

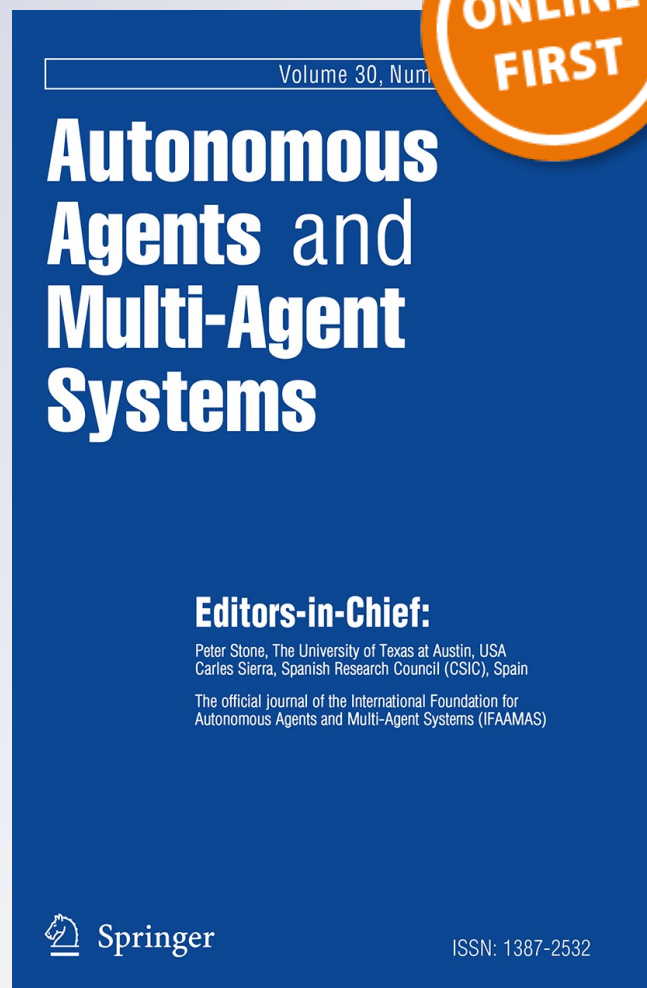
# *Simulating protection rackets: a case study of the Sicilian Mafia*

**Luis G. Nardin, Giulia Andrighetto, Rosaria Conte, Áron Székely, David Anzola, Corinna Elsenbroich, Ulf Lotzmann, Martin Neumann, et al.**

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# Simulating protection rackets: a case study of the Sicilian Mafia

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**Abstract** Protection racketeering groups are powerful, deeply entrenched in multiple societies across the globe, and they harm the societies and economies in which they operate in multiple ways. These reasons make their dynamics important to understand and an objective of both scientific and application-oriented interest. Legal and social norm-based approaches

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arguably play significant roles in influencing protection racket dynamics. We propose an agent-based simulation model, the Palermo Scenario, to enrich our understanding of these influences and to test the effect of different policies on protection racket dynamics. Our model integrates the legal and the social norm-based approaches and uses a complex normative agent architecture that enables the analysis of both agents' behaviours and mental normative representations driving behaviour. We demonstrate the usefulness of the model and the benefits of using this complex normative architecture through a case study of the Sicilian Mafia.

**Keywords** Protection rackets · Norms · Normative agent architecture · Sicilian Mafia

## 1 Introduction

Groups all over the world systematically produce and sell private protection in exchange for money or other resources. Latin American gangs [46], the Yakuza [34], the Russian Mafia [65,66], and the main mafias operating in Italy: the Sicilian Mafia, the 'Ndrangheta, and the Camorra [58], all, to a greater or lesser extent, undertake such activity. Some of these groups provide genuine protection to their buyers: deterring thieves and other criminals from exploiting businesses, and enforcing contracts and cartels [28], while others practice pure extortion and force resources from businesses or individuals in exchange for the good of not harming their 'buyers'. Here, we present the Palermo Scenario,<sup>1</sup> an agent-based simulation model of protection rackets, results derived from the model for a specific racketeering organisation, the Sicilian Mafia in Palermo, and a validation of the model using data collected from Sicily.

Irrespective of whether they extort or sell genuine protection, such criminal groups cause both social and economic harm. Extortion racketeers directly harm those that