

## ORIGINAL ARTICLE OPEN ACCESS

# Green Grease: Environmental Crime, Corruption and Money Laundering

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## ABSTRACT

We offer a theoretical and empirical analysis that shows how corruption can be a ‘green grease’ that facilitates both environmental crimes and money laundering. Corruption can be an accelerator that amplifies the multiplier effect on illegal revenues. We model these relationships using a logistic function, which we calibrate to estimate overall environmental crime revenues using Italian regional data from 1995 to 2020.

**JEL Classification:** D7, F18, K4, R30

## 1 | Introduction

In this paper, we present a theoretical and empirical analysis that shows how corruption can be a ‘green grease’ that facilitates both environmental crimes and money laundering. Corruption can be an accelerator that amplifies the multiplier effect on illegal revenues. This result can be obtained using in a simultaneous and systematic way two different strands of literature, devoted to the role of corruption in influencing respectively environmental crimes, on the one side, and money laundering, on the other side.

Our starting point is the fact that the nexus between environmental crime and corruption has been progressively and widely recognised at the institutional level, as well as in the economic literature.

Environmental crime has spread globally in recent years, causing significant harm and posing a significant risk to the environment and human health (European Commission 2021). The low likelihood of punishment combined with the potential for huge profits make environmental crime a magnet for organised criminal groups, which have traditionally engaged in other

illicit activities (Hyatt and Trexler 1996). In many European countries, including Malta, Germany, Sweden and Bosnia and Herzegovina, environmental damage is treated as an administrative offence that carries no criminal penalties, even though law-enforcement investigations have confirmed that criminal organisations had begun engaging in environmental crime alongside their other criminal activities (Colantoni, Sarno, and Bianchi 2022; Europol 2022a). Other countries, such as Hungary, Italy and Spain, are oriented towards the penal code. In the United States, where environmental crime is labelled ‘white-collar’ crime, the government has implemented a complex scheme of statutes and uses its Environmental Protection Agency (EPA) to regulate activities that affect the environment.

These country-to-country differences make the definition of environmental crime contentious and ambiguous (White 2010). Moreover, the lack of uniformity among regulations in various countries facilitates environmental crime, even though the international community has focused on transnational environmental crime for more than a decade. In 2010 the United Nations Office on Drugs and Crime (UNODC) included environmental crime as a type of crime worthy of attention in its Transnational Organized Crime Threat Assessment. In 2012, INTERPOL took

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several actions that highlighted its concerns about the extent of environmental crime and its connection to other organised crimes (INTERPOL and UNEP 2012).

The problem is that the main challenge for the law enforcement agencies has been identifying the complex strategies that organised crime groups adopt to undertake systematic environmental offences (Europol 2022b). Here, the relationship between environmental crime and corruption comes in. In fact, for the past 10 years, the international community has increasingly stressed the relationship between environmental crime and corruption in multiple fora, including the 2016 Convention on International Trade in Endangered Species, the 2019 UN Convention against Corruption, the 2020 UN Convention against Transnational Organised Crime and the Financial Action Task Force (Micallef 2022). Academics have also shown an interest in the effects of corruption on environmental goods and services (Lopez and Mitra 2000; Fredriksson, List, and Millimet 2003; Damania, Fredriksson, and List 2003; Lisciandra and Migliardo 2017).

The key question becomes then how corruption and environmental crime can be interlinked, and consequently how to analyse their complex relationships. In this perspective we propose here a setting where also money laundering is present, taking into account the suggestions that have been recently offered at the institutional level. In fact, in 2021, the FATF published its first report on the laundering of money from environmental crimes with a focus on funds obtained from illegal logging, illegal mining, waste trafficking, and illegal land clearing for building purposes or real-estate speculation. Moreover, Recommendation 1 of the FATF requires governments to pay greater attention to the risk of money laundering and terrorist financing (ML/TF) related to environmental crimes.

Our setting is the ‘Triple C’ framework. Such framework is a device to investigate in a systematic and simultaneous way all the possible links that can exist between environmental crime, money laundering and corruption. Its peculiarity is due to the fact that it takes stock from the studies that analysed in general the money laundering multiplier mechanism (Masciandaro 1999; Buchanan 2004; Reuter and Truman 2004; Kennedy 2005; Unger et al. 2006; Unger 2007; Barone and Masciandaro 2011; Levi 2014; Barone, Delle Side, and Masciandaro 2018), and in particular the role of corruption as an accelerator factor (Barone, Masciandaro, and Schneider 2022).

The paper is organised as follows. Section 2 presents the facts that can be explained using the ‘Triple C’ narrative. This narrative can be theoretically modelled using a logistic function, which is presented in Section 3, while in Section 4 the model is calibrated using Italian data. In section 5 we conclude, highlighting possible future research steps.

## 2 | Environmental Crime, Corruption and Real-Estate Money Laundering: The ‘Triple C’ Narrative

Our starting point is the distinction of two different types of environmental crimes: ‘dirty’ green crimes and ‘cleaning’ green

crimes. ‘Dirty’ green crimes are environmental crimes that generate illegal profits that require money laundering, such as illegal waste disposal or illegal trade in ozone-depleting substances. ‘Cleaning’ green crimes are environmental crimes that facilitate money laundering, such as arson, illegal logging, deforestation, and illegal building and real-estate activities. In dirty green crimes, criminals’ behaviour may be similar to their behaviour in other crimes, such as drug trafficking, prostitution and smuggling. In cleaning green crimes, the illegal activities cease to be antecedent crimes and instead become instrumental in cleaning dirty money derived from other crimes.

In such settings, corruption can play a triple role. On the one side, it can be a gateway to an environmental crime (stage one). The profits resulting from that crime create demand for money laundering. Then, corruption can facilitate the use of the real-estate sector as a money-laundering channel (stage two). Finally, the laundered money can be reinvested through new environmental crimes, and again corrupted public servants can play a role (stage three). The three phases can be visually all together using the ‘Triple C’ framework (see Figure A1). All in all, corruption can become an accelerator of the multiplier effect that links environmental crime and money laundering. In the following, we discuss each of the phases going into the details.

### 2.1 | Stage One: Environmental Crime and Corruption

As highlighted by literature and anecdotal evidence, corruption and organised crime can be two significant elements in implementation of an environmental crime. The perpetrators of environmental crime can use corruptive measures to fulfil their criminal business aims. Often, corruption can act as a ‘door opener’ for environmental crime (Williams 2019), and environmental crime seems to be particularly relevant in regions where corruption is high and production capacity is low (Bergenas and Knight 2015). It has been shown that corrupted public officials responsible for the administration and monitoring of environmental regulations may intentionally underestimate the negative impact of a zoning project on the environment (Leitao 2016; Damania, Fredriksson, and List 2003; Duri 2020).

