

Sticks, Carrots, and Environmental Crime

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ABSTRACT

This paper investigates the effect of legal deterrence (sticks) and economic conditions (carrots) on environmental crime in Italy. We have a unique dataset of environmental crime by type (wastewater, waste, construction, landscape, and forest fires) across regions for the decade 2006-2016. Considering that, albeit scant, a first recent literature on environmental crimes in Italy has already begun to study the relationship between economic growth, socio-economic variables, and environmental crime, our analysis is committed to explore the extent to which enforcement and deterrence variables can have an impact on the phenomenon under observation. Consistent with the law and economics literature, our empirical findings show evidence that both economic conditions and enforcement efforts are effective tools for the fight against environmental crime and thus support policy makers to better target environmental crime-control policies in Italy. Interestingly, we also find that environmental enforcement takes heterogeneous paths in the different Italian regions.

Keywords: environmental crime, enforcement, Italy.

JEL classifications: Q53, K32.

1. Introduction

Over the last decade, in Italy, the increase of criminal environmental protection regulations and the growing attention to environmental issues have led to a greater number of criminal proceedings that went from almost 4.800 in 2007 (the Environmental Code entered into force in 2006) to almost 13.000 in 2014, dropping slightly, in 2016, to just over 10.000, right after the enactment of a new law on eco-crimes (Law 68/2015) which introduced a new set of environmental crimes. Environmental crime is a high profit, low risk, and low-visibility offense, which offers growing opportunities, and in Italy, in particular, eco-mafia has become a big business (Sollund, Stephe, Germani, 2016) occupying a wide range of economic sectors (e.g., waste, agri-food, construction, forest fires, wildlife and cultural heritage). According to Legambiente (2021),¹ the Covid-19 pandemic did not stop environmental criminals, and, in 2020, despite

¹ Legambiente is the most prominent Italian environmental NGO (<https://www.legambiente.it/english-page/>).

a decrease in inspections and investigations (-17%), environmental crimes reached almost 35.000 (+ 0.6% compared to 2019), with a 0.6% rise in eco-mafia cases with respect to 2019. The impact of environmental crime continues to grow in the Southern regions with a traditional mafia presence (47% of the total) and both people reported (+ 12%) and those arrested (+ 14.2%) increased in 2020 compared to 2019.

Notwithstanding the evident impact of environmental crimes in Italy,² actions against environmental crime still remain hindered by a number of political issues related to the current legislative and operative frameworks.³ Several studies (for a comprehensive review see Chalfin and McCrary, 2017) have identified the most effective enforcement models in an attempt to shape, on one side, the incentives that could induce compliance with the law and, on the other side, the deterrents that could influence criminal behaviors. Incentives can be classified as both ‘carrot’ and ‘stick’ (Corman and Mocan, 2005): more opportunities in the illegal environmental market may induce individuals to join criminal activities, whereas higher detection and trial rates may discourage individuals and firms from committing unlawful conducts.

Despite the socio-economic and environmental relevance of environmental crime, a gap emerges in the empirical literature on its determinants (Castaldo *et al.*, 2021; Germani *et al.*, 2020) and, above all, on the specificities of different types of environmental crime. Against this background, the main motivation behind this study is to explore whether the types of deterrence and socio-economic conditions found to be relevant in general crime literature could be also pertinent to the study of environmental crime in Italy. In other words, we aim to deepen our understanding on the relevant economic factors (such as wages, unemployment, poverty) and judicial and enforcement characteristics, that could encourage or deter environmental compliance across Italian regions, making a contribution towards filling this gap in the literature. Environmental authorities, in Italy, have been (and are currently) largely dominated by an enforcement model based on the sticks – which are applied upon violation - rather than the carrots – which are applied upon compliance - and on a general tendency towards the tightening of sanctions rather than towards the provision of incentives rewarding regulatory compliance; actions taken at institutional level have, in fact, generally seen the prevalence of ex-post (repressive) measures rather than ex-ante (preventive) provisions (Nicotra and Salanitro, 2010).

² A notable case includes the “Land of Fires” in Campania, Italy, where systematically, since the end of the 1980s, toxic waste has been illegally burnt and buried by the criminal organizations.

³ The Italian Environmental Code, both in its original 2006 version and in the latest 2019 update, does not include any definition of environmental crime. Law 68/2015 introduced into the Italian criminal code the notion of “Crimes against the Environment”, listing a series of critical offences and also addressing the involvement of organised crime, yet failing to provide a comprehensive definition including, for instance, wildlife trafficking.

We conduct an empirical analysis of the determinants of environmental crime using both socio-economic and legal variables. Specifically, we use a panel dataset (ISTAT - Italian Statistical Agency) at regional level in Italy from 2006-2016, on the environmental criminal proceedings related to i) waste violations, ii) wastewater violations, iii) landscape violations, iv) violations in the construction sector, and v) forest fires. Using a panel fixed effects model, we find that enforcement and judicial variables have a statistically significant effect on environmental crime while controlling for regional economic characteristics and type and area fixed effects. The remainder of the manuscript is organized as follows. In section 2, we frame the contribution of our manuscript within the relevant literature. In Section 3, the data are presented together with the econometric methodology. Estimation results are discussed in section 4. Section 5 outlines our conclusions and policy implications.

