

# Illegal firm behaviour and environmental hazard: The case of waste disposal

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## Abstract

This study provides an analysis of illegal waste disposal examining how and why it occurs, with a focus on illegal industrial dumping. Organizational resource dependency theory and the bad barrel theory are used as conceptual frameworks to highlight the reasons leading firms to engage in illegal waste disposal, influenced by the firm's operational environment and characteristics, and how firms make use of it. The effects of environmental resource dependency variables and micro variables in terms of the hazard level associated with illegal waste disposal were tested separately and jointly by means of logistic regressions. Environmental resource dependency is found to be a powerful driver of the behaviour of firms, both independently and combined with certain organizational factors, with an impact on the hazardousness of illegal waste disposal. The policy implications of the findings are discussed, and a number of suggestions for preventing illegal dumping are put forward.

## KEYWORDS

bad barrel theory, hazardous waste disposal, illegal behaviour, resource dependency theory

## INTRODUCTION

In recent years, many countries have taken steps to address the issue of illegal industrial waste disposal, an environmental and social hazard with a long-term impact that can undermine the viability of entire communities (Murphy et al., 2020). Compared to household waste, industrial waste typically contains more toxic substances that pollute the soil and water, resulting in a major threat to ecosystems and human health (ISPRA, 2021). Moreover, the damage is frequently irreversible due to the tendency to transform the territory from a renewable to a non-renewable resource, altering the natural recovery of the soil (and groundwater) while slowing natural recovery processes (Breure et al., 2018; Otwong et al., 2021).

As in the case of many environmental issues, illegal waste disposal is often viewed as a problem generated by the business sector as a whole, focusing on the detrimental repercussions at societal level. However, such an approach is based on the assumption that agent behaviour

is relatively uniform, oversimplifying the dynamics characterizing illegal waste disposal. Through the lens of organizational behaviour, this study proposes a shift in perspective, emphasizing the fact that decision-making is firm specific, together with the underlying motives and practices adopted.

This perspective allows for the examination of specific characteristics and factors that cannot be identified at the aggregate level. Particularly, the focus on the behaviour of firms in terms of organizational decision-making may be said to have two dimensions. First, the micro dimension highlights how illegal choices can be normalized, organized and enabled within the firm (Gottschalk, 2011). Second, the meso dimension considers the contribution of the environment to illegal practices, particularly the essential resources required for the survival of the firm (Tashman, 2021).

This approach can provide a better understanding of the phenomenon. It can offer a degree of contextualization and a framework for addressing the complexity of

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the illegal disposal of industrial waste. It has significant implications, especially in terms of policy options: framing the motivations and modes as firm specific rather than impersonal can help to improve the design of preventive policies and sanctions.

Generally, studies examining illegal waste disposal as collectively generated by firms distinguish two aspects. On one hand, studies from the management perspective cast light on why illegal waste disposal occurs, indicating that the driving factors are personal, natural and social (Du et al., 2021). On the other, studies from an economic perspective have examined how firms implement their decisions, such as choosing the kind of waste to dispose of illegally or the time of year of the disposal. (Seror & Portnov, 2020). These approaches offer only a partial understanding of the phenomenon and, as a result, the link between ‘the how and the why’ is still unclear.

The aim of this study is to bring together the two standpoints and to examine them from the subjective perspective of the firms, emphasizing the reasons that lead firms to engage in illegal dumping, and how they engage such practice.

A few studies treat the two dimensions as distinct sources of influence on illegal behaviour. In the present study, they are considered as determinants of the decision to engage in illegal waste disposal both separately and jointly.

Specifically, taking into account both internal dynamics and environmental factors, this study draws on two conceptual frameworks: the bad barrel theory (Cialdini et al., 2019) and organizational resource dependency (Salancik & Pfeffer, 1978). The bad barrel theory is particularly well suited to casting light on the micro dimension, demonstrating how and under what conditions firms create their own structural opportunities when engaging in improper or illegal behaviour. Resource dependency theory is particularly useful in casting light on the meso dimension. In this framework, firms are embedded in their environment and rely on external resources to operate and survive. The more dependent the firm, the more likely it is to resort to illegal practices in order to gain autonomy (Tashman, 2021).

Following the logic of these two perspectives, we address the research gap outlined above by investigating whether the reasons for engaging in illegal waste disposal, which are contingent on micro and meso conditions, influence the way decisions are implemented. The effects of micro and meso factors are considered both separately and jointly.

The key criterion to identify the mode of illegal dumping is the related hazardousness. This is because, first, it is an accepted measure of environmental offences such as illegal waste disposal (White, 2018). Second, the hazardousness can deal with cases ranging from the occasional illegal disposal of a small amount of industrial waste to the long-term dumping of large amounts of

waste, which in the worst-case scenario may be toxic. At the same time, since in many systems illegal waste disposal constitutes a criminal offence, this may be adopted as a criterion for determining the gravity of the practice.

With regard to data, this study employs a large survey database mainly drawn from the judgements of the Italian Court of Cassation. It thus casts light on the dynamics of illegal waste disposal using an objective source, whereas previous studies were characterized by a comparative lack of detailed information about these illegal practices. The dataset allows us to test two main hypotheses. First, by means of a cluster analysis, illegal practices with the same hazardousness are grouped together by considering various characteristics of the hazard. Second, logistic regressions are applied to investigate the effects of resource-dependent environmental variables and the organizational micro variable on the seriousness of the illegal waste disposal, both separately and jointly.