So far these phenomena of ‘crime convergence’ or ‘cross-over crime’—that is, the intersection of environmental crime with other serious crimes, such as smuggling, corruption, fraud, tax evasion, money laundering or murder—has been investigated in the Asia-Pacific region (White 2016; INTERPOL and UNEP 2012). Moreover, the low risks and high profits associated with environmental crime—for example, illegal logging, wildlife crime, dumping and illegal transport of hazardous waste, illegal mining—have attracted organised criminal groups in Latin America, traditionally engaged in illegal drug trafficking (Bargent 2014; Global Initiative against Transnational Organized Crime 2016; Duri 2020). In Italy, from 2010 NGOs claim the existence of a stable association between corruption and environmental crime (Legambiente 2021), while the role of corruption has been uncovered in the illegal soil and sand mining conducted by Italian organized crime groups (Parliamentary Inquiry Committee 1997 and 2012; Rege and Lavorgna 2016).

## 2.2 | Stage Two: Environmental Crimes Revenues, Real-Estate Money Laundering and Corruption

The real-estate market serves as a primary avenue for the laundering of money stemming from various criminal activities, such as drug trafficking, prostitution and smuggling.

The abuse of the real-estate sector is one of the oldest methods used to launder ill-gotten gains stemming from various organised criminal activities (Nazzari 2024; European Parliament 2019; OECD 2007; FATF 2007; FinCEN 2008; ESAAMLG 2013; AUSTRAC 2015). The European Parliament (2019) has highlighted several cases of money laundering through real estate in different European Union countries, as the Czech Republic, France, Finland, Germany, Greece, Portugal and the Netherlands. The role of the real-estate sector in money laundering has been highlighted also in the economic literature (van Duyne and Soudijn 2009; Ritzen and Nelen 2011; Saul and Levin 2015; Naheem 2017; Teichmann 2018; Maloney, Somerville, and Unger 2019; Barone 2023).

Into the real-estate sector the ‘cleaning’ green crimes can play a key role in facilitating money laundering in this regard. In fact, new constructions—whether for recreational (parks), transport (roads and railways), agricultural (farms), residential (housing and settlements) or commercial (businesses and factories) purposes—may require expansion of urban areas or changes in land use. These steps can be achieved illegally through environmental crimes, such as arson, illegal logging and illegal construction (Rendana et al. 2015; Sonter et al. 2017; Brisman, South, and White 2015; UNEP 2011; Lee et al. 2015; UNEP 2020; Walker 2021). Here, again, corruption can play a role, undermining the effectiveness of the AML (anti-money laundering) regulations (Europol 2022a; Barone, Masciandaro, and Schneider 2022).

## 2.3 | Stage Three: Environmental-Crime Reinvestments and Corruption

Finally, the re-investment of laundered money could committing new environmental crimes, is more likely to occur if corruption is present (Emmers 2002; Elliott 2007). Countries considered to be more corrupt have fewer environmental guidelines in place, have less land protected and participate in fewer international environmental agreements (Williams and Dupuy 2017; Martini 2012; Leitao 2016; Transparency International 2013).

Local communities influenced by organised crime use opaque environmental and urban-planning procedures to change farmland into building areas. Under the pressure of corruption and organised crime, natural resources, cultural and historic heritage, national parks and the general common good, which should be protected by urban-planning laws, are exploited (Cole 2007; Mekinc, Kociper, and Dobovšek 2015).

A great deal of empirical research analyses the role of corruption in the construction and natural-resource sectors around the world (Branis 1994; Momtaz 2002; Paliwal 2006; Kolstad

and Søreide 2009; Dougherty 2013, 2015; Neu, Everett, and Rahaman 2015; Williams and Dupuy 2017). In a project's environmental-impact assessment stage, there is a risk of corruption, such as bribery aimed at encouraging assessors to downplay the negative impact on the environment (Canter 1996; Jay et al. 2007; Williams and Dupuy 2017, 121).

The illegal circuit then starts again. A case study of this type of corruption is found in the Barro Blanco Dam project in Panama. That project was nearly completed, allegedly due to corruption in both the government and the construction company. Legally required assessments were not undertaken, and protests from local communities regarding the project's environmental and social impacts were disregarded. In Brazil, authorities investigated the Vale SA mining company in relation to a possible cover-up regarding safety procedures. The investigation was triggered by the death of more than 300 people when a dam burst at the Córrego do Feijão mine (Lima 2019). Other types of corruption and actors are involved in illegal logging and other cleaning green crimes (Callister 1999; Contreras-Hermosilla 2002; Richards et al. 2003; Vandergert and Newell 2003; Siebert and Elwert 2004; Alemagi and Kozak 2010; Miller 2011; Piabuo et al. 2021).

## 3 | Environmental Crime, Corruption and Real-Estate Money Laundering: A Dynamic Model

The dynamic relationships among environmental crime, corruption and real estate-based money laundering can be described by applying the consolidated multiplier approach and modifying it for this novel setting (Masciandaro 1999; Barone and Masciandaro 2011; Barone, Delle Side, and Masciandaro 2018; Barone, Masciandaro, and Schneider 2022).

Let us analyse the behaviour of a criminal who has committed an environmental crime and achieved a profit  $I_0$  at time  $t = 0$ . Notably, this initial profit is higher when the leverage that corruption can create is higher net of the implied corruption costs. It is the Stage One in the 3 C sequence, where the first channel of corruption as an accelerator device can be active.

A share, ‘ $\theta$ ’, of the dirty capital derived from the environmental crime  $I(t)$  needs to be laundered. The demand of money laundering is borne. This behaviour characterizes any crime that generates a revenue, if this revenue increases the probability of detection of the criminal (Masciandaro 1999). However, when the money laundering takes place through the real-estate sector, environmental crimes play a key role as facilitators of the clean-up activity. Therefore, the share ‘ $\theta$ ’ is influenced by the transaction costs associated with the probability of crime discovery and, therefore, incrimination, and by the opportunity to launder through the real-estate sector. To grasp this hypothesis, we take the degree of illegal building into consideration. Here, the presence of corrupted public officials in the design and the implementation of the AML (anti-money laundering) policy can undermine the policy of prevention and deterrence (Barone, Masciandaro, and Schneider 2022). It is the Stage Two in the 3 C sequence, representing the second potential channel where corruption can play its role.

Finally, a share, ' $\gamma$ ', of the laundered money will be reinvested in the illegal market at the illegal interest rate ' $r_i$ ', where it will be used to carry out new environmental crimes. The share of laundered money reinvested in the illegal market (' $\gamma$ ') will depend on the 'capturability' of local officials, which we measure as the number of municipalities dissolved by the mafia and as environmental corruption. At the same time, a portion ' $(1 - \theta)$ ' of illegal capital must be reinvested in the illegal market prior to being laundered and, consequently, spent on consumption goods, and invested in the legal and illegal markets. It is the Stage Three in the 3 C sequence.

Here, the concept of 'carrying capacity' that can constrain the growth of the illegal revenues comes in (Barone, Masciandaro, and Schneider 2022).

This concept has been used in economics to analyse specific fields, like technological innovation (Griliches 1957; Mansfield 1961; Metcalfe 1981; Andersen 1999; Metcalfe 2003) and industrial growth (Kuznets 1930), applying the more general perspective that cyclical fluctuations in economic growth matters.