2. Economic and deterrence conditions on crime

Since Becker's (1968) pioneering work based on the rational decision of a utility-maximizing individual who decides whether or not to commit a crime, taking into account the probability of being detected and punished and the magnitude of the sanction,⁴ the economics of crime has shifted toward a more flexible and interdisciplinary approach (Argentiero *et al.*, 2020) in which several socio-economic and demographic variables can play a role in explaining criminal offences (e.g., Fajnzylber *et al.*, 2002; Buonanno and Leonida, 2009; Glaeser and Sacerdote, 1999). Much of the research on the economics of crime has been conducted on the economic model of crime in general (see Chalfin and McCrary, 2017) and only a part of it has investigated, more specifically, environmental crime focusing on deterrence and compliance (Almer and Goeschl, 2015, 2010; Eckert, 2004; Ogus and Abbott 2002), on characteristics of environmental offenders and their crimes (Crow *et al.*, 2013), on punishment (Lynch *et al.*, 2019; Billiet *et al.*, 2014; Billiet and Rousseau, 2014; Faure and Svatikova, 2012; Almer and Goeschl, 2010; Stafford, 2002), on sentencing decisions (O'Hear, 2004; Atlas, 2001; Simon, 2000; Cohen, 1992), on enforcement (for waste crimes see, for instance, D'Amato *et al.*, 2018, 2015; Germani *et al.*, 2015; Almer and Goeschl, 2015, 2010; Massari and Monzini, 2004), on illegal wildlife hunting and poaching (Crow *et al.*, 2013; Wyatt, 2012), on illegal mining and harvesting and logging (South and Brisman, 2012; Boekhout van Solinge, 2008).

⁴ In Becker's framework, the expected utility of a potential offender is defined as: $EU = pU(Y - f) + (1 - p)U(Y)$, where Y is the generic benefit of success in committing a crime, f is the sanction if apprehended, and p is the probability of being apprehended. Hence, Y represents the expected benefit, while f and p are the expected costs. In Becker's model, f "is to be interpreted as the monetary equivalent of the punishment" (Becker, *ibid.*, p.177).

All these studies have advanced the literature on environmental crimes in important ways but, nevertheless, there is still a lack of empirical research on a variety of crimes and their determinants. As stated by Chalfin and McCray (2017), a topic often omitted from the reviews of the economics of crime literature is the role of economic conditions in deterring crime via “carrots” (i.e., better employment opportunities, higher wages, higher education levels, higher social cohesion) rather than “sticks” (i.e., tougher enforcement policies). Based on this shortcoming, our main contribution is aimed to extend this literature in this vein by disentangling the effect of economic conditions and deterrence measures on environmental crime in Italy. In the economic literature on law enforcement, some studies explicitly consider the use of carrots as alternative to sticks (Depoorter and De Mot, 2006; Cooter and Garoupa, 2000; Becker and Stigler, 1974), while some others (Levmore, 1985, 1986; Gordon, 1982) explore the connections between carrots and sticks in a more comparative way. Several studies (Su and Cao, 2021; Jasch, 2013; Savage *et al.*, 2008; Hannon and de Fronzo, 1998; Zhang, 1997; Devine *et al.*, 1988; De Fronzo, 1983) often find that social policies eliminate or reduce those social conditions favorable for crime, suggesting that carrot policies move people away from illegal activities to participate in legal income opportunities and accumulate human capital.

The economics of crime empirical literature on the impact of economic conditions on crime tend to find evidence of a fairly robust relationship between both unemployment and wages and crime (Gould *et al.*, 2002; Raphael and Winter-Ebmer, 2001; Freeman and Rodgers, 2000; Grogger, 1998).⁵ To the extent that unemployment is thought to generate incentives to engage in criminal activity, prominent studies have found significant positive effects of unemployment rates on crime rates, in particular on property crimes (Andresen, 2013; Phillips and Land, 2012; Chalfin and Raphael, 2011; Mustard, 2010; Ihlanfeldt, 2007; Rosenfeld and Fornango, 2007; Arvanites and Defina, 2006; Machin and Meghir, 2004; Entorf and Spengler, 2000; Papps and Winkelmann, 2000; Piehl, 1998; Freeman, 1983).

Deterrence theory demonstrates that increasing enforcement efforts leads to increasing probabilities that wrongdoers will be detected, convicted, and punished (Cohen, 2000; Polinsky and Shavell, 2000; Gray and Deily, 1996). We use the conviction rate (i.e., number of convicted offenders for environmental crimes over the population at regional level) as a proxy of the enforcement effectiveness (i.e., increasing convictions is a result of higher detection and successful prosecutions).

However, despite these compelling theoretical arguments, the existing empirical studies have found very mixed results on the effect of the stick policy (Stretesky *et al.*, 2017; Almer and Goeschl,

⁵ However, earlier works (Corman *et al.*, 1987; Freeman, 1983, 1995) did not provide conclusive evidence on the relationship between unemployment and wages on crime.

2010; Marvell and Moody, 1996; Howsen and Jarrell, 1987) and whether economic conditions or deterrence measures have a larger impact on crime is still an unresolved issue, due mainly to data limitations (Corman and Mocan, 2005). Similarly, most of the empirical results (Chalfin and McCrary, 2017; Freeman, 1983) on the impact of economic conditions and deterrence on crime also presents a mixed and often contradictory picture, being sensitive to the time-period, the type of wage or unemployment rate chosen, the population under consideration, as well as the criminal offenses analyzed.

While it remains a question whether one of these approaches is more effective than the other, stick policies and carrot policies on environmental crime reduction have not yet been studied so far and we take up this issue in the analysis that follows. To that end, we use Italian regional data, by environmental crime type, between 2006 and 2016 to investigate the extent, if any, to which both carrots and sticks explain the dynamic characteristics of environmental crime. In particular, while carrots can be captured from the economic conditions of the regions (i.e., unemployment rate, wages, poverty), the sticks can be inferred from measures of enforcement and deterrence, such as the conviction rate and the judicial efficiency, controlling for some other socio-economic variables, such as the level of education and house overcrowding. From this review, it is clear that the relationship between economic characteristics, enforcement efforts and environmental crime is a relatively novel and unexplored topic in the existing literature. Given that, some first recent literature on environmental crimes in Italy has already begun to study the relationship between economic growth, socio-economic variables, and environmental crime (Castaldo *et al.*, 2021; Germani *et al.*, 2020), our analysis aims primarily to explore the extent to which enforcement and deterrence variables can have an impact on the phenomenon under observation. Our paper aims to fill this gap by contributing to the debate, being aware that environmental crime in Italy, both on a general and specific level, is one of the least empirically investigated criminal phenomena.