The focus of the study is on the illegal disposal of industrial waste in Italy. Although the exact number of illegal waste sites is unknown, Italy is said to be Europe’s ‘largest and most dangerous illegal waste dump’ (Slaybaugh, 2017). The 2005 inventory of illegal waste sites drawn up by the European Commission<sup>1</sup> ranked Italy the worst of all European countries. In addition, underlining the seriousness of the problem, and the difficulty of dealing with it, Italy was recently subjected to the highest fine ever imposed on an EU Member State from the Court of Justice of the European Union for failing to tackle illegal waste disposal (Case C-196/13). Illegal waste sites often contain highly toxic material. Toxic waste is also a specific target of mafia organizations, which have dealings with Italian and international companies and dispose of highly toxic materials in various sites in southern Italy, predominantly in the Campania Region (Carriero et al., 2018).

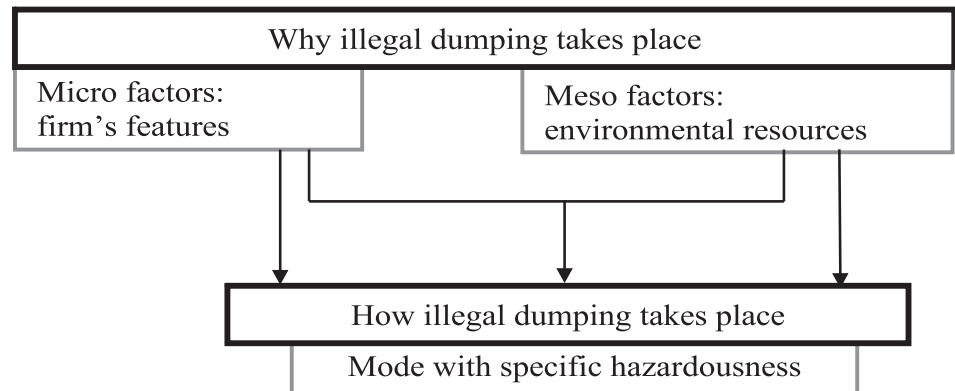
The remainder of this paper is structured as follows: The Conceptual Framework section outlines the conceptual framework, providing insights into the effects of the meso factors according to resource dependency theory, the effects of micro factors according to the bad barrel theory and then the combined effect of the meso and micro factors. The Data section provides an overview of the data, and the Method and Results section provides the methods and results. The Discussion section examines the results, and the Conclusions section concludes.

## CONCEPTUAL FRAMEWORK

The conceptual framework is intended to explain why and how firms resort to illegal waste disposal. Arguably, the decision to engage in illegal waste disposal is contingent on the occurrence/degree of micro factors considered

<sup>1</sup>[https://ec.europa.eu/environment/pdf/waste/landfill/report\\_landfill.pdf](https://ec.europa.eu/environment/pdf/waste/landfill/report_landfill.pdf)

**FIGURE 1** The conceptual framework.



in cultural, structural and organizational terms; then, it is contingent on the environmental factors expressed in terms of resource dependency, due to resource constraints.

They can both impact on the mode of illegal dumping expressed in terms of hazardousness.

Furthermore, the effects on the hazardousness of the micro factors and resource dependency are considered first separately and then jointly. Figure 1 provides an outline of the conceptual framework.

### The effects of micro factors according to the bad barrel theory

The bad barrel theory considers the reasons for a firm's misconduct at the micro level, based on the assumption that the illegal behaviour of firms has a significant structural basis, creating an environment conducive to criminal behaviour. Essentially, the bad barrel theory (Cialdini et al., 2019) underlines the fact that organizations are not simply a context but rather a source of motives, opportunities and ways of engaging in illegal behaviour.<sup>2</sup> Micro factors can be related to specific cultural or structural features or consist of more general organizational factors that can have an impact in various ways in terms of the pursuit of illegal outcomes, as well as the degree of seriousness.

We formulated a hypothesis about the effects of the rationalization of illegal behaviour (through its main proxies) as a cultural factor, the number of hierarchical levels as a structural factor and the age and size of the firm as organizational factors since they have been extensively explored in terms of the potential to influence the misconduct of the firm and the degree of its seriousness.

As a cultural factor, the rationalization of illegal behaviour has been the subject of extensive research. It has mainly been studied in cases of corruption

(Prabowo & Cooper, 2016), but it can be generalized since an organizational climate tolerating criminal behaviour may be used to justify all kinds of illegal behaviour (Boakye et al., 2022) that may be permitted or even deemed to be necessary. Jaakson et al. (2019) argue that this is particularly the case for firms facing financial hardship. In such cases, it has been found that illegal practices increase and are more widely accepted as a possible way of addressing financial hardship (Cheng & Ho, 2019). Moreover, it has been found that firms under intense financial pressure tend to be more vulnerable to external forces. As a result, they are more likely to make compromises in an attempt to increase profits (e.g., price fixing) or cut costs (Lopatta et al., 2016). In cases in which firms have previously committed crimes, it has been proven that making ethical compromises to achieve goals may be deemed more acceptable, as such behaviour is a continuation of existing practices (Troisi et al., 2021).

In terms of structural features, the organizational structure of illegal behaviour can capture the misuse of power at different levels. It is often related to the number of levels in a business organization, with the level of seriousness closely correlated to the multiplicity of hierarchical levels (Lou, 2002). In this connection, Pinto et al. (2008) make a further distinction between group and individual involvement at various levels of the hierarchy in terms of the implications for the seriousness of the crime. This reflects the idea that a corporate crime is manifested as an organizational dysfunction, the degree of seriousness of which reflects the extent of the misallocation of organizational resources (Jávor & Jancsics, 2016; Troisi et al., 2021). In a hierarchy consisting of multiple levels, this can facilitate or exacerbate misconduct since the use of resources increases, while identifying the individuals involved becomes more difficult (Troisi & Alfano, 2022).