Kuznets observed long-term 'waves' in economic growth (Kuznets 1955, 1966, 1971), influenced by factors like technology, population and government structures (Kondratieff 1935, 2002; Schumpeter 1939). These waves, characterized by periods of acceleration and deceleration, suggest that economic growth is not a linear process but rather exhibits cyclical behaviour. Recently, some authors empirically tested the growth cycle model (Grasselli and Maheshwari 2018).

Moreover, it is worth noting that carrying capacity itself is a dynamic concept; it can fluctuate over time. This is particularly relevant in economics, where cyclical patterns are common. One such concept is the 'predator-prey' model, originally from biology (Lotka 1956), which can be applied to economic relationships like wages and profits, or investment and consumption (van der Ploeg 1984, 1985, 1987). Goodwin's 'growth cycle model' (Goodwin 1946, 1967) incorporates this concept, demonstrating how economic growth can exhibit cyclical patterns.

The application in the field of the economics of crime is motivated by the fact that in general the growth of revenues—in terms of flows—and/or capital—in terms of stocks—can be constrained by two limits: market saturation (Knyviene, Girdzijauskas, and Grundey 2010; Koltan, Girdzijauskas, and Štreimikienė 2013) and policy action. Moreover, the limits themselves can be triggered, at least partially, by the revenue growth, as it is usually the case in the anti-trust policies; for example, data show us the profitability path of tradable and non-tradable sectors can be different, due to the different effects on market conditions and antitrust policies, where the former sectors profitability is constrained by market saturation due to competition, while the non-tradable sectors profitability are constrained by much stronger anti-trust policies (Besley, Fontana, and Limodio 2021). In other words, the revenue/capital growth is constrained, which is the opposite respect to the standard assumption of unlimited exponential growth.

In the context of the analysis of illegal revenue growth, the saturation of illegal markets can emerge, as well as the policy reactions in preventing and contrasting the criminal activities. The same is true for the specific case of environmental crimes.

Environmental crime generates illegal profits for perpetrators. The likelihood of these crimes occurring is heavily influenced by the associated costs, particularly the risk of detection and prosecution. Effective institutions, by penalizing those who violate environmental regulations (free riders), are crucial in deterring such crimes and promoting community well-being (Lee et al. 2019). However, the lack of clear regulation and the collusion of local authorities with organised crime fuel environmental crimes and public resentment.

As elections approach, politicians tend to increase the number of building permits, sometimes even granted in protected areas, and by awarding contracts to companies in collusion with organized crime (D'Amato, Marin, and Rampa 2019). As already highlighted, these companies also use the real estate sector for money laundering purposes. If a certain degree of corruption is tolerated by public opinion, because it is considered endemic, as corruption cases and money laundering scandals come to light, the popularity of controllers is undermined, and the risk of political turnover increase (Feichtinger and Wirl 1994; Lisciandra, Miralles Asensio, and Monteforte 2024).

The level of corruption considered tolerable depends on society's tolerance or oblivion. The increased turnover can weaken political institutions and create opportunities for further corruption. As corruption escalates, public resentment intensifies, resulting in a drop in popularity. Therefore, to maintain a certain level of popularity, the controllers begin to engage in a tough fight against corruption. A decrease in corruption reduces opportunities to engage in illegal construction and speculation. However, the endemic nature of corruption means that the positive effect of counteractive policies will be a short-term phenomenon (Ventelou 2002), after which corruption will once again enable new crimes, and the cycle go on.

In terms of theoretical modelling, the carrying capacity can be designed as sinusoidal, mirroring cyclical nature of corruption and its impact on environmental crime. By incorporating this sinusoidal carrying capacity into the logistic growth model, we can transform the 'Triple C' conceptual framework in an economic specification that can be econometrically tested. It will be the empirical 'rule of thumb' that will confirm/reject the fact that the adopted specification can be a possible identification of the 'Triple C' framework.

Going into the details, we assume that the carrying capacity  $I^*(t)$  is time dependent according to a sinusoidal function, we consider the following equation for  $I^*(t)$ :

$$I^*(t) = I_0^* + I_a \sin \omega t, \quad (1)$$

where  $I_0^*$  is the average value of the carrying capacity and  $I_a$  is the amplitude of the carrying capacity. The frequency of the oscillation is  $\omega = \frac{2\pi}{T}$ , where  $T$  is the period of oscillation.

The general solution to the problem of time-dependent carrying capacities is given by

$$I(t) = \frac{I_0 e^{\alpha t}}{1 + \alpha I_0 \int_0^t \frac{e^{\alpha z}}{r^*(z)} dz}. \quad (2)$$

We assume that the growth coefficient,  $\alpha$ , is constant with  $\alpha = \ln[(\gamma\theta(1 - C) + (1 - \theta))(1 + r_i)]$ , where  $C$  is the cost of money-laundering activities. By substituting (1) into (2), we obtain

$$I(t) = \frac{I_0 e^{\alpha t}}{1 + \alpha I_0 \int_0^t \frac{e^{\alpha z}}{I_0 + I_a \sin \omega z} dz}. \quad (3)$$

#### 4 | Calibration

- a. The theoretical specification presented above can be calibrated using Italian data. This country case is particularly interesting, given that in general the growth of Italian criminal organizations has been influenced by shocks of a cyclical nature (Mocetti and Rizzica 2024). At the same time, it is worth noting that the calibration could be replicated for other realities, provided that the data are available. In the following, we present the data used for this calibration: We extrapolated data on illegal revenue derived through environmental crime from Legambiente (2021) and extrapolated the data presented in the figure on page 72. The starting year was 1995—the year in which the ‘Parliamentary Commission of Inquiry into the Waste Cycle’ was established. The data were used as observed data for the fit analysis.
- b. With respect to the growth factor, the decision regarding the share of illegal capital that needs to be laundered ( $\theta'$ ) depends on the probability of the crime’s discovery and prosecution and, in this study, on the possibility of laundering through the real-estate sector (i.e., on the possibility of engaging in illegal construction). To provide a conservative estimate of this parameter, which serves as input data in the fit analysis, we considered both the information found in the literature on the percentage of illicit capital that is laundered and our hypothesis on the possibility of laundering money through the real-estate sector. Walker (2007) used various socio-economic indicators to estimate the proportion of dirty money that is laundered and countries in which the laundering occurs. He defined an ‘attractiveness index to money launderers’ based on several factors that express the attitude of countries towards money laundering, the level of corruption and GNP (Walker 2007). The percentage of dirty money that the criminal decides to launder depends on the country of reference and the types of crime, and ranges from 5% to 100% (See Table A1). Smekens and Verbruggen (2004) suggest that for drug-trafficking proceeds, this share amounts to 70%, while it is much lower for other crimes. As the literature does not provide information on the percentage of dirty funds that need to be laundered in the case of a crime such as illegal building, we used a conservative estimate. More specifically, we considered a minimum threshold of 50%, to which we added the degree of illegal building in Italy, which amounts to an average of 15%.