3. Data description and empirical strategy

3.1. Data and variables description

Using a panel dataset (ISTAT - Italian Statistical Agency) on the environmental criminal proceedings related to i) waste violations, ii) wastewater violations, iii) landscape violations, iv) violations in the construction sector, and v) forest fires, at regional level in Italy from 2006-2016, we aim to empirically investigate whether economic conditions and deterrence policies are effective tools for combatting environmental crime, taking into account socio-economic heterogeneity. The panel consists of annual data for the 20 Italian regions (NUTS-2) over the 10-year period 2006 to 2016. The data were

obtained by the Italian Statistical Agency (ISTAT),⁶ and by the Italian Ministry of Justice. Table 1 presents a summary of the variables that we used in our estimations.

Table 1. Variable Description and Data Sources

Variable	Description	Source
<i>Dependent variable(s)</i>		
Wastewater violations	ratio of wastewater criminal proceedings over population per 100,000 inhabitants	ISTAT years 2006-2016
Waste violations	ratio of waste criminal proceedings over population per 100,000 inhabitants	ISTAT years 2006-2016
Forest fires violations	ratio of forest fires criminal proceedings over population per 100,000 inhabitants	ISTAT years 2006-2016
Landscape violations	ratio of landscape criminal proceedings over population per 100,000 inhabitants	ISTAT years 2006-2016
Construction violations	ratio of construction criminal proceedings over population per 100,000 inhabitants	ISTAT years 2006-2016
<i>Economic explanatory variables (carrots)</i>		
Unemployment	unemployment rate relative to a time period of work inactivity longer than 12 months	ISTAT years 2006-2016
Wages	ratio of the remuneration paid by the employers before tax deductions and social security contributions payable by wage-earners/10,000 workers	ISTAT years 2006-2016
Poverty	regional poverty index (households)	ISTAT years 2006-2016
<i>Enforcement/deterrence-related explanatory variables (sticks)</i>		
Trial length	criminal trials length (expressed in number of days)	Italian Ministry of Justice years 2006-2016
Conviction rate	total number of environmental crimes convicted by judicial authorities	ISTAT years 2006-2016
<i>Other socio-economic explanatory variables</i>		
House overcrowding	people living in overcrowded housing situations, in homes without some services and with structural problems as a percentage of the resident population	ISTAT years 2006-2016
Schooling abandonment	percentage of the population aged 18-24 years, with at least the middle school diploma, who has not	ISTAT years 2006-2016

⁶ <https://www.istat.it>

	completed/attended any school or educational activities for more than 2 years	
University	percentage of population aged 15 and over with a university degree /post graduate diploma	ISTAT years 2006-2016
High school	percentage of population aged 15 and over with a high school diploma	ISTAT years 2006-2016
Middle school	percentage of population aged 15 and over with a middle school diploma	ISTAT years 2006-2016

By merging the above described socio-economic, deterrence and judicial data, we build a database that can contribute to the exiguous literature on the specificities of environmental crime in Italy.

Dependent Variable

We use the number of criminal proceedings for environmental crimes (regulated by both the Environmental Code and by the Penal Code)⁷ which include illegal constructions, illegal waste disposal, illegal wastewater discharges, offenses in terms of landscape violations, and illegal forest fires. Waste and wastewater violations are included in the Environmental Code (L.D. 152/2006) which defines and regulates the procedures related to waste and water resources management (such mixing of waste, unauthorized waste management, illegal traffic of waste, discharges of wastewater from industrial plants or non-compliant behaviors with regard to maximum pollution thresholds). In the Penal Code are regulated the other types of environmental offenses considered, i.e., forest fires, violations related to construction and urban planning, and violations in the landscape sector. The values are expressed in per capita for one hundred thousand inhabitants for each region. Figure 1 depict the geographical distribution of each dependent variable in terms of average values (2006-2016) of criminal proceedings.

Figure 1. Territorial heterogeneity of environmental crime type - Geographical (region-level) distribution of proceedings for each type of considered environmental crime (2006 - 2016, average values).

⁷The Environmental Code (Law Decree 152/2006) regulates several issues: environmental impact assessment, protection of soil and water, regulation of the waste and wastewater sectors, and decontamination of polluted sites. It consists of seven parts: i) Environmental general principles, ii) Environmental impact assessment and integrated pollution prevention and control (IPPC) permit, iii) Water resources management and soil protection, iv) Waste and packaging management, v) Remediation of contaminated sites, vi) Air protection and air emissions, vii) Environmental Damage.

Fig. 1.1. Waste-related criminal proceedings

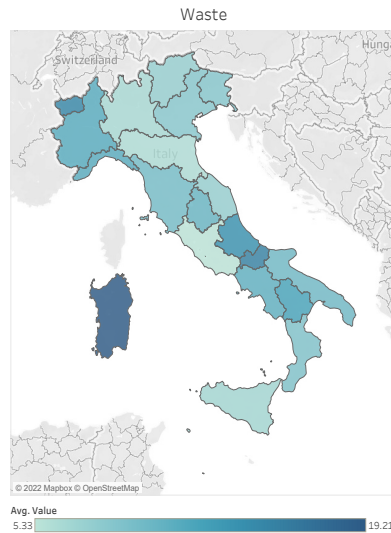
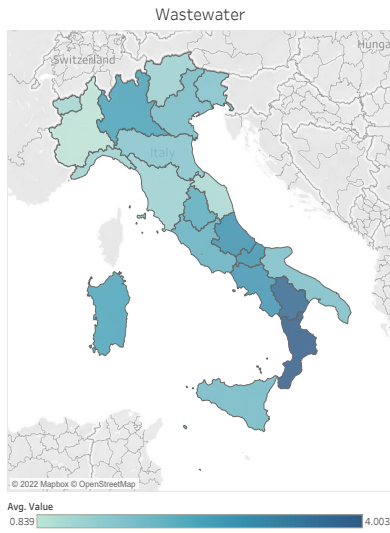