Finally, a number of organizational features are considered as factors in relation to illegal behaviour, such as the firm's age and size. The age of the firm, in the sense of the number of years it has been in business, reflects the firm's experience. It has been found that in the case of older and larger firms, crimes are likely to decrease

<sup>2</sup>We deliberately do not refer to the 'bad apple theory', often considered as complementary to the bad barrel theory. Despite its relevance in explaining organizational crime, it focuses on individual actors and thus is not within the scope of this analysis.

in terms of both incidence and seriousness (Troisi et al., 2021). The managers of these firms consider illegal behaviour detrimental to the reputation of the firm (Collins et al., 2009). In addition, firms that have been in business for longer may have more extensive experience in dealing with resource adversity (Baker & Nelson, 2005). Larger firms typically have ready access to financial resources, enabling them to deal with the problems of high resource dependency, and tend to rely on established relationships with resource providers (Hessels & Terjesen, 2010). To the best of our knowledge, none of the studies in the literature applies the bad barrel theory to illegal waste disposal or environmental crimes in general. However, arguments about the organizational origins of misconduct can be extended to this kind of illegal behaviour.

Based on these arguments, our first hypothesis is as follows:

**H1.** The rationalization of illegal behaviour, the organizational levels, the firm's young age and small size are likely to have a positive impact on the hazardousness of the illegal waste disposal.

### The effects of the meso factors according to resource dependency theory

Resource dependence theory provides an explanation for organizational and inter-organizational behaviours in terms of critical resources enabling the firm to survive and function (Salancik & Pfeffer, 1978). The environment in which an organization operates can give rise to dependency in terms of both tangible and intangible resources. Firms require raw materials, employees, capital, trust, reputation and personal obligations (Favre-Bonté & Thévenard-Puthod, 2013). At the same time, regulatory power can give rise to a number of issues for firms and may be a source of dependency as the public authorities grant rights and status (Greenwood & Tao, 2021).

The degree of dependency is a key concept in explaining the behaviour of firms, mainly determined by two factors: first, the firm's need for resources and, second, the availability of alternative resources (Hessels & Terjesen, 2010). In this connection, an essential good is one that is indispensable or sold by a monopolist, leading to a high level of dependency. Previous studies have suggested that resource constraints can lead firms to engage in risk-taking behaviour, which in the worst-case scenario may be illegal (Situmeang et al., 2016). When environmental conditions are not conducive to obtaining sufficient resources, firms attempt to deal with the uncertainty associated with dependency by accessing resources illegally (Cuervo-Cazurra, 2016; Kunsch et al., 2016).

These studies focus mainly on the relation between resource constraints and bribery, while neglecting other

types of illegal practices (Zhou et al., 2013). However, they are relevant to our study in two ways. First, they provide evidence that firms with limited resources are generally more likely to engage in illegal activities. Second, they show that there are various methods for implementing break-up strategies to reduce dependency, including illegal dealing and outsourcing of resources. The greater the degree of dependence on resources, the more stable and complex the strategies adopted tend to be (Drees & Heugens, 2013).

In emerging markets, where access to resources is particularly uncertain, firms consistently pay bribes to avoid or reduce taxes or to circumvent laws and regulations, according to studies on corruption (Yan & Qi, 2020). Resource constraints have been studied at the industry level, and there is evidence that price pressures and difficulties in maximizing profits are the primary environmental drivers associated with illegal activity, as a means to deal with such constraints (Cuervo-Cazurra, 2016).

To the best of our knowledge, the resource dependency perspective has not been applied to environmental crimes such as illegal waste disposal. However, recent reports on Italian industrial waste have revealed an increase in waste management costs (ISPRA, 2021). Waste management facilities are a resource that firms depend on, with costs and waiting times more than doubling in recent years. Administrative charges for local government waste disposal facilities have also increased. According to resource dependency theory, waste disposal facilities are high dependency resources as they are indispensable, and firms are required to obtain them by paying administrative charges, such as local taxes that vary by location. Firms that generate the most waste tend to operate in volatile markets or sectors. For example, the construction industry is a leading industrial waste producer (Wang et al., 2020) and is considered high risk due to its specific characteristics (high financial leverage, project-oriented operations and high bankruptcy rates). According to resource dependency theory, sectors with scarce resources are characterized by high levels of dependency and competition, which may be the root cause not only illegal behaviour but also more serious cases of illegal behaviour. Based on these considerations, the following hypothesis can be formulated:

**H2.** High resource dependency is likely to positively influence the hazardousness of the illegal waste disposal.

### The joint effect of the meso and micro factors

The idea that micro and environmental factors can play distinct roles leading to illegal waste disposal captures a portion of the phenomenon. Business decisions can be influenced by the internal dynamics of the firm or by the surrounding environment. Since micro and



environmental factors coexist and reinforce each other, they are likely to have concurrent and synergistic effects. Only a small number of studies examining illegal corporate practices combine the two viewpoints. There appears to be a demarcation that considers the micro level to be the typical unit of analysis, where most crimes are committed by individual perpetrators taking account of the organizational resources available to them (Piquero & Piquero, 2006).

The addition of the meso level is relevant when the study is more comprehensively about business and market or business sectors (Barkemeyer et al., 2018). Only a limited number of studies into illegal corporate behaviour combine the two perspectives, based on the idea that a multi-level approach provides a more comprehensive appraisal of the phenomenon and must therefore consider all the major factors relating to the decision to engage in illegal behaviour, as well as their interaction (e.g., Glebovskiy, 2021).