- c. A share ‘ $\gamma$ ’ of laundered capital is reinvested in the illegal sector at a rate ‘ $r_i$ ’. As Unger (2007, 175) observed, it is difficult to estimate this value. Based on the literature (Meloan et al. 2003; Unger 2007), this share amounts to 32% of total illegal capital. In fact, reinvesting clean liquidity in the illegal sector is generally difficult after completion of a risky laundering process. This does not guarantee that this is the exact share of clean capital reinvested in the illegal sector. However, considering Unger’s (2007, 175) hypothesis that this share varies between 20% and 50% of clean illegal capital, we take the percentage proposed by Meloan et al. (2003) as valid. As the probability of being able to reinvest in the illegal sector depends on the risk of discovery and prosecution, we expect the likelihood of success to depend on the extent to which local authorities can be captured. To take these costs into account, we increase the percentage of laundered money reinvested in the illegal sector by the average rate of Italian environmental corruption from 1991 to 2021 based on data provided by Legambiente (2021) and the number of municipalities dissolved by the mafia in each region divided by the total number of infiltrated municipalities (data provided by Openpolis 2021).
- d. Laundering activities are not free. Moreover, their costs may be influenced by corruption (Barone, Masciandaro, and Schneider 2022, the ‘accelerator effect’). FATF (2011) reports several cases of weakness in financial institutions’ due diligence in which suspected proceeds of corruption were allowed to flow freely through accounts. To take this relationship into account, Barone, Masciandaro, and Schneider (2022) assume that the cost,  $C$ , of money-laundering activities is composed of two parts: the technical cost,  $C_0$ , of money-laundering procedures and the cost,  $R$ , of AML regulations. The latter can be affected by corruption—a higher level of corruption makes the AML regulations more ineffective. Therefore, the cost of the AML regulations,  $R$ , decreases. According to Barone, Masciandaro, and Schneider (2022), the cost of AML regulations or the actual probability of being discovered,  $R$ , is equal to 0.46, while the *de jure* probability of being discovered is equal to 0.94. Table 1 provides a summary of our initial data.

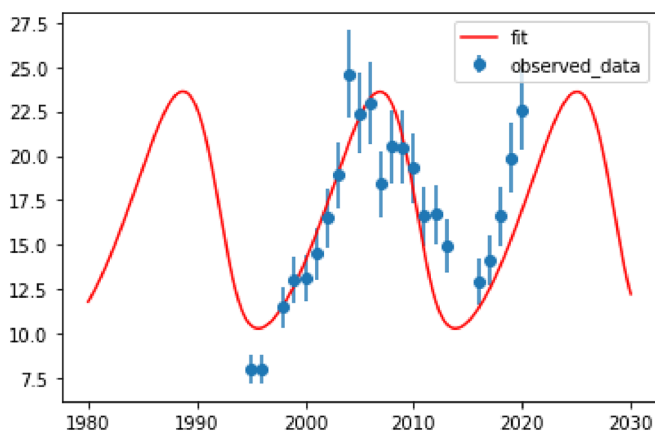
Using the Python programming language, we developed a code that performed a logistic fit with a sinusoidally variable carrying capacity against the data we collected from Legambiente (2021). To account for some noise in Legambiente’s (2021) data, we introduced a background constant parameter into the model.

Python uses standard SciPy and NumPy library functions.<sup>1</sup> To perform the fit, we considered the general equation (B4) and left out the simplification of the parameters because we initially had no information about the values of  $I_a$  and  $I_0^*$ . The initial assumptions were the following: 1944 is the starting time ( $t_0$ ) of the hoarding process; the initial environmental-crime illegal capital ( $I_0$ ) is worth EUR 2.042 billion; and the logistic growth rate  $\alpha$  is equal to 0.192. As Figure 1 shows, the average value of the carrying capacity ( $I_0^*$ ) is EUR 22.710 billion, but it fluctuates around this value, showing a trend reversal about every 10 years. The time ( $T = \frac{2\pi}{\omega}$ ) taken to complete one oscillation is almost 18 years. The data tell us that we should currently be in an

**TABLE 1** | Model parameters and their sources.

Parameters	Source
$\theta = 0.65$ (share of illicit capital to be laundered)	Own elaboration based on data in Smekens and Verbruggen (2004), Walker (2007) and ISTAT (2022)
$\gamma = 0.41$ (share of the laundered money reinvested in the illegal activity)	Own elaboration based on data in Unger (2007), Openpolis (2021) and Legambiente (2021)
$\alpha$ (the logistic growth rate)	Result of fit calculations
$C_0 = 0.1$ (technical cost of money laundering)	Reuter and Truman (2004); Barone and Masciandaro (2011)
$R = 0.46$	The actual probability of being discovered (the de facto AML cost) (Barone, Masciandaro, and Schneider 2022)
$I_0^*$ (the average value of the carrying capacity)	Result of fit calculations
$I_0$ (the starting illegal revenue arising from environmental crime)	Result of fit calculations
$I_a$ (the amplitude of the carrying capacity)	Result of fit calculations

Source: Own elaboration based on extant empirical analyses. For any parameter, the source is disclosed.



**FIGURE 1** | Cumulative illegal environmental-crime capital—logistic path. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

upward phase of the cycle. This depends on the interactions between public authorities and criminal organisations (Barone, Masciandaro, and Schneider 2022)—when regulatory conditions stabilise, criminal networks are likely to adapt to the new system by finding new ways to accumulate illicit capital. In this phase, the more the AML authorities’ focus on this phenomenon is likely to increase, the more the trend may reverse in the coming years.

To confirm the quality of the sinusoidal model, in Appendix C we show a comparison between the simple logistic model (i.e., the logistic model with scalar carrying capacity) and the proposed model.

In order to assess the quality of the fit, we tested whether the predicted values of illegal capital derived through environmental crime and observed values could originate from different distributions ( $H_1$ ) or not (the null hypothesis,  $H_0$ ). To answer this question, we used Welch’s t-test. The specification passed the test with a result of 0.55 and a  $p$ -value of 0.58.

Moreover, we performed a chi-squared test that used the following null and alternative hypotheses:

$H_0$ : A variable follows the hypothesised distribution.

$H_1$  (alternative hypothesis): A variable does not follow the hypothesised distribution.

The statistic of the test is  $3.8\bar{3}$  with a  $p$ -value of 0.429. As the  $p$ -value is not less than 0.05 (the confidence interval is 95%), we cannot reject the null hypothesis. Therefore, we do not have sufficient evidence to say that the distribution of observed data is different from the distribution of the fit.

To evaluate the robustness of the fit, we generated 1000 synthetic residuals. These residuals were sampled from the (normal) distribution of the true residuals, calculated as the difference between Legambiente’s (2021) data (corrected with a 10% margin of error) and the fit. Then, we obtained values from the fit functions for each of the 1000 times between 1995 and 2020. Finally, we generated 1000 synthetic observations summing the 1000 fit values and the synthetic residuals.