Fig. 1.2. Wastewater related criminal proceedings



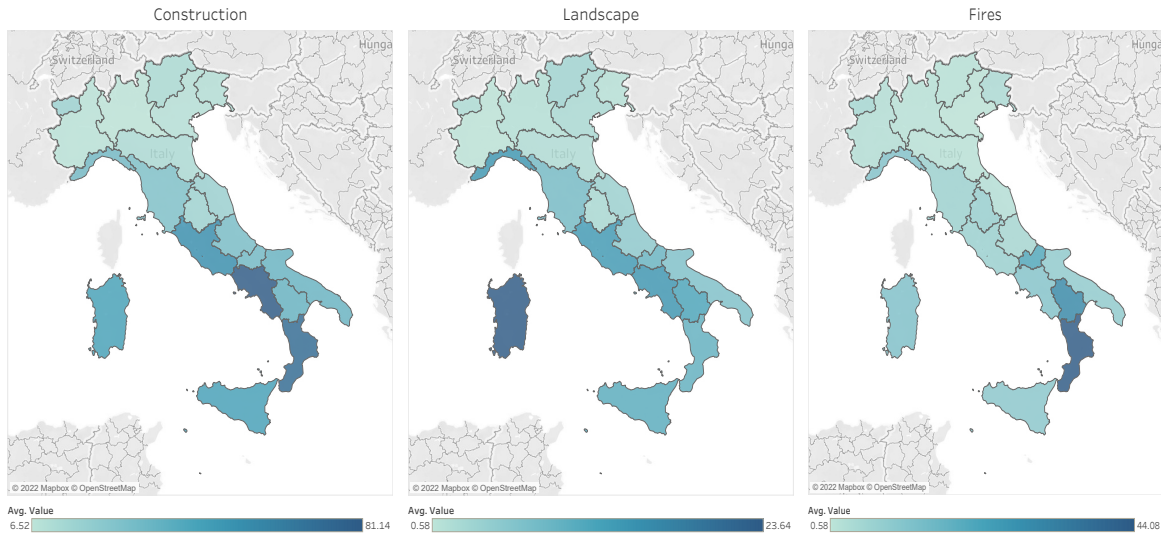
The average incidence of waste criminal proceedings with respect to the total number of environmental crimes, over the time period under consideration (2006-2016), is 15.08%. In Figure 1.1., for this specific type of crime, the cross-regional territorial heterogeneity rate (measured as the ratio of criminal proceedings over population per 100,000 inhabitants, with average value in the period 2006-2016) seems to suggest that a North/Center versus South bifurcation is less pronounced. However, Sardinia exhibits the highest (regional) incidence of waste proceedings (19.1) and, in the top ten ranking, we find five South regions, i.e., Molise (15.3), Abruzzo (13.8), Basilicata (12.1), Campania (10.9), Puglia (9.9). This evidence is confirmed when considering the macro territorial area distribution (note that this territorial macro aggregation of regions will be used in the empirical analysis for the geographical fixed effect controls). The South area accounts for approximately the 44% of the total waste-related criminal proceedings in Italy. The remaining two macro-regions display lower incidence rates, i.e., North (33%), and Center (23%), even though, to a less wider extent, we can observe a South territorial prevalence of this specific type of offense compared to the other types of environmental crime considered.

Turning to wastewater-related violations, the overall incidence rate with respect to the total number of environmental crime proceedings is the less representative (3.45%) among the different types of offenses. In Figure 1.2, we can observe that a North/Center and South territorial divide is indeed pronounced; in particular, in the top three ranking we see three Southern regions, i.e., Sardinia (21.3), Molise (17.7), and Abruzzo (16.2), and in the top ten ranking other two Southern regions, i.e., Basilicata (14.5), Campania (13) are shown. Overall, the South macro territorial area accounts for the 46% of the phenomenon, against the 25% of the Center and the 41% of the North.

Fig. 1.3. Construction-related criminal proceedings

Fig. 1.4. Landscape-related criminal proceedings

Fig. 1.5. Forest fires criminal proceedings



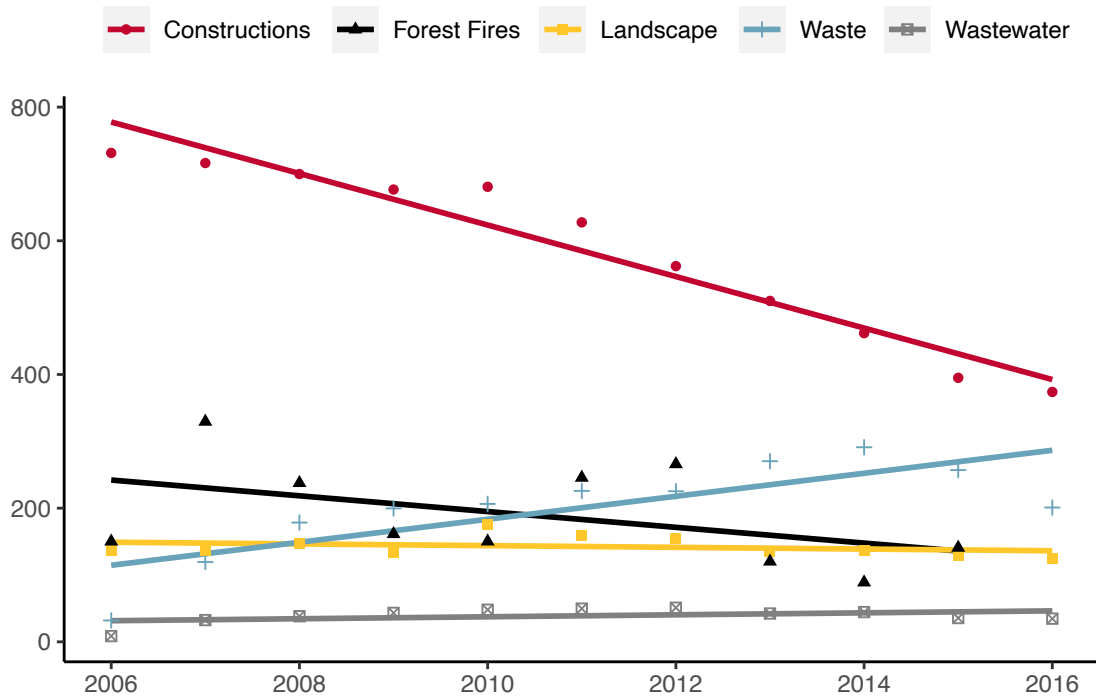
Considering illegal construction proceedings, we observe that this type of illegal behavior, with an overall incidence rate of 56.64% on total crimes, is the most representative environmental crime. In Figure 1.3, it is possible to observe a clearer South macro territorial prevalence; specifically, Campania region leads the ranking of regional average incidence rate with 81.1, and we observe six Southern regions in the top ten ranking, i.e., Sardinia (43.9), Basilicata (34.6), Puglia (34.1), Molise (30.7), Abruzzo (38.4). In aggregate terms, the South macro territorial area holds the 62.5% of the total criminal proceedings in this crime category (10.3% in the North, 27.2% in the Center).

