.3360
Shapiro-W. (p-val.)	.1547	.8665	.3139	.5483
Adjusted R^2	.4917	.4932	.4750	.4290

Table 4 OLS regressions between organized crime and food and non-alcoholic drinks CPI. Notes: Standard Errors in brackets. Significance level: *p-value < 0.10; **p-value < 0.05, ***p-value < 0.01. We control for the regions with traditional presence of mafia-type groups (dummy takes 1 for Apulia, Calabria, Campania and Sicily's provinces) and for the size of the provinces (dummy takes 1 if the provinces are the regional capitals).

In order to correct the violation of the normality assumption, we consider the logarithm of the food and non-alcoholic drinks CPI. Table 4 shows that all the OLS models are well specified, in fact both Whyte (1980) and Shapiro-Wilk (1965) tests allow to accept the null hypothesis. So, the normality and homoscedasticity assumptions of residuals are both met.

Moreover, the models are always statistically significant; in fact, the Fisher-Snedecor distributions of model 1, 2, 3 and 4 are respectively 5.24, 5.27, 5.2 and 5.24, far higher than the tabulated critical values at 1% level of significance. To this must be added that the explanatory power of models ranges from 0.43 to 0.49.

All the regression models include the nine control variables and two territorial dummies. Specifically, in model 1 we add extortions, counterfeiting, forest fires, money laundering and suspicious money transfers. Among crimes, extortion rates have the strongest positive effect on food and non-alcoholic drinks CPI and a coefficient of 0.0069, which is statistically significant at the 1% level. In the same way, the counterfeiting rates of brands and industrial goods and forest fires rates seem to be positively correlated to CPI dynamics, with coefficients statistically significant at the 1% and 5% level, respectively. However, the size of coefficient is just 0.0025 for counterfeiting rates and 0.0011 for forest fires rates, two values lower than that for the extortion rates, so their impact on CPI is weaker.

By contrast, the money laundering and suspicious money transfers rates are negatively correlated to the CPI with coefficients respectively of -0.0063 and -0.0005, and these are statistically significant at the 5% and 1% level, respectively. In other words, it seems that illegal firms would have a strong cost advantage that causes a crowding out of commercial competition, and that carries out a centrifugal force against firms in the local economic cluster, which don't adapt to the new prices. In fact, the most part of economic resources stolen from southern regions are usually reinvested in illegal and illicit firms in northern regions (DIA 2016; DNA 2016, 2017). About the control variables, only two variables are significant: specifically, agricultural value added is positively correlated to the CPI, while rule of law is inversely correlated to the CPI dynamics.

In the first case the positive relationship between agricultural value added per worker and CPI may indicate that although southern provinces have improved more rapidly their long-term economic performance, they aren't able to use this competitive advantage because of the costs that organized crime imposes on the firms. In fact, in southern provinces agricultural value added per worker increased by 24.93% in the 2000-2015 period, about 17.7 percent more than central and northern provinces (+7.23%).

About the rule of the law, the negative interaction with CPI seems to be implicitly consistent with the previous output. When the authority of the law tends to decrease, the pressure of organized crime becomes larger, with a stronger effect on CPI.

In model 2 we add contraband and all types of fire but excluded counterfeiting and forest fires. The first two variables show a positive and strong correlation to food and non-alcoholic drinks CPI, even if the coefficients are lower than for extortions. In fact, the coefficient for contraband and all types of fire are respectively 0.0029 and 0.0012, and they are both statistically significant at the 1% level. For the remainder, the model completely confirms the previous output, with the only exception of statistical significance of agricultural value added, money laundering, and suspicious money transfers, which drops to 10% for the first two, and to 5% for the latter. To this must be added that the first two models confirm the complementary relationship between contraband and counterfeiting crimes: both are directly and strongly related to food CPI[43].