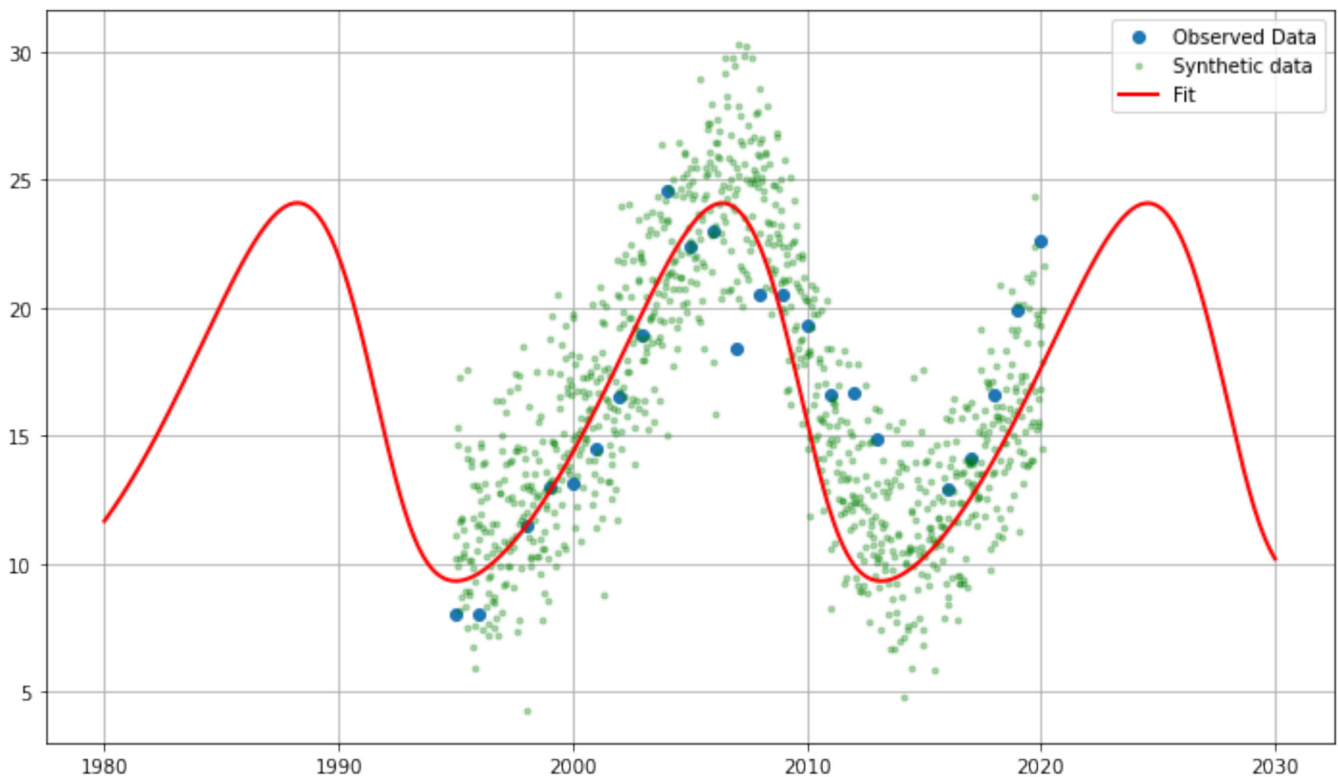
Thereafter, using the bootstrap method, we sampled a subset of 100 random synthetic observations and, for each of those observations, we again undertook fit calculations. We obtained 100 different estimations for each fit parameter and then calculated a 95% confidence interval for each. This procedure provided an error margin for each of the parameters estimated by the fit calculations. More specifically, we obtained the following margins of error for the parameters:

$$I_0 = 2.042 \pm 0.066,$$

$$t_0 = 1944 \pm 1,$$

$$\alpha = 0.192 \pm 0.019,$$

$$I_0^* = 22.710 \pm 1.299,$$



**FIGURE 2** | Cumulative illegal environmental-crime capital obtained from the fit parameters, 1980 to 2030. The figure shows the logistic curve with a sinusoidally variable carrying capacity for the illegal capital accumulated through environmental crime. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/kykl.12455)]

$$\omega = 0.346 \pm 0.003, \text{ and}$$

$$I_a = 17.408 \pm 2.060.$$

The synthetic data obtained using the bootstrap method (see Figure 2) and applied to evaluate the robustness of the other estimated parameters of the logistic fit confirms the alignment between the data on illegal capital and the theoretical specification (see Figure 1).

How to explain the fact that the data confirm the ‘carrying capacity’ assumption in the case of Italy? Which has been respectively the market and the policy constraints that could have limited the growth of the illegal revenues due to the perpetration of environmental crimes?

The starting date of the phenomenon in Italy is the post-war period. The years of post-war reconstruction (1944–1945) saw disordered growth in Italian municipalities, and the lack of clear regulations promoted the growth of illegal buildings. This practice was also made possible by the presence of Italian organized crime, which intensified over the years. Organized crime, exercising pervasive control over the territory, was able to intimidate local politicians and public officials.

Since the post-war period, the management of building permits has become one of the main tools of political clientelism. Parties gave voters connected to local politics permission to gain electoral support. This has led to rapid and disorderly

urban development, with serious problems of illegal building and violations of urban planning regulations. The management of permits has also been intertwined with money laundering by organized crime (Dalla Pellegrina et al. 2020; Germani and Castaldo 2024). Environmental crime went hand in hand with corruption and money laundering.

Yet, the more the illegal revenues due to environmental crimes increased, the more constraints that hindered such growth progressively emerged: natural disasters and policy reactions.

In fact, on the one side these illegal behaviours have been associated with the destruction of natural ecosystems, pollution and an increase in hydrogeological risk, such as floods and earthquakes. A well-known example of how the environmental illegal activities made by criminal before and after an earthquake is the Irpinia (in Campania region) case in 1980 (Martone 2014; Dandolo 2021).

On the other side, the authorities started to put attention on the damage due to environmental crimes. A period of reforms aimed at regulating wild urbanization and combating illegal building has begun. During the Andreotti government, the Bucalossi Law n.10/1977 was approved. It aimed to regulate urbanization and combat illegal building, but enforcement remained weak (Cecchini 2013; Falco 2016).

Organized crime continued to invest in real estate to launder dirty money; the reconstruction after the 1982 Irpinia earthquake is an example of corruption and humanitarian funds ending up in the hands of organized crime. Again, in 1982, with the approval of the Rognoni-La Torre law, the crime of

TABLE 2 | Cumulative illegal environmental-crime capital and the other results obtained from the bootstrap.