With regard to landscape-related violations, we observe that the total incidence rate lowers to 12.4%. In Figure 1.4, it is possible to pin down an observed territorial heterogeneity, that highlights a Southern prevalence. In particular, Sardinia leads the ranking (23.64) followed by four Southern regions in the top ten ranking (Campania, Basilicata, Molise, Puglia). The South macro territorial area accounts for the 59.1% of the total proceedings in this type of crime (11.1% in North, 29.8% in the Center).

In relation to forest fires proceedings, it emerges that the incidence rate, similarly to landscape infringements, is 12.4%. In Figure 1.5, we can observe again a Southern prevalence. In particular, the ranking is headed by Calabria region with 44.08 and in the top four rankings appear only Southern regions (i.e., Basilicata, Molise and Sardinia), while in the top ten we find six Southern regions with the addition of Campania and Puglia regions. Overall, the South macro territorial area holds the highest level of incidence of the phenomenon with an almost 70% over the total number forest fires criminal proceedings.

Finally, in Figure 2, it is possible to observe the time trend of our dependent variable revealing that time trends are quite heterogeneous across environmental crime type. Summing up, the main aspects that emerge on the heterogeneity of environmental crime in Italy are: (i) the pronounced bifurcation between North/Central and South macro territorial areas; and (ii) that each type exhibits a unique time trend. As a result, we include type macro-region fixed effects, environmental crime types fixed effects, and individual crime type trends as opposed to yearly fixed effects.⁸

Figure 2. Environmental Crime by Type (averaged across regions)



Independent Variables

The primary sources for the socio-economic, deterrence, and judicial variables are the Italian Statistical Agency (ISTAT) and the Italian Ministry of Justice. The independent variables were chosen according to those most commonly used in the economics of crime literature that might influence criminal behaviour in general (Baltagi, 2006; Cornwell and Trumbull, 1994; Ehrlich, 1973) and environmental offences in particular (Almer and Goeschl, 2015, 2010; Eckert, 2004; Stafford, 2002; Helland, 1998). We use criminal *trial length* and *convictions rate* as measures of inefficiency of the

⁸ Not surprisingly, in our empirical analysis the year fixed effects (which are aggregated across environmental crime type) are statistically insignificant yet the trend interacted with environmental crime type are statistically significant.

judicial and enforcement system at regional level.^{9,10} The time necessary for the definition of proceedings (i.e., the time needed to conclude the preliminary investigations and establish whether to dismiss the case or initiate a criminal proceeding) is defined in terms of average length (expressed in number of days) of all criminal trial proceedings. We use the average of all criminal trials to ensure endogeneity. As it is well known (Cohen, 2000; Polinsky and Shavell, 2000), more efficient judicial courts should lead to increased deterrence; arguably, environmental crime will be lower in regions with higher conviction rates and with more efficient courts (those characterized by a shorter length of criminal proceedings). Lower enforcement efforts and/or longer trials are likely to postpone the timing of punishment (Becker, 1968), and this could be an important factor in inducing individuals and firms to undertake illegal activities. Similarly, an increase in the level of deterrence proxied by conviction of environmental crimes is expected to reduce the number of environmental crimes. The *conviction rate* is the number of convictions divided by the number of proceedings and it is lagged one year to avoid reverse causality. It should be noted that convictions in a given year are resulting from crimes committed anywhere from one to five years in the past.

We use *unemployment rate*, *wages* and *poverty* as measures of economic conditions in the Italian regions. According to the unemployment rate, economic conditions worsened in the most recent years, from 2013 to 2016, reaching a peak in 2014 with an average unemployment rate, at national level, of 13.13%. The existence of a causal link between unemployment and crime has been widely investigated in the literature, although the strength of this relationship remains ambiguous both in its nature and in its robustness (Chalfin and McCrary, 2017). Research examining the relationship between wages and criminal participation finds strong evidence that higher wages deter criminal activity (Grogger, 1998) and decreasing wages of unskilled workers act as an incentive to engage in criminal activity (Gould *et al.*, 2002).

In addition to the above economic variables, with regard to the other socio-economic control variables, it is well established in literature that education, consistent with a human capital-based theory of crime, can have a relevant role in reducing the inclination to commit general crimes (Hjalmarsson *et al.*, 2015; Machin *et al.* 2011; Lochner, 2007; Buonanno and Leonida, 2006, 2009; Lance and Enrico, 2004; Lochner, 2004; Lochner and Moretti, 2004) even though the effect could be, *a priori*, ambiguous, given that the net effect of educational attainment on criminal behaviour may reduce the cost of committing a crime, but may also raise the resulting revenues (Lochner, 2011) when considering the

⁹ Data released by the Italian Ministry of Justice.