The combined effect of the two types of variables finds theoretical support in both frameworks considered. As a result, when it comes to the hazardousness of the illegal waste disposal, the approach adopted in the present study is as follows. A firm-specific decision to dispose of waste illegally can be seen as a combination of criminal dynamics and the potential consequences. It can be determined by the extent to which external resources are required but not readily available. Cultural, structural and organizational factors can work to reinforce the decision.

**H3.** The joint effect of meso factors (resource dependency) and micro factors (the rationalization of illegal behaviour, the number of organizational levels, the young age and the small size of the firm) are likely to positively influence the hazardousness of the illegal waste disposal.

## DATA

### Data sources

The data used in this study were mainly retrieved from the archives of the Italian Court of Cassation from 2015 to 2019<sup>3</sup> comprising about 160 judgements relating to randomly selected firms engaging in illegal waste disposal. This was the most recent timeframe for which data were available at the time of writing. These judgements represent the third and final instance in Italian criminal proceedings and thus provide judicial evidence, which is hard to gather from other sources. As the cases are described in detail, most of the information about the various types of illegal waste disposal was drawn from

these cases. As for the dependent variable, the judgements specify most of the elements used to develop the hazardousness index (see above): the total surface area, the involvement in criminal activity (individual or group), the occasional or continuous nature of illegal waste disposal and the nature of the waste (toxic or otherwise). In addition, information about market uncertainty and market concentration was obtained from the Italian National Institute of Statistics (ISTAT). As for the explanatory variable of resource dependency, multiple sources of information from various institutional sites were consulted. The cost of legal waste management and the time required for completing the procedure in compliance with the law were obtained from regional sites, and local waste disposal charges from municipal sites. With regard to the micro explanatory variables, the number of hierarchical levels and previous involvement in criminal activity by the firms were obtained from the judgements. The ORBIS database,<sup>4</sup> which provides business information, was sourced for further data such as the size of the firm, the number of years in business and economic hardship.

## Variables

This section outlines the variables used in the logistic regression to define the effects of the explanatory variables in terms of resource dependency and the effects of micro factors affecting the firm on the hazard level of the illegal waste disposal.

The dependent variable of interest is the hazardousness of the illegal waste disposal. In this study, hazard is a multifaceted concept determined by means of a set of four variables used in previous qualitative studies on illegal waste disposal: (i) the total area of the illegal dumping (Troisi & Alfano, 2020), in square metres; (ii) involvement in crime (Nese & Troisi, 2019), codified as a categorical variable with three groups in ascending order: individual, simple criminal association in cases in which individuals jointly commit just one offence and organized crime, characterized by ongoing criminal collaboration and organizational structure; (iii) the persistency of waste disposal (Barba et al., 2011), a binary variable assuming a value of 1 if the illegal waste disposal continued over time and 0 if it was occasional; and (iv) the presence of toxic waste (D'Alisa et al., 2010), codified as a dichotomous variable assuming a value of 1 if the illegal waste was toxic and 0 if not.

Furthermore, in order to match the sanctions to the offence, the criteria were taken from the Italian Criminal Code, and they may be found in a number of international normative sources. Table 1 shows the occurrence of illegal dumping as an environmental crime as well as the criteria used to assess the hazardousness in the legislation of selected European countries.

<sup>3</sup><http://www.italgiure.giustizia.it/sncass/>

<sup>4</sup><https://orbis.bvdinfo.com/>

**TABLE 1** Examples of legal systems and statutes providing the illegal dumping as a crime and the hazardousness criteria.

Normative source	Presence of illegal dumping as an environmental crime	Waste type	Land type	Incident size	Involvement in crime	Kind and entity of the damage
Directive 2008/99/EC of on the protection of the environment through criminal law	x	x				x
Germany 28 StGB, §§ 27 to 27c of the Law on Chemicals (Chemikaliengesetz, ChemG) and §§ 71 and 71a of the Law on Nature Conservation (Bundesnaturschutzgesetz, BNatSchG)	x	x	x		x	x
Netherlands Economic Offences Act (Wet op de economische delicten)	x	x	x	x		x
France Article 410–1 lists Article 521–1 CC of the general offence of “ <i>délinquance écologique</i> ”	x					x
Spain Art. 328 Código penal	x					
United Kingdom Environmental Protection Act 1990 (EPA) Section 34–36 3. Waste (England and Wales) Regulations 2011 Regulation 42(1)(a): 5. Hazardous Waste (England and Wales) Regulations 2005 (HWR) Regulation 19	x	x	x	x	x	x

Since the hazardousness of the illegal waste disposal is a complex concept involving different combinations of variables, cluster analysis was carried out to identify groups of illegal waste management practices with the same hazard features. Using R software, a k-means cluster analysis using Euclidean distances was carried out. Gap statistics and silhouette value (0.44) enabled two clusters of illegal waste management practices to be identified. Table 2 shows the summary statistics of the hazardousness for the specific clusters.