Region	Illegal building %	$I_0$ (€bn)	$t_0$	$\alpha$	$I_0^*$ (€bn)	$\omega$	$I_\alpha$ (€bn)	$T$ (years)	Welch's $t$ -test	$p$
Sicily	0.145	0.398 ± 0.021	1920 ± 0	0.252 ± 0.042	2.859 ± 0.171	0.399 ± 0.004	2.353 ± 0.251	15.739 ± 0.158	0.46	0.64
Campania	0.129	0.393 ± 0.013	1920 ± 0	0.218 ± 0.011	3.103 ± 0.095	0.400 ± 0.002	2.108 ± 0.015	15.700 ± 0.079	0.87	0.38
Puglia	0.118	0.103 ± 0.016	1925 ± 0	0.210 ± 0.036	2.531 ± 0.066	0.349 ± 0.000	2.050 ± 0.151	17.994 ± 0.000	0.20	0.83
Calabria	0.095	0.561 ± 0.052	1924 ± 7	0.227 ± 0.037	2.769 ± 0.289	0.390 ± 0.029	2.659 ± 0.324	16.103 ± 1.197	0.12	0.90
Lazio	0.074	0.264 ± 0.010	1925 ± 0	0.195 ± 0.014	2.825 ± 0.260	0.399 ± 0	2.537 ± 0.302	15.739 ± 0.000	0.28	0.77
Tuscany	0.069	0.425 ± 0.005	1930 ± 0	0.186 ± 0.007	1.241 ± 0.054	0.383 ± 0.005	0.928 ± 0.006	16.397 ± 0.214	0.72	0.46
Lombardy	0.063	0.558 ± 0.040	1930 ± 8	0.178 ± 0.028	2.720 ± 0.174	0.399 ± 0.032	2.699 ± 0.277	15.739 ± 1.262	0.27	0.78
Veneto	0.038	0.668 ± 0.047	1930 ± 4	0.136 ± 0.023	2.753 ± 0.332	0.400 ± 0.008	2.729 ± 0.338	15.700 ± 0.314	0.40	0.68
Abruzzo	0.035	0.962 ± 0.028	1930 ± 2	0.119 ± 0.014	2.744 ± 0.260	0.399 ± 0.001	2.695 ± 0.271	15.739 ± 0.039	0.76	0.44
Piedmont	0.035	0.957 ± 0.024	1930 ± 0	0.122 ± 0.019	2.796 ± 0.373	0.396 ± 0.017	2.747 ± 0.390	15.859 ± 0.681	0.53	0.59
Basilicata	0.031	0.218 ± 0.012	1919 ± 6	0.101 ± 0.015	0.652 ± 0.017	0.403 ± 0.016	0.496 ± 0.002	15.583 ± 0.619	1.59	0.12
Marche	0.029	0.217 ± 0.009	1925 ± 4	0.099 ± 0.014	0.680 ± 0.031	0.385 ± 0.017	0.486 ± 0.044	16.312 ± 0.720	1.63	0.11
Sardinia	0.026	0.543 ± 0.014	1929 ± 2	0.108 ± 0.015	2.760 ± 0.269	0.399 ± 0.011	2.679 ± 0.277	15.739 ± 0.434	0.71	0.47
Liguria	0.026	0.216 ± 0.014	1921 ± 5	0.098 ± 0.005	0.671 ± 0.038	0.386 ± 0.013	0.481 ± 0.052	16.269 ± 0.548	1.67	0.10
Emilia romagna	0.024	0.100 ± 0.008	1940 ± 4	0.118 ± 0.020	2.758 ± 0.307	0.394 ± 0.030	2.747 ± 0.362	15.939 ± 1.214	0.49	0.62
Umbria	0.021	0.391 ± 0.025	1936 ± 3	0.104 ± 0.013	1.051 ± 0.154	0.377 ± 0.002	1.009 ± 0.161	16.658 ± 0.088	0.66	0.50
Molise	0.018	0.666 ± 0.053	1929 ± 5	0.100 ± 0.018	2.698 ± 0.238	0.398 ± 0.016	2.693 ± 0.238	15.779 ± 0.634	0.70	0.48
Trentino	0.012	0.015 ± 0.001	1925 ± 3	0.098 ± 0.005	0.329 ± 0.006	0.383 ± 0.011	0.283 ± 0.008	16.397 ± 0.470928	1.22	0.22
Friuli venezia giulia	0.009	0.398 ± 0.038	1938 ± 9	0.087 ± 0.006	1.124 ± 0.172	0.385 ± 0.008	1.108 ± 0.165	16.312 ± 0.338944	0.72	0.47
Valle d'aosta	0.003	0.649 ± 0.028	1930 ± 1	0.078 ± 0.012	2.954 ± 0.137	0.396 ± 0.026	2.954 ± 0.137	15.859 ± 1.04122	0.64	0.52

Source: Own elaboration based on the empirical analysis and the economic literature.

mafia association was introduced (art. 416-bis) (Balsamo 2006; Spina 2008).

In the following years, other laws were approved, such as Law 47/1985 'Galasso Law'. It had the aim of slowing down the expansion of illegal construction, in particular in protected areas and at hydrogeological risk. Despite its importance, its enforcement has been poor and demolitions have often been postponed due to strong local resistance and difficulty in raising resources (Pinotti 2015; Pungetti and Oles 2016). Given the national laws, it is likely that the sensibility of the local politicians, and in general of the public authorities, can be different, region by region.

Finally, it is worth remembering that the national reaction in terms of environmental reforms that seek to address problems related to corruption and illegal building has been also influenced by a global trend. At an international level, with the Kyoto Protocol (1997) first and then the Paris Agreement, the objective was to stimulate greater attention towards the environmental impact of buildings and the need to limit illegal urban expansion which contributes to climate change.

All in all: two factors that can be, at least partially, associated with the growth of the illegal revenues gained by the perpetration of environmental crimes can explain the endogenous fluctuations of this growth. Moreover, other things being equal, the trend of profits from environmental crime can vary with the levels of corruption, illegal building and costs of anti-money laundering regulations.

To take into account all these possible variations between different contexts, we subdivided national illegal capital by assigning a weight to each region based on the region's share of total environmental crimes (Legambiente 2021). The results reported in Table 2 (obtained through the same procedure used for the national case) indicate that the logistical growth rate increases as the degree of illegal building increases. On average, the time it takes for illegal capital to spread varies between 15 and 17 years. This trend may depend on, for instance, changes in the number of criminals, the regulatory system, the crime's limitation period, anticorruption attitudes or the technologies criminals' use. To derive an adequate answer, the opinions of politicians, jurists and bureaucrats would be necessary.

For the sake of transparency, it is worth mentioning that the model's calibration using the available Italian data should be handled with great caution. The empirical results show that the illegal capital resulting from environmental crime is growing slowly and suggest that the phenomenon has not yet 'exploded'.

Two possible non-alternative explanations can be offered. First, and as we discussed before in presenting the Italian case, environmental crimes are likely to be local or national phenomena with few international connections, unlike other crimes, such as arms (Langlois et al. 2022) or drug trafficking (Boivin 2014; Gommoni, Berlusconi, and Aziani 2022). Second, the money-laundering activities associated with environmental crime are less cash based than in other financial crimes (Schmidt 2004; Riccardi and Reuter 2024): therefore, the involvement of public officials, is more likely to occur, and all else equal, the corruption risk is likely to be higher.