In Model 3, after excluding contraband, all types of fire, money laundering and suspicious transactions, we include extortions, forest fires and the synthetic index for money laundering. The latter is negatively correlated to CPI, with a coefficient of -0.004 and a statistical significance level of 1%. So, the synthetic money laundering index obtained by standardization mean of money laundering and suspicious transactions, allows to increase statistical significance from 5%-10% to 1%. It's confirmed the absence of statistical

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[43] As also shown in Table 9 in the Appendix.

significance for the control variables, with the exception of the agricultural value added and rule of law, which are statistically significant at the 10% and 5% level, respectively. Finally, in the model 4 we include the eco-criminal pressure index and remove all the other criminal offenses. Eco-crimes show a strong and positive correlation with CPI; in fact, they assume a coefficient of 0.0343, with a statistical significance level of 1%. Moreover, this index allows approximately to explain 43 percent of the CPI variability by itself. It's a very interesting output, even in light of the fact that farms/MMR ratio is not significant at all (as in all models). So, we can state that the degree of monopsony power in the market doesn't affect food prices[44], and the eco-crimes index is a good measure for Agromafia phenomenon. For the remainder is confirmed the previous output (model 3).

7 Conclusive remarks

This paper shows that the proposed eco-criminal pressure index may explain a good deal of the CPI variability in the 1998-2016 period. In particular, among the Agromafia's crimes, extortions and money laundering are the most influential variables, followed in order of decreasing by contraband, counterfeiting, forest fires, all types of fire, and suspicious money transfers. However, if extortions, contraband, counterfeiting, and fires are positively related to CPI, money laundering indexes are negatively correlated to CPI dynamics.

Environmental crimes may severely affect the Italian agri-food sector's supply chain, specifically causing two main economic consequences: 1) a significant increase in the food and non-alcoholic drinks CPI, especially in the southern regions; and 2) a distortion of "usual" competition in food wholesale and retail trade through the medium of a strategy of selling below-cost prices.

The first consequence incurs damages both for legal agri-food firms and for consumers. In fact, for stakeholders, as stated by Konrad and Skaperdas (1998), and Kumar and Skaperdas (2008), the Mafia represents a negative externality that causes an increase in management costs and a reduction and distortion of investments[45] and total earnings. Additionally, these effects do not concern Mezzogiorno exclusively, but also some non-traditional areas, like the provinces in Liguria and Lazio; an output consistent with Asmundo (2011), Gunnarson (2015), Ganau and Rodrìguez-Pose (2017), and Perone (2018). For consumers, a strong and incessant increase in food CPI may considerably reduce their purchasing power, with important social and redistributive effects. This is particularly true in Mezzogiorno, where the relative poverty rate has reached 24.3% in 2017, about four times as much as the rate (5.9%) for the north of Italy (ISTAT 2018c, p. 12). In fact, as stated by Blisard and Steward (2007) and Wiggins and Levy (2008) low income households usually spend a higher share of their budgets on food than do higher

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[44] As is well known, the power market along the value chain is not an easy characteristic to investigate. This is confirmed both by Borenstein et al. (1997) and McLaren (2015), which use different approaches to study the phenomenon, and achieve different results. In particular, Borenstein et al. (1997) use cumulative adjustment functions, while McLaren (2015) use a price up dummy. About results, Borenstein et al. (1997) show the presence of asymmetry in the response of the retail gasoline prices to crude oil price changes, compatible with the presence of short-run market power among retailers, and McLaren (2015) confirms the presence of asymmetric price transmission from international to local agricultural markets, consistent with the presence of large intermediaries with monopsony power.

[45] Usually, in traditional criminal areas, firms invest their economic resources in equipment and activities that are unlikely to be destroyed or looted by the Mafia (Kumar and Skaperdas 2008, p. 13-14).

income households. So, they may be forced to reduce their intake of more nutritious food, or drop the expenditure on other basic needs, such as health care or education. So, this may result in a reduction of food demand and in a shift from animal source foods to cheaper foods, such as cereals, eggs, fats, and oils (Green et al. 2013).

About second consequence, in the center-north of Italy, money laundering seems to reduce the CPI through the reinvestment of illicit proceeds in firms with strong cost advantages. In fact, the largest part of economic resources stolen from traditional areas are usually reinvested in apparently legal business in northern Italy, especially in wholesale and retail distribution. So, it is possible to hypothesize that the rewards position of illegal firms causes a reduction in prices for food and non-alcoholic drinks. In particular, the presence of this kind of firms could favor the emergence of cartel pricing practices that crowd out existing investors and distort competition.

Definitively, Agromafia cannot be regarded merely as a southern problem, but it should be addressed from a national point of view. In fact, on the one hand the pressure of organized crime is gradually distorting "normal and acceptable" bargain among economic agents and reducing consumer purchasing power, and the other hand it represents a serious threat to public health and a hideous crime against nature.