¹⁰ Note that trial and appeal delays are one of the major problems associated with the inefficiency of justice in Italy.

probability of committing white collar crimes (i.e., tax fraud).¹¹ With regard to environmental crime, more specifically, Castaldo *et al.* (2021) found the existence of a U-inverted relationship between education and environmental crime, showing that environmental crime with respect to the level of education increases at a decreasing rate. *University* is measured in terms of population (thousands) aged 15 and over with a university degree/post graduate diploma; *high school* is measured in terms of population (thousands) aged 15 and over with a high school diploma; *middle school* is measured in terms of population (thousands) aged 15 and over with a middle school diploma; *school abandonment* is measured in terms of percentage of the population (aged 18-24 years), with at least the middle school diploma, who has not completed or attended any school or educational activities for 2 more years. *House overcrowding* is also considered in order to control for economic deprivation and social exclusion. Several studies (Laub and Sampson, 2003; Lewontin, 2000; Krivo and Peterson, 1996; Bursik and Grasmick, 1993; Hsieh and Pugh, 1993; Land *et al.*, 1990; Roncek, 1975) have analyzed the critical impacts that disadvantaged neighborhoods can have on individuals' likelihood of criminality, generally, founding a substantial positive effect on crime rates and supporting the argument that economic deprivation creates social-strain and social-disorganization (Kornhauser, 1978): in regions where poverty and disadvantaged economic conditions are more diffuse, it is likely that crime perception is conceived less negatively, and the incidence of environmental criminal activities is higher. Table 2 provides an overview of the selected variables and their summary statistics.

Table 2. Descriptive statistics

Variables	Mean	Std. Dev.	Median	Min.	Max.
<i>Dep. variables - Environmental crime types:</i>					
Wastewater crim. proceedings	1.947	0.877	1.752	0.436	3.956
Waste-related crim. proceedings	10.028	3.705	9.714	4.534	19.12
Forest fires crim. proceedings	9.449	10.85	6.480	0.583	44.081
Landscape crim. proceedings	7.169	6.006	5.870	0.579	23.639
Illegal constructions crim. proceedings	29.251	21.2	27.345	6.523	81.142
<i>Enforcement/deterrence related explanatory variables (sticks):</i>					
Trial length	341.260	92.838	330.321	178.265	563.190

¹¹ This result is explained considering that higher educated individuals generally earn more than lower educated one, and the potential benefits of tax evasion and fraud increase with taxable earnings. Another possible explanation is that higher educated individuals are more knowledgeable about the possibilities for committing tax fraud.

Conviction rate	0.606	1.123	0.266	0.001	14.000
<i>Economic explanatory variables (carrots):</i>					
Unemployment	5.402	3.706	4.519	0.603	15.902
Wages	3.390	3.206	1.736	0.156	14.710
Poverty	11.763	7.446	9.000	2.500	34.900
<i>Other socio-economic controls:</i>					
House over-crowding	8.045	2.950	7.677	2.748	17.935
School abandonment	16.152	4.578	15.435	6.729	28.717
University	0.115	0.020	0.113	0.083	0.182
High school	0.289	0.027	0.288	0.230	0.361
Middle school	0.314	0.030	0.311	0.255	0.399

A cursory look of Table 2 illustrates significant heterogeneity in our variables, which appears very pronounced for our dependent variables and for the covariates of interest (especially for *trial length*). Not surprisingly, an exception is represented by the different levels of education attainment, where the standard deviation is smaller, denoting a low dispersion of the data around the mean values.

3.2. Estimation strategy and methods

We wish to model the relationship between environmental crime, economic conditions and enforcement and deterrence measures for Italian regions. We have five types of environmental crime, across 20 regions for 11 years. However, given that we lag one of our independent variables (*conviction rate*), we only have 10 years. We use the following fixed effects panel model:

$$EnvCrime_{pit} = \beta_p + \beta_R + \beta_{py}Year + \beta_1 TrialLength_{pit} + \beta_2 ConvictionRate_{pit} + \beta_3 V_{pit}^{carrots} + \beta_4 X_{pit}^{SE} + \varepsilon_{pit}$$

We have fixed effects for unobserved heterogeneity across environmental crime type (β_p) and macro-territorial areas (β_R).¹² We found the yearly fixed effects insignificant but did find heterogenous trends across the crime type statistically significant. To account for this, we interacted the trend variable with the environmental crime type (β_{py}) thereby allowing different trends for each environmental crime type. Matrix V comprises the carrots explanatory economic variables (*wages*, *poverty*, *unemployment*);

¹² The macro-territorial subdivision of regions in Italy is the following. The Northern regions are Valle d'Aosta, Liguria, Lombardy, Piedmont, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Emilia-Romagna. In the Center macro-area there are Tuscany, Umbria, Marche, and Lazio regions. The Southern regions are Abruzzo, Molise, Campania, Apulia, Basilicata, Calabria, Sicily, and Sardinia.

X is a set of the other socio-economic controls (*house over-crowding, education*). Our main parameters of interest relate to legal deterrence (sticks) are β_1 (*trial length*) and β_2 (*conviction rate*).

An important issue faced by empirical studies in the economics of crime is the endogeneity of deterrence or enforcement variables due to simultaneity (Levitt and Miles, 2007). A traditional example of simultaneity is when a higher number of crimes leads to a greater effort by enforcement authorities which in turn leads to more violations being detected. To this end, we use *trial length* of all criminal proceedings, not trial length of just environmental crime proceedings. Given environmental crime proceedings make up on an extremely small percentage of total criminal proceedings, we are not concerned with endogeneity of our *trial length* variable. With respect to our *conviction rate* variable, the average time for Italian criminal proceedings is three years and nine months and this time increases to four years and four months from the preliminary investigation to the Supreme Court ruling (Italian Ministry of Justice, 2020).¹³ As such, the number of convictions is a function of the number of proceedings from three to four years prior. Furthermore, we lag this variable one year. Therefore, we are not concerned with endogeneity issues with our *conviction rate* variable.