Finally, the proposed model can be used for other countries that have similar cultural, political, economic and social characteristics. For example, taking always into account the data availability problem, India could be an interesting case study to explore. In fact, while in general Italy and India are different in many respects, in this particular topic Italy and India show similarities. In both countries organized crime groups are deeply involved in environmental illegal activities (Rege and Lavorgna 2016), and the interconnection with corruption is an issue as well (Levien 2021).

Therefore, in an institutional context different from the Italian one, the sinusoidal carrying capacity may not be able to adequately explain the phenomenon. In that case, a linear carrying capacity might be more appropriate, as the probability that cyclical trends may occur is presumably reduced. In any case, the answer to the identification question is genuinely just an empirical one.

## 5 | Conclusion

In this article, we offered a theoretical and empirical analysis that shows how corruption can be a 'green grease' that facilitates both environmental crimes and money laundering. Corruption can play three different roles, amplifying the multiplier effect due to the interconnections between environmental crimes and money laundering, in terms of overall illegal revenues. The potential multiplier function of corruption has been described using a dynamic 'Triple C' narrative. Such narrative has been theoretically modelled adopting a logistic function, which in turn has been calibrated using Italian regional data from 1995 to 2020.

The calibration highlighted how toxic could be the quantitative outcome—in terms of illegal revenue growth—of the 'Triple C' narrative. But, even more importantly, it is the qualitative message of the 'Triple C' narrative, in terms of policy implications, that matters: the governments in charge shall reserve increasing attention to the intertwined dynamics between environmental crimes, corruption and money laundering, taking in account how the national and international scenario is going to evolve.

In future research, taking inspiration from Varvarigos (2023), it would be interesting to evaluate how a mechanism of cultural evolution that combines public education, which aims to instill civic virtue, and education received from older generations—which can be pro or anti-corruption—will impact the level of tolerance for corruption. This, in turn, will impact the propensity of local officials to be corruptible, affecting the adoption and the contemporaneous effectiveness of environmental policies (Fredriksson and Neumayer 2016).

Furthermore, the likelihood that anti-corruption measures will be effective is higher where individualistic values are widespread and where there is a certain degree of institutional trust (Amini, Douarin, and Hinks 2022). In our 'Triple-C' setting, the latter could impact the cost of anti-money laundering regulation and hence the flow of illegal capital. At the same time, a high rate of corruption may mean less secrecy, and this facilitates the creation of transnational movements of assets related to illegal

activities (Aziani, Ferwerda, and Riccardi 2022). It would therefore be interesting to evaluate the overall result of two effects that operate in opposite directions. Evaluating these dynamics, therefore, would offer insights into the interplay of two opposite effects that shape the effectiveness of anti-corruption and anti-money laundering measures, which is crucial for understanding the full extent of the ‘Triple C’ perspective.

In recent years, the mixed spread of globalisation and digital networks have created new opportunities for organised crime. Beyond their traditional criminal activities, these organisations have begun to commit environmental crime to derive extra profits. In many European Union member states and abroad, environmental offences do not yet fall within the framework of the penal code. Elsewhere, the awareness of the need to track the flow of money from environmental crimes to counteract money laundering has pushed legislators to accelerate the criminalisation of such activities (United Nations 2020).

In general, greater cooperation and coordination among AML authorities, environmental-crime agencies and the anti-corruption authorities is needed, both at national and international level.

At the national level AML authorities, environmental agencies and anti-corruption authorities have usually different backgrounds and experiences that, on their own, do not help efforts to identify and counter the intertwined risks of money laundering, environmental crimes and corruption. Moreover, as reported by the FATF (2021), the Financial Intelligence Units (FIUs) in most jurisdictions have received very few suspicious-activity reports related to environmental crimes. Therefore, in every country, a close and systematic collaboration between FIUs, environmental agencies and anti-corruption authorities becomes a necessary condition to design and implement a more effective and general action against crime.

At the international level, criminals follow to take advantage of the limited cooperation and communication between national authorities and international institutions. These dangerous loopholes require more cooperation and communication between jurisdictions, following the example of Egmont, Interpol and regional initiatives that have provided support in this regard.

However, it is a matter of fact that the above mentioned general considerations that stress the need of cooperation, coordination and communication require more detailed specifications to become concrete policy actions. But the possibility to improve the policy implications goes hand in hand with further progress in terms of research.

From a theoretical perspective, the newer qualitative studies and investigations will be available, the more will be likely to test the relevance and the robustness of the ‘Triple C’ case, the more knowledge of the intertwined mechanisms that link environmental crimes, corruption and money laundering will help the public officials in designing and implementing effective countermeasures to all three phenomena.

More specifically, better knowledge is likely to increase the transparency of the relationships between public officials and

private agents. Consequently, it is more likely that interactions and cooperation among the various agencies involved in preventing and addressing the three illegal phenomena will be strengthened. In turn, positive, intertwined spillover effects between transparency in the procedures and cooperation among authorities should reduce the probability of corruption, thereby reducing the accelerator effect, and consequently the multiplier effect. The economic and social integrity will be higher.

With respect to the public authorities, a final question naturally arises from an empirical perspective: All else equal, does the multiplier effect of the ‘Triple C’ depend on the properties of AML governance? Notably, the attention paid to the effectiveness of AML agencies and their different governance features has increased significantly in the United States, where Anti-Money Laundering Act (AMLA), which expanded FinCEN’s powers, was enacted in 2020 (Galeazzi, Mendelson, and Levitin 2021). The attention paid to this issue is also high in Europe, where a series of banking scandals in several countries—Cyprus, Denmark, Estonia, Finland, Latvia, Malta, the Netherlands and the United Kingdom—has highlighted the need to strengthen the AML institutional framework (Isolauri, Zettinig, and Nummela 2021). If sufficient data was available to calibrate our model in a cross-country context, the corresponding estimates could be used as dependent variables in econometric analyses with the extant metrics related to AML governance as independent variables (Bartolozzi et al. 2022).

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#### Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

#### Endnotes

<sup>1</sup> SciPy is a library of numerical routines that provides fundamental building blocks for modelling and solving scientific problems. It is built on NumPy, which provides array data structures and related fast numerical routines (see Virtanen et al. 2020, for more details).