This is a key point both because agri-food sector represents a fundamental part of the Italian's production base, and because it's able to attract large amounts of capital and to kick-start sustained growth (De Filippis 2012; ISMEA 2018). So, it's necessary to put in place as quickly as possible an agreed plan of action between public bodies and civil society, which allows not only to free the agricultural supply chain from any criminal interference, but also to recover a full socioeconomic and military control over the territory.

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Appendix

Table 5 Description of the variables used to build the eco-criminal pressure index at regional level.

Eco-crimes categories	Description	Source
Illicit waste trafficking	It includes all crimes related to illegal waste management and illegal disposal of hazardous wastes. Wastes can be used as fertilizer or buried in cultivated lands, roads, quarries, building sites, and in the sea.	Legambiente (2017a, 2017c)
Building speculation	It includes all crimes related to illegal buildings and other buildings constructed without a building permit.	Legambiente (2017a, 2017c)
Crimes against forests, green areas and farmland	It includes all fires against forests, green areas, pasturelands, and cultivated lands.	Legambiente (2017a, 2017b)
Offenses to agri-food sector, animals and fauna	It especially includes food frauds, counterfeiting and Sounding of Italian food, crop production from polluted lands, livestock rustling, and clandestine slaughter.	Legambiente (2017a)

Table 6 Standardization of environmental crimes for Italian regions in the 1998-2016 period.

Regions	Eco-crimes per 100,000 inhabitants	Eco-crimes per 100 sq. Km. (1998-2016)	Eco-criminal pressure index (1998-2016)
Piedmont	2,81	16,48	16,48
Aosta Valley	1,62	42,2	42,2
Liguria	23,81	81,93	81,93
Lombardy	4,78	11,98	11,98
Trentino A. A.	2,86	38,77	38,77
Veneto	4,84	18,63	18,63
Friuli V. G.	6,11	40	40
Emilia R.	3,68	19,48	19,48
Tuscany	7,93	50,23	50,23
Umbria	6,65	64,96	64,96
Marche	7,15	44,4	44,4
Lazio	13,85	43,85	43,85
Abruzzo	6,99	58,33	58,33
Molise	6,63	93,46	93,46
Campania	30,14	71,48	71,48
Apulia	13,2	63,72	63,72
Basilicata	7,03	121,11	121,11
Calabria	21,11	162,4	162,4
Sicily	12,5	64,52	64,52
Sardinia	7,54	110,74	110,74
North	6,31	33,68	33,68
Center	8,9	50,86	50,86

Mezzogiorno	13,14	93,22	93,22
Italy	9,56	60,93	60,93

Source: own elaboration on ISTAT database (1998-2016) and Legambiente data (1999-2017).

Table 7 Some descriptive statistics for Italian provinces (1998-2016).

Variables	Obs	Mean	St. Dev.	Min	Max
Food CPI	80	141.1	6.897	128.7	167.6
GDP per capita	80	115.6	9.631	98.64	142.9
Unemployment	80	3.955	2.443	-1.810	13.13
Pop. density	80	269.7	373	38.21	2642
Gini index	80	0.275	0.021	0.247	0.325
Agricult. V.A.	80	111.4	34.78	52.26	274.1
Uncultivated L.	80	3.887	3.844	0.541	33.3
Farm size	80	10.14	7.005	1.232	37.22
Farms/MMR	80	153.69	140.88	4.389	760.51
Rule of law	80	0.602	0.173	0.158	0.97
$MMR_{(Change)}$	80	156.8	91.89	61.01	780.2
$MMR_{(Density)}$	80	225.4	62.66	86.75	359.3
Extortions	80	9.504	3.383	5.1	24.45
Counterfeiting	80	7.189	6.762	1.065	42.84
Forest fires	80	7.255	11.11	0.08	67.44
Contraband	80	2.49	6.829	0.0	56.15
All types of fire	80	17.99	15.19	5.293	95.697
Money Launder.	80	2.268	1.545	0.49	8.19
Suspicious Tran.	80	87.33	31.42	42.47	220.4
Synthetic M. L.	80	100.0	41.703	42.758	249.56
Eco-criminal Index	80	1.0	0.903	0.234	6.349

Obs: Observations. St. Dev: Standard deviation. Min: Minimum. Max: Maximum.

Table 8 Variance inflation factor (VIF) for OLS models.