4. Empirical results and discussion

The estimation results of the fixed effects model are presented in Table 3. Standard errors are clustered by both environmental crime type and area. Parameters associated with fixed effects and trends are omitted below but are generally statistically significant.

Table 3. Estimation results

Variables	Estimate	SE	p-value	Clustered SE (by macro- territory)	p-value	Clustered SE (by EC type)	p-value
<i>Enforcement/deterrence related explanatory variables (sticks)</i>							
Trial length	0.019	0.005	0.000	0.005	0.000	0.012	0.114
Conviction rate	-0.754	0.376	0.045	0.273	0.006	0.153	0.000
<i>Economic explanatory variables (carrots)</i>							
Unemployment	-0.028	0.278	0.919	0.183	0.876	0.084	0.736
Wages	-0.522	0.152	0.001	0.174	0.003	0.172	0.002
Poverty	0.454	0.120	0.000	0.049	0.000	0.315	0.150
<i>Other socio-economic controls</i>							
House over crowding	0.347	0.150	0.021	0.158	0.029	0.302	0.250

¹³ <https://webstat.giustizia.it/SitePages/StatisticheGiudiziarie/Statistiche%20giudiziarie.aspx>

School abandonment	-0.080	0.173	0.644	0.039	0.043	0.098	0.413
University	193.133	43.178	0.000	24.853	0.000	106.362	0.070
High School	60.654	30.696	0.048	40.785	0.137	45.580	0.184
Middle	113.112	26.827	0.000	8.639	0.000	73.347	0.123
<i>Fixed effects (FE) and trend</i>							
Macro-territorial FE	Yes						
Environmental crime type FE	Yes						
Linear trend	Yes						
EC type FE*linear trend	Yes						
R ²	0.558						
F (21,888)	53.480						

The results confirm the effect exerted by both carrots and sticks on environmental crime. Looking at our strategic explanatory variables on enforcement and judicial measures (*trial length*, *conviction rate*), we find a positive and significant relationship between *trial length* and environmental crime under conventional and clustered standard errors by macro-territorial areas and marginally insignificant under clustering by environmental crime type. This result is very interesting in that the propensity for environmental crime increases with the expected judicial inefficiency as measured by judicial delay. The intuition is that the judicial inefficiency increases the expectation that no sanction may follow at all. Discounting of sanctions that may be imposed after a lengthy trial to their present value could also reduce deterrence. The estimated parameter associated with *conviction rate* is negative and statistically significant under all standard errors indicating that an increase in the local enforcement efforts (measured by the number of environmental offenders convicted) results, *ceteris paribus*, in a lower number of environmental crimes. This evidence confirms that increasing the certainty of punishment improves deterrence (Cohen, 2000; Sigman, 1998; Nadeau, 1997; Gray and Deily, 1996; Laplante and Rilstone, 1996)¹⁴ by improving the likelihood that criminal behavior would be detected.¹⁵

We find a negative and statistically significant relationship between environmental crime and *wages*, consistent with the Becker's approach (1968) for which legal wages represent the opportunity cost to crime: higher wages should reduce the environmental criminal activities under consideration. Therefore, higher wages act as deterrent on environmental violations. *Unemployment* is inversely related to environmental crime but is not significant. *Poverty* is positive and highly statistically significant under

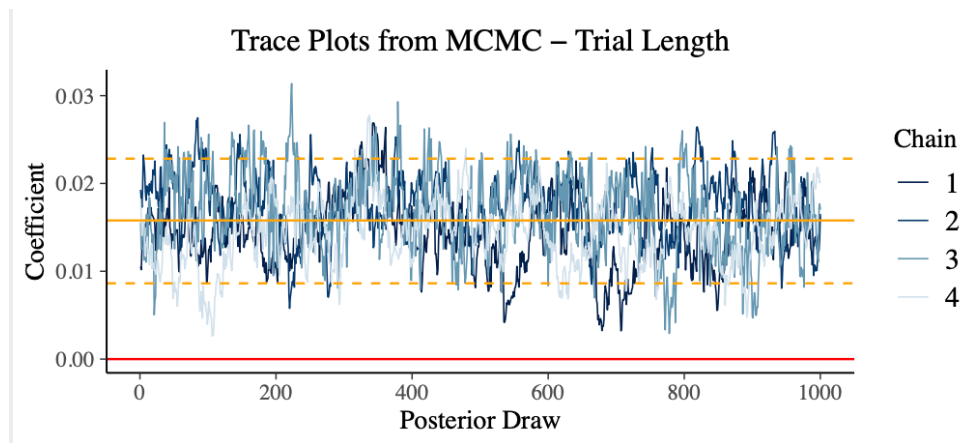
¹⁴ This is also the core of the prediction of Becker's model (1968): increasing the expected costs of crime due to an increase in the probability of inspections, leads to lower rates of non-compliance (Gray and Deily, 1996).