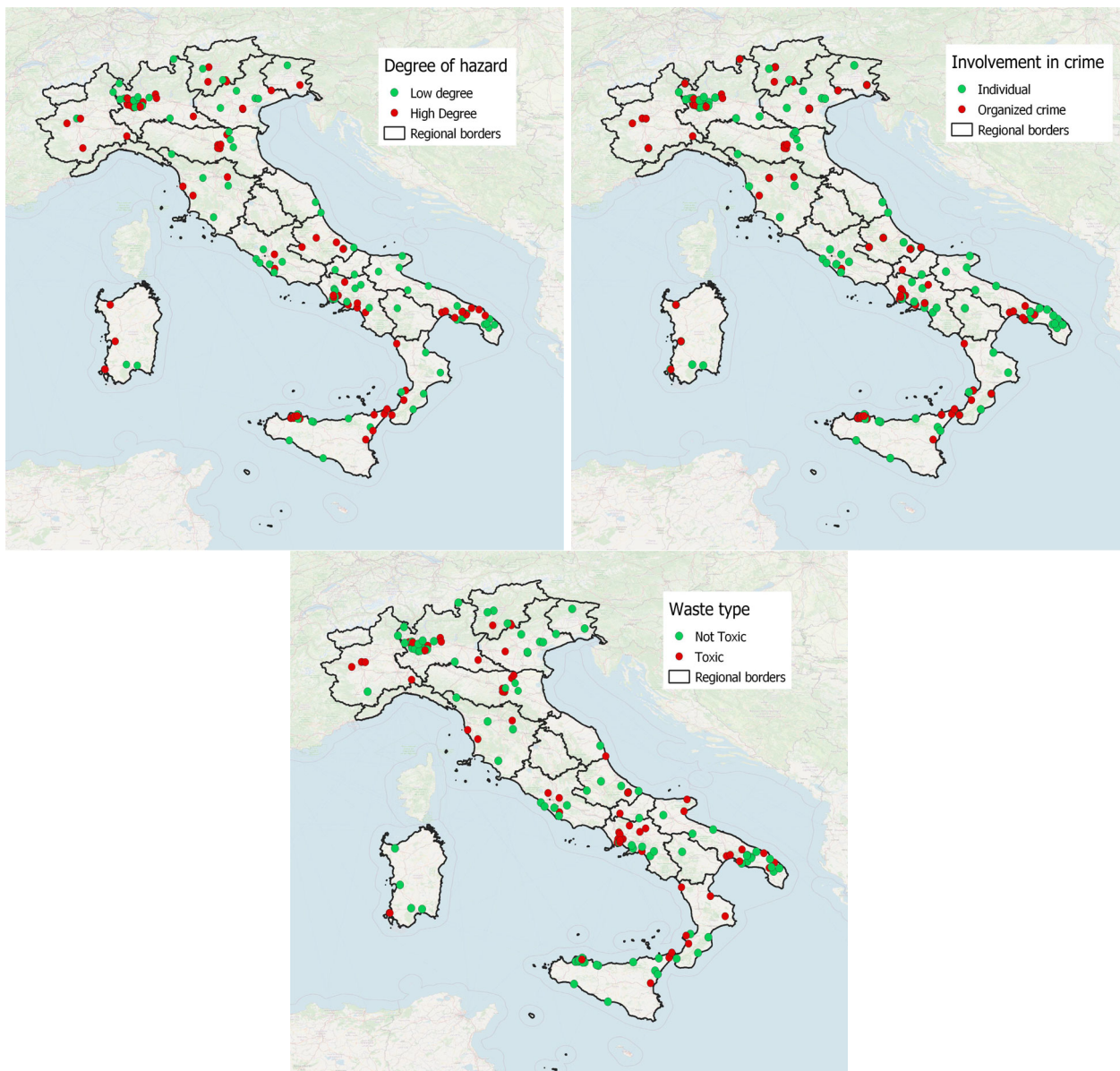
In Table 2, Cluster 1 consists of cases of illegal waste disposal characterized by higher values of hazard as related to the variable. This cluster groups together larger scale cases of waste disposal (62% over 3,000 m<sup>2</sup>) predominantly involving criminal organizations (75% of the cases), with illegal waste disposal continuing over time (97%). Cluster 2 groups together smaller scale cases of waste disposal (in 63% of the cases less than 3,000 m<sup>2</sup>) by a single firm (84%) and occasionally and mainly involving non-toxic waste (72%). Overall, the cluster analysis enables us to distinguish between illegal waste disposal characterized by the highest hazardousness (Cluster 1) and that with a lower value (Cluster 2). Finally, the dependent variable is codified as a binary

**TABLE 2** Summary statistics of the hazardousness for the clusters identified.

Variables	Cluster 1	Cluster 2	Total
Area of the illegal waste disposal			
<3,000 m <sup>2</sup>	38%	85%	63%
≥3,000 m <sup>2</sup>	62%	15%	38%
Involvement in crime			
Individual	24%	84%	55%
Simple criminal association	56%	16%	36%
Ongoing criminal collaboration	19%	0%	9%
Waste disposal over time			
Occasional	3%	100%	53%
Continued over time	97%	0%	48%
Toxic waste			
No	47%	72%	60%
Yes	53%	28%	40%

variable, assuming a value of 1 if the illegal waste disposal is placed in Cluster 1 and 0 if not.

The territorial incidence of the two clusters is uniform throughout the Italian regions, as seen in Figure 2. When



**FIGURE 2** The geographical distribution of the illegal dumping.

only the ‘criminal participation’ variable is considered, the corresponding distribution appears to be validated. Focusing on the toxic effects of illegal waste, on the other hand, exacerbates and overlaps with cases of organized crime in southern regions, leading to the conclusion that the mafia is frequently behind the most serious cases.

The explanatory variables are then divided into environmental resource dependency related and micro factors. Previous studies consider the first group as follows: (i) The bankruptcy rate of firms in a particular sector in the year of the illegal waste disposal is considered as a proxy for market uncertainty (Stolbov & Shchepeleva, 2020); (ii) market concentration (Hofer et al., 2012) is measured as the sum of the market shares of the largest five firms in the sector in percentage terms; (iii) local waste management costs are expressed as the

unit cost of the specific type of waste disposal in euros (Troisi, 2022); (iv) the time required for legal waste disposal was expressed as the number of weeks necessary for waste disposal; and (v) local waste disposal charges (Paes et al., 2019) are calculated in euros.