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Appendix A

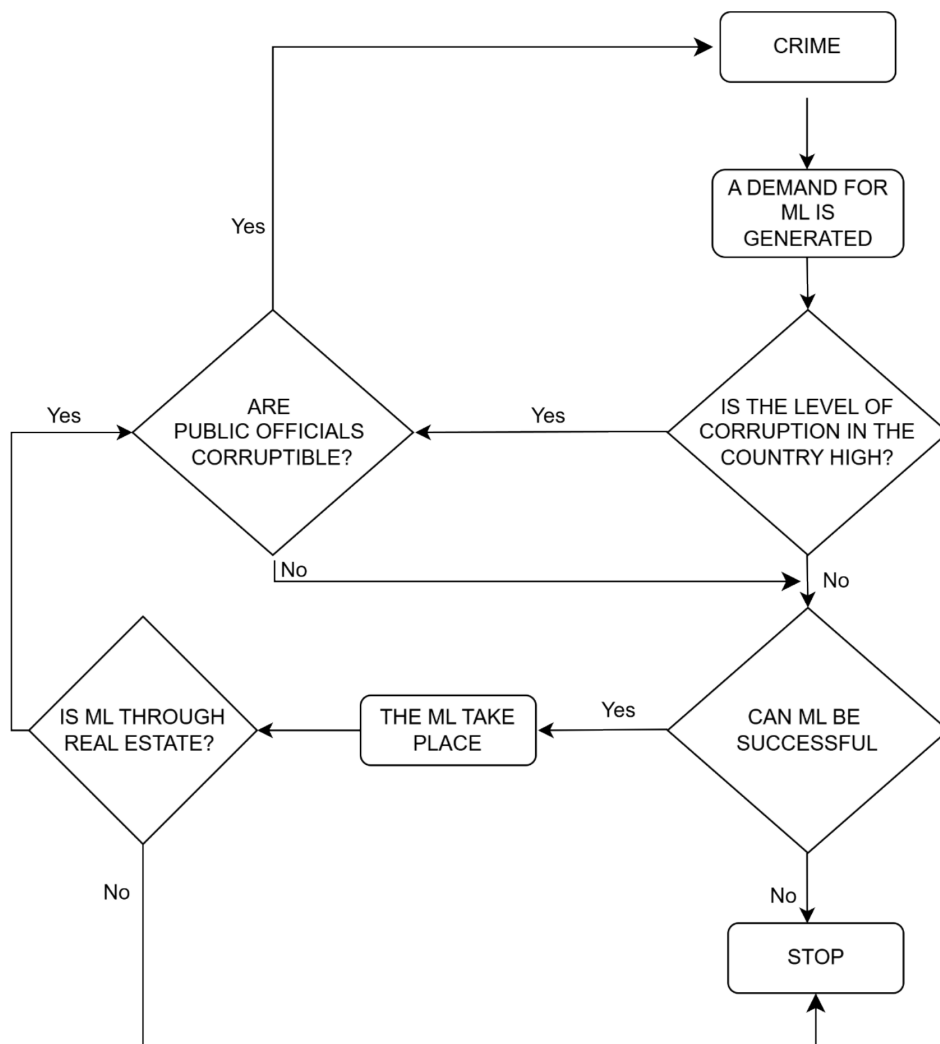


FIGURE A1 | Environmental crime, money laundering and corruption: the Triple C narrative. Source: Own elaboration.

TABLE A1 | Share of crimes proceeds that needs to be laundered.

Crime type	% share of laundered crime proceeds		
	WODC (2003)	Smekens and Verbruggen (2004)	Walker (2007)
Drug trafficking	—	70% <sup>a</sup>	50%–100%
Robbery	10%	—	—
Burglary	10%	—	—
Fraud	—	—	15%–100%
Arms trafficking	—	—	30%–100%
Illegal gambling	—	80%	30%–100%
Theft	10%	—	10%–100%
Extortion	—	—	30%–100%
Stock-/equity-market fraud	—	—	80%–100%
Illegal prostitution	—	80%	60%–100%
Human trafficking	—	—	20%–100%
Computer crime	80%	—	10%–100%

Source: Walker 2007, 56; WODC 2003; Smekens and Verbruggen 2004; as used by Unger et al. 2006, 47–48.

<sup>a</sup>This value is used by Unger (2007, 174).

## Appendix B

The solution of the logistic-type growth process.

Let the following differential equation be given

$$\frac{\partial I}{\partial t} = \alpha \left( 1 - \frac{I(t)}{I^*(t)} \right) I(t)$$

The general solution to the problem of time dependent carrying capacities is given by

$$I(t) = \frac{I_0 e^{\alpha t}}{1 + \alpha I_0 \int_0^t \frac{e^{\alpha z}}{I^*(z)} dz} \tag{B1}$$

Considering the case in which the carrying capacity is sinusoidally variable over time, we have the following equation for  $I^*(t)$ :

$$I^*(t) = I_0^* + I_a \sin \omega t, \tag{B2}$$

in which  $I_0^*$  is the average value of the carrying capacity, while  $I_a$  is the amplitude of the carrying capacity. The frequency of the oscillation is  $\omega = \frac{2\pi}{T}$ , where  $T$  is the period of oscillation.

We assume that the growth coefficient,  $\alpha$ , is constant with  $\alpha = \ln [\gamma \theta (1 - C) + (1 - \theta)] (1 + r_i)$ , where  $C$  is the cost of money-laundering activities. By substituting (B2) into (B1), we obtain

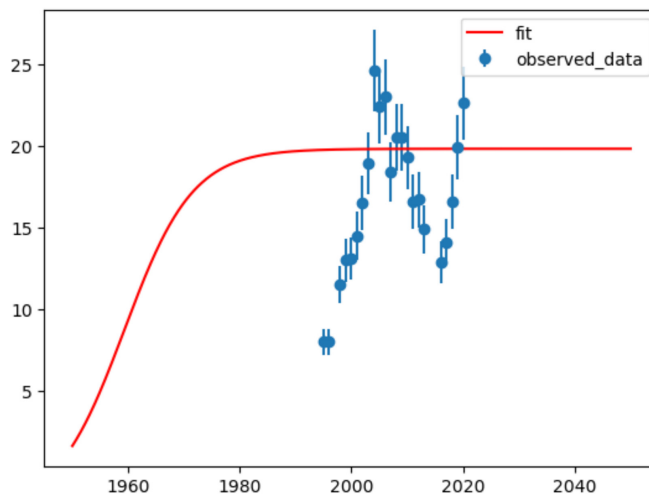
$$I(t) = \frac{I_0 e^{\alpha t}}{1 + \alpha I_0 \int_0^t \frac{e^{\alpha z}}{I_0^* + I_a \sin \omega z} dz} \tag{B3}$$

Equation (B3) can be rewritten as

$$I(t) = \frac{I_0 e^{\alpha t}}{1 + \alpha \frac{I_0}{I_0^*} \int_0^t e^{\alpha z} \left( 1 + \frac{I_a}{I_0^*} \sin \omega z \right)^{-1} dz} \tag{B4}$$

## Appendix C

We performed a comparison between the simple logistic model (i.e., the logistic model with scalar carrying capacity) and the proposed model with sinusoidal carrying capacity. In Figure C1, we plot the cumulative illegal environmental-crime capital obtained using the simple logistic path. To confirm that the sinusoidal model is not just fitting noise, we used the Akaike information criterion-based model (AIC). The result of AIC test (calculated with the following formula:  $2 \cdot k + N \cdot \log(\text{RSS}/N)$ , where  $k$  is the number of the model parameters,  $N$  is the number of data points and  $\text{RSS}$  is the residual sum squared) is  $\cong 60$  for the proposed model and  $\cong 100$  for the simple logistic model.



**FIGURE C1** | Cumulative illegal environmental-crime capital—simple logistic path. [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]