Variables	Model 1	Model 2	Model 3	Model 4
GDP per capita	1.331	1.32	1.331	1.297
Unemployment	1.478	1.416	1.456	1.345
Pop. density	2.384	3.591	2.12	2.454
Gini index	3.792	3.756	3.791	3.27
Agricultural V.A.	1.385	1.38	1.378	1.352
Uncultivated L.	1.242	1.266	1.211	1.198
Farm size	1.78	1.585	1.78	1.635
Farms/MMR	3.818	3.917	3.724	2.742
Rule of Law	1.615	1.702	1.562	1.486
$MMR_{Change)}$	1.534	1.537	1.484	1.462
$MMR_{(Density)}$	2.855	2.797	2.814	2.364
Extortions	2.744	2.785	2.569	
Counterfeiting	2.142		2.102	
Forest fires	1.998		1.996	
Contraband		3.051		
All types of fire		2.998		
Money Laund.	1.596	1.584		
Suspicious Trans.	2.035	2.172		
Synthetic M. L.			2.086	
Eco-criminal Index				2.823

Table 9 Correlation matrix, using observations 1-80; 5% critical values (two-tailed) = 0.2199 for n=80.

GDP	U	P_o	Gini	A_{va}	U_{land}	Farm size
1.0	-0.0724	0.1221	-0.2334	0.0019	0.0935	-0.1395
	1.0	-0.0225	0.1247	0.0856	0.1521	-0.1226
		1.0	0.2073	0.0866	-0.1785	-0.081
			1.0	0.232	-0.0976	-0.1382
				1.0	-0.097	-0.2652
					1.0	-0.0519
						1.0

Farm/MMR	R. of Law	MMR_c	MMR_d	E_x	C_{ount}	F_{fires}
-0.0747	-0.0004	0.0801	0.1686	-0.0731	0.1686	-0.0904
-0.0351	-0.024	-0.2731	0.0074	0.1127	0.0074	0.2153
-0.2856	-0.2162	-0.0412	0.5195	-0.1852	0.5194	-0.1601
0.439	-0.2925	0.3301	0.3060	0.5752	0.306	0.3674
0.3291	0.1747	0.0594	0.1072	0.1336	0.1072	0.1815
-0.015	0.1555	-0.0877	-0.0930	-0.0592	-0.093	0.0135
-0.2224	0.1795	-0.1606	-0.2373	-0.2718	-0.4196	-0.3242
1.0	-0.0158	0.2188	0.1264	0.3649	-0.0123	0.6289
	1.0	-0.2224	-0.3991	-0.2206	-0.2373	-0.1068
		1.0	0.4657	0.2913	0.1264	0.0777
			1.0	-0.4736	-0.3991	-0.4326
				1.0	0.4197	0.2951
					1.0	0.068
						1.0

C_{ontr}	A_{fires}	M. L.	S_T	Eco_{crime}	CPI	
0.0639	-0.0946	0.2254	0.1121	0.0192	-0.2052	GDP
0.0355	0.1676	0.0878	-0.0117	0.1461	0.0898	U
0.6699	-0.1347	0.205	0.4945	0.4556	0.1532	P_o
0.3986	0.5051	-0.0709	-0.1077	0.561	0.5176	Gini
0.1822	0.2195	-0.0947	-0.0878	0.2412	0.2577	A_{va}
-0.0499	-0.0446	-0.0586	0.0348	-0.0503	-0.0553	U_{land}
-0.2623	-0.3539	-0.1918	0.0098	-0.444	-0.208	F. Size
-0.0051	0.7227	-0.0978	-0.352	0.3576	0.3731	F/MMR
-0.1104	-0.1962	-0.185	-0.1654	-0.197	-0.2788	Law
0.1552	0.171	0.0801	-0.1856	0.1946	0.2359	MMR_c
-0.3424	-0.5034	-0.2164	-0.1225	-0.5673	-0.3389	MMR_d
0.3899	0.5062	0.3038	0.1667	0.5928	0.5434	E_x
0.7602	0.1224	0.3337	0.2355	0.7544	0.4064	C_{ount}
-0.0075	0.9324	-0.0082	-0.168	0.5535	0.4288	F_{fires}
1.0	0.0531	0.1658	0.1239	0.8082	0.426	C_{ontr}
	1.0	0.0524	-0.1771	0.5922	0.5283	A_{fires}
		1.0	0.209	0.202	-0.0289	M. L.
			1.0	0.0585	-0.14	S_T
				1.0	0.626	Eco_{crime}
					1.0	CPI