As these variables are correlated (average correlation value 0.38) and, at the same time, constitute the environmental explanatory variable of resource dependency, we performed a second k-means cluster analysis to distinguish between environments characterized by the same level of resource dependency. The cluster analysis enabled us to define two clusters (silhouette value 0.35) for the environment (Table 3). Mean values and standard deviation are shown in parentheses.

Cluster 1 consists of observations with lower bankruptcy rate values (on average 6.69), local waste

**TABLE 3** Resource dependency cluster analysis results.

Variable	Cluster 1	Cluster 2
Bankruptcy rate	6.69 (1.71)	8.00 (1.54)
Market concentration	28.06 (21.52)	4.12 (1.33)
Local waste management cost	112.66 (57.47)	147.40 (35.19)
Legal waste management time	4.22 (2.42)	9.6 (1.83)
Local waste management taxes	4.65 (2.43)	17.33 (4.76)

management costs (112 euros), the time required for legal waste management (4.22 weeks) and local taxes (4.65 euros mean value) and with the highest market concentration (28.06%). Conversely, Cluster 2 consists of observations characterized by the highest resource dependency values and the lowest market concentration values (4.12%). Overall, cases in Cluster 1 are environments with a lower level of resource constraints, whereas cases in Cluster 2 represent more competitive markets with more significant resource constraints. Finally, the degree of resource dependency variable is coded as dichotomous, assuming the value of 1 in cases of a high degree of resource constraints (Cluster 2) and 0 otherwise.

With regard to the micro variables of each firm, the following were considered: (i) the hierarchical levels involved (Pinto et al., 2008), expressed in numbers; (ii) the firm's recidivism, that is, the propensity to reoffend (Cheng & Ho, 2019) codified as a dichotomous variable, assuming a value of 1 if the firm has previously committed other offences and 0 otherwise; (iii) the size of the firm (Collins et al., 2009) expressed as the number of employees; (iv) the number of years the firm had been in business (Baker & Nelson, 2005) measured from its legal foundation until the time of the offence; and (v) the economic hardship of the firm (Jaakson et al., 2019), a dichotomous variable assuming a value of 1 if the firm is experiencing economic hardship and 0 if it is economically sound.

## METHOD AND RESULTS

Considering the binary nature of the dependent variable, the separate effects of resource dependency and the micro variables for each firm were evaluated by means of logistic regression. Using maximum likelihood estimation, the model shows the effect of each explanatory variable on the logarithm of the odds ratio of the dependent binary variable, that is, the hazardousness of the illegal waste disposal. The logistic regression model is formally described by the following equation:

$$\log\left(\frac{P(y=1)}{1-P(y=1)}\right) = \beta_0 + \beta_i x_i + u,$$

in which  $y$  is the binary dependent variable under investigation, in this case the degree of hazard. The  $\beta_i$  coefficient describes the effect of each explanatory variable  $x_i$  on the logarithm of the odd ratio,  $\beta_0$  represents the intercept and  $u$  is the residual error.

The main results of the analysis (Model 1) and the diagnostic tests are shown in Table 3. In addition, the joint effects between resource dependency and the micro variables were explored using a two-way interaction analysis (Dawson, 2014) (Models 2 to 6 in Table 4).

Overall, our hypotheses were confirmed by the logistic regression results.

First, regarding the separate effect of the micro variables, the number of hierarchical levels involved is significant and positively related to the dependent variable (0.567,  $p < 0.05$ ). The greater the number of hierarchical levels involved, the greater the hazardousness. Firms' recidivism is negatively related to the illegal waste disposal hazardousness ( $-1.004$ ,  $p < 0.05$ ). Thus, a lower level of hazardousness is more likely when firms have previous experience of committing crimes. Similarly, the age of the firm is negatively related to the hazardousness ( $-0.076$ ,  $p < 0.001$ ). Specifically, older firms have a greater propensity to engage in illegal waste disposal with a lower level of hazardousness. These results provide evidence in support of H1. In contrast, the size of the firm and economic hardship are not significant, thus not supporting H1.

Second, as for the separate effect of the meso variable, the resource dependency is significant and positively related to the hazardousness of the illegal waste disposal (1.273,  $p < 0.05$ ). The high degree of environmental resource dependency leads to a high level of hazardousness, thus supporting H2.

Third, our results for the interaction term that captures the two-way joint effect of the meso factors and micro factors are as follows. Resource dependency \* recidivism is significant and positively related to the hazardousness (2.357,  $p < 0.05$ ), whereas when the effect of recidivism is separately considered, it is negative. This means that the firm's recidivism, together with the condition of high environmental resource dependency, leads to a higher level of hazardousness, thus confirming H3.

Resource dependency \* firm size and resource dependency \* age of the firm are both negatively related to the dependent variable ( $-0.064$ ,  $p < 0.01$ , and  $-0.353$ ,  $p < 0.01$ , respectively, in Models 4 and 5). The joint effect of resource dependency and size is significant, unlike cases in which the size of the firm is separately considered. A lower level of hazardousness is thus more likely to occur in cases of environmental resource dependencies when combined with cases of larger firms. This result also confirms H3.

In terms of the age of the firm, the joint effect of resource dependency further confirms that older firms are



**TABLE 4** Binomial logistic regression results.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	0.481 (0.600)	0.169 (0.645)	0.674 (0.603)	-0.052 (0.650)	-0.488 (0.676)	0.414 (0.613)
Resource dependency	1.273* (0.501)	2.858* (1.182)	0.542 (0.570)	3.277*** (0.986)	5.934*** (1.667)	1.667* (0.779)
Hierarchical levels involved	0.567* (0.252)	0.785** (0.292)	0.592* (0.257)	0.556* (0.259)	0.723** (0.272)	0.557* (0.253)
Recidivism/tendency to reoffend of the firm	-1.004* (0.420)	-1.038* (0.427)	-1.539** (0.513)	-0.935* (0.440)	-1.286** (0.474)	-0.978* (0.421)
Size of the firm	0.003 (0.007)	0.003 (0.007)	0.002 (0.007)	0.012 (0.021)	0.005 (0.007)	0.003 (0.007)
Age of the firm	-0.076*** (0.020)	-0.076*** (0.020)	-0.077*** (0.020)	-0.065** (0.021)	-0.040# (0.021)	-0.076*** (0.020)
Economic hardship affecting the firm	-0.122 (0.399)	-0.163 (0.404)	-0.195 (0.410)	0.022 (0.414)	-0.150 (0.430)	0.016 (0.446)
Resource dependency * Hierarchical levels		-0.894 (0.575)				
Resource dependency * recidivism			2.357* (1.113)			
Resource dependency * size				-0.064** (0.0234)		
Resource dependency * age					-0.353** (0.118)	
Resource dependency * economic hardship						-0.688 (0.996)
Pseudo $R^2$	0.28	0.29	0.30	0.33	0.37	0.28
Wald test	37.8	39.2	39.6	36.0	31.4	37.2

Note: The logit linearity assumption was checked by the Box-Tidwell test; absence of multicollinearity was verified using the variance inflation factor.

# $p < 0.1$ , \* $p < 0.05$ , \*\* $p < 0.01$ , and \*\*\* $p < 0.001$ .

more likely to engage in illegal waste disposal characterized by a lower hazardousness, thus supporting H3.

However, resource dependency \* number of hierarchical levels and resource dependency \* economic hardship are not significant, thus not supporting H3.

## DISCUSSION

The impact of the variables on the hazardousness is established by comparing the effects of the individual variables with their effects when jointly employed. We first consider resource dependency for its separate effect. A positive impact on the hazardousness is not surprising, as it can lead to high levels of illegal waste disposal. This behaviour may provide benefits, particularly when resource dependency is high. The decision to become autonomous from the legal management of waste has cost implications, as waste becomes untraceable and thus neither (high) fees nor administrative charges are incurred. The higher the costs, the more stable the illegal alternative tends to be, giving rise to a continuous flow of

industrial waste. In addition, a significant reduction in costs may enable firms to manage their (high) market resource dependencies in a more cost-effective manner. This tends to distort competition: By engaging in unfair competition, firms incur lower costs in comparison with firms complying with the law.

As for the separate effect of the structural micro variables, the greater the number of hierarchical levels involved, the higher the hazardousness. This result is in line with the previous literature (Pinto et al., 2008), as it shows that an increase in organizational units and, thus, personnel can be reflected in an increase in the number of cases of illegal waste disposal, the amount disposed of, and illegal waste disposal hazards. Additionally, it does not show a combined effect with the resource dependency variable on the hazardousness. The results show that the involvement of the units is independent of external environmental constraints, representing an illegal practice with a degree of internal acceptance that is sufficient to impact on the hazardousness of the illegal waste disposal.

In terms of cultural micro variables, the impact of previous crime, when considered on its own and together

with resource dependency, represents a significant finding. Its separate impact on the hazardousness is negative, but when combined, it becomes significantly positive. The negative impact suggests that the learning process from previous crimes can lead to illegal waste disposal with a low level of hazardousness, as these crimes may be less detectable (Cheng & Ho, 2019). However, in conditions of environmental resource dependency, previous crimes are related to higher hazardousness. Environmental constraints act as an incentive for reoffending firms to raise the level of hazard and thus lose their low traceability. Under such constraints, making significant compromises to achieve goals can still be acceptable, as firms have previous experience (Tonoyan et al., 2010), although with a greater impact.

In terms of the organizational variable of size, a negative impact on the hazardousness has been demonstrated, both when considered as an isolated variable and when considered jointly with resource dependency. The decision to contravene the waste management regulations does not appear to be radical, as illegal dumping is characterized by irregular occurrences and low volume, without resorting to external criminal collaboration on a continuous basis. The hazardousness is always the same, suggesting that larger firms do not face the problem of high resource dependency, as presumably they have ready access to financial resources, enabling them to solve problems of this kind (Hessels & Terjesen, 2010). Similarly, older established firms are more likely to resort to illegal waste disposal with a lower hazardousness, thus only temporarily contravening waste management regulations. It is likely that the greater the illegal waste disposal hazard, the more detrimental the effect on the firm's reputation, which is important for older established firms in terms of value (Collins et al., 2009). Finally, the impact of size on the hazardousness is not significant when combined with resource dependency. Long established firms may have more experience in facing resource adversity and may be less dependent on certain resources (Baker & Nelson, 2005).

The shift in emphasis from criminal behaviour collectively performed by firms to firm-specific decisions based on internal and external dynamics allows for the identification of some theoretical implications.

The findings indicate that explanations for illegal dumping ('why') can be found at both the micro and meso levels. Micro and meso factors can address 'how' firms resort to illegal dumping, as the hazardousness varies accordingly.

This demonstrates that the theoretical approach to illegal dumping by firms is partial when the focus is exclusively on an issue examined as a collective. When compared to literature that examines a unique phenomenon with common causes and modalities, the occurrence as well as the combination of micro and meso factors results in a gradual increase in the severity of firm's decisions and thus a more accurate representation of the phenomenon. As a result, this research makes

several contributions to the literature. First, by focusing on industrial cases, the study adds to the research into illegal waste management, thereby filling the aforementioned gap. We provide a more comprehensive understanding of the causes of illegal dumping by analysing the driving factors at multiple levels. As said, the decision to break the rules appears to be firm specific and influenced by a variety of factors and varying degrees of risk. Second, we employed two theoretical models: the bad barrel theory for the micro dimension and the resource dependency theory for the meso level. Both of these theoretical perspectives are important, not only because they provide a more complete picture but also because they can be considered separately and jointly when capturing the firm's decisions. We therefore contribute to the literature on resource dependency with new insights. In the resource dependency literature, the decision to engage in illegal practices is viewed as a single option (Bretherton & Chaston, 2005). In this study, this is further explored to understand whether different resource constraints along with different micro features result in different decisions. This refers to sub-types of illegal waste disposal expressed in terms of the degree of hazard.

## CONCLUSIONS

This study highlights the fact that the causes of unlawful waste disposal are firm-specific, revealing micro and meso mechanisms that foster the illegal behaviour and its hazardousness.

The effects of micro and meso factors are considered both separately and jointly.

It has significant implications, especially in terms of policy options for addressing illegal waste disposal. Framing the motivations and modes as firm specific rather than impersonal can help to improve the design of specific policies in the field. Particularly, it helps to understand how to prevent it: Based on the findings, prevention seems to be the essential policy measure to avoid or at least reduce the phenomenon. In this study, illegal waste disposal appears to be location specific. Contexts in which local waste management charges are high, together with long waiting times and substantial waste management costs, give rise to an incentive for newer and more vulnerable firms to break the rules and resort to illegal practices. It is therefore necessary to take preventive action at the local level.

Reducing taxes and costs for the most vulnerable firms would make it possible to reduce the risk of perpetuating vicious cycles. If waste management costs are not covered by the firms themselves, the local authorities are likely to further increase charges, thus penalizing firms that manage their industrial waste in compliance with the law. Equally, an important means of prevention is to implement reforms for markets in which the high level of risk is in itself an incentive to engage in illegal practices.

An emphasis on repressive measures is equally important since the effective application of sanctions should have a deterrent effect on other firms.

It appears to be a key action for many countries (see Table 1), where illegal waste disposal is almost uniformly considered a crime, albeit with varying features and degrees of severity reflecting the local characterization.

However, this does not deal with the consequences of illegal waste disposal. Once an illegal landfill site has been created, the costs of reclamation are particularly high, and in many cases, the damage caused by toxic waste is irreversible. However, prevention can lead to much more significant results.

Several managerial implications are then related to the main findings. Resource dependency, both in isolation and, in some cases, jointly with the internal dynamics of the firm, is a significant factor making the consequences of illegal waste disposal more severe, indicating that the decision to engage in illegal dumping is essentially a simpler and quicker way to reduce costs relating to waste management, delays and training. Firms appear to seek short-term solutions, overlooking the risk of considerably higher costs in the long term, most notably for the environment in general. What seems to be missing is a general waste management culture, which would entail additional costs especially in the short term. However, it is also the case that an effective waste management culture would include adequate recycling facilities, especially in the construction sector. In countries where green economy practices are more widespread, we are witnessing the reduction of illegal waste management. Promoting proper waste management is not only an objective that companies should set for themselves but also for the obvious reduction of environmental problems that often have an impact on the communities in which they operate.

This study has two main limitations. The first concerns the concept of hazard. Its legal meaning is derived from the definition in the Italian Criminal Code, mainly considered in quantitative terms. An increase in illegal dumping and in the number of individuals and firms involved in illegal waste disposal over time increases the hazard. The only non-quantitative factor concerns toxic industrial waste, capturing only one specific element. The potential deterioration of the physical characteristics of the soil is not considered, although this is important in the definition of hazard. However, the legal definition can be considered appropriate for this study. The focus is in on understanding the criminal behaviour of firms, and thus, criminal conduct and its consequences are under investigation. The second limitation concerns the data used, which may suffer from selection bias. The illegal dumping cases examined are not necessarily representative of the phenomenon as a whole but may reflect the degree of efficiency of the judiciary in the cases prosecuted. Other cases that are not brought to court could offer different insights into illegal waste disposal. However, these data are valuable as reliable observations

of illegal waste disposal are limited, at least in terms of understanding its general dynamics, as such cases are otherwise non-traceable.

Finally, three potential lines of further inquiry emerge from this study. The framework proposed here could be used to investigate the diachronic evolution of illegal waste disposal. Furthermore, throughout this analysis, it has become clear that illegal waste disposal has a significant local character. It is noticeable both nationally (see Table 1) and regionally (see maps in Figure 2), raising two issues. At the national level, the presence of regulations based on local characteristics of the phenomenon, with varying levels of sanctions, may, paradoxically, encourage international waste trafficking between European countries over time. Consequently, a future re-evaluation of the characteristics of the phenomenon may be necessitated by a study of the movements of such trafficking in countries with less stringent regulations. Then, the maps identify illegal waste disposal in individual Italian regions along a spectrum ranging from the absence of cases to the most severe cases of primarily toxic spills, which are present, albeit in smaller quantities, even in regions with a comparative absence of organized crime. By disaggregating the phenomenon at the regional level and emphasizing both formal and informal territorial institutions, it may be possible to gain an in-depth understanding of the decisions made by firms.

## CONFLICT OF INTEREST


The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon request.

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