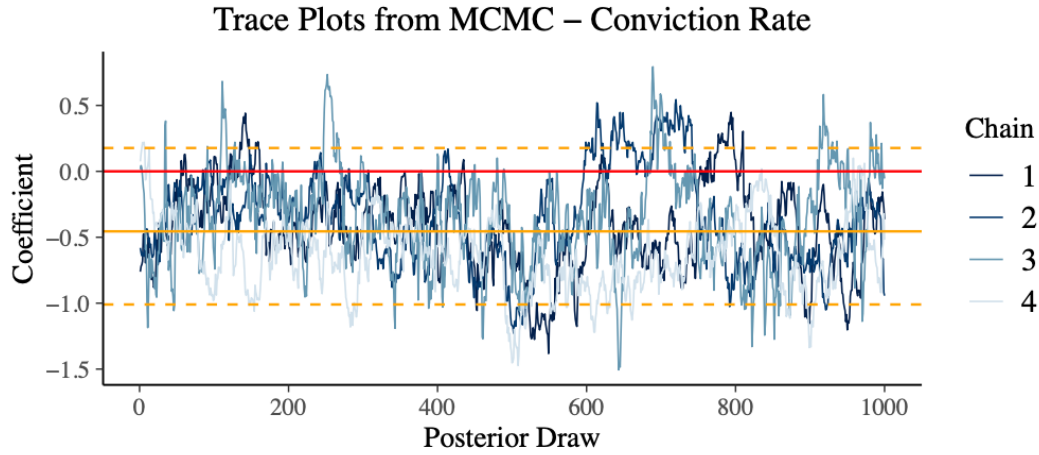
¹⁵ In literature (Nagin and Pogarsky, 2001) the certainty of punishment is often found to be more effective to deter crime than the severity of punishment: this approach would free up resources devoted to imprisonment and allow to increase crime prevention policies.

conventional and clustered standard errors by macro-regions but becomes marginally insignificant under clustering by environmental crime type. *House overcrowding* is positive and statistically significant at the 5% under conventional and clustered standard errors by macro-regions but statistically insignificant under clustering by environmental crime type. Both these explanatory variables support the argument that higher levels of social exclusion and dearth lead to increased environmental violation. When looking at the chosen human capital measure, all levels of *education* are positive and statistically significant under conventional standard errors with that significance weakening with clustering. Quite interestingly, the magnitude of the estimated coefficient is significantly larger in the case of attainment of a *university* degree level. This result is consistent with previous literature findings (Castaldo *et al.*, 2021) showing that environmental crime is a corporate type of crime which requires both high skills and resources (i.e., white collar) in order to address the complexity of such offenses.

As a robustness check, we undertook the fixed effects panel model estimation using Bayesian methods (Markov Chain Monte Carlo – MCMC; diffuse priors on all parameters including the error variance parameter ε_{pit}). Doing so, in Figure 2, we provide evidence of parameter stability, or lack thereof, for our parameter estimates across the Markov chain. We use four chains of length 1000 with a 1000 burn-in samples (commonplace). Plotted below are the trace plots for the two parameters of interest; *trial length* and *conviction rate*. Both plots illustrate fairly stable parameter estimates across the chain with *trial length* almost exclusively negative and *conviction rate* tending to be mostly positive, confirming the parameter and standard error estimates from Table 3.

Figure 2. Trace plots from Markov Chain Monte Carlo simulation





5. Policy issues and concluding remarks

Environmental crime is an increasingly significant issue in Italy that has become an important political issue at national level but, despite the ever-increasing attention in the various political and institutional venues, has yet to receive attention in the empirical literature. The relationship between economic characteristics, enforcement efforts and environmental crime is, in fact, a relatively novel but unexplored topic in the literature. Our analysis is grounded on a unique dataset of environmental crime by type (i.e., wastewater, waste, construction, landscape, and forest fires), across Italian regions for the decade 2006-2016, that comprises judicial and socio-economic characteristics, and implements a panel fixed effects model. Our results help us better understand environmental crime-control policies in Italy, enriching our knowledge on the policy instruments to prevent and contain illegal environmental behaviors.

Considering that, albeit scant, a first recent literature on environmental crimes in Italy has already begun to study the relationship between economic growth, socio-economic variables, and environmental crime (Castaldo *et al.*, 2021; Germani *et al.*, 2020), our analysis is committed to explore the extent to which enforcement and deterrence variables can have an impact on the phenomenon under observation. Environmental crime and its enforcement may very well take divergent paths in the different macro-territorial areas as they may depend by different political objectives and priorities, cultural endowments, economic and productive system characteristics, enforcement, and deterrence strategies. Our main findings reveal that our strategic (stick) explanatory variables on enforcement and judicial measures, exert a relevant and significant effect on our outcome variable; the propensity to commit environmental crime increases with the expected judicial inefficiency (measured by court ruling delay) and decreases with conviction rates. Overall, our empirical results are consistent with the idea that environmental crime

in Italy can be best deterred through a complementary and balanced mix of both incentive carrots and enforcement sticks.

It is interesting to note that, in 2015 in Italy, with the enactment of Law 68/2015 there has been a sharp tightening of criminal enforcement and sanctioning that has seen the introduction of a new chapter (VI bis) in the Italian Penal Code regarding and defining crimes against the environment.¹⁶ Despite the extraordinary relevance of this disruptive normative reform, our analysis highlights that the enhancement of the enforcement system's efficiency remains the main policy challenge to fight environmental crime in Italy, where the marked fragmentation of both environmental regulations and competent enforcement authorities (aggravated by a diffuse lack of coordination) hampers the attainment of the desired public policy makers' target, widening the territorial heterogeneity of criminal environmental activities and sharpening the North/Center vs. South economic dualism. These considerations lead to the evidence that strengthening the severity of the sanctions without enhancing the probability of being detected, convicted and punished, may involve the risk of being ineffective with respect to the main goals settled by the legislator's reform at the national level. In this perspective, acknowledging this weakness, the reform of the Italian justice system (oriented to enhance its efficiency and effectiveness) is considered so urgent that it has been required, in the bilateral negotiation agreements between Italy and the European Commission for the definition of the National Recovery and Resilience Plan, as an essential pre-condition to access the financial resources provided by the Next Generation EU initiatives.

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¹⁶ More specifically, some aggravating circumstances for organised crimes (e.g., mafia-like organization) were introduced, together with four new types of environmental crimes: environmental disaster, intentional crimes against the environment, fatal injuries as a result of the crime of environmental pollution, and traffic of and abandonment of toxic or highly radioactive material (and related consequential side effects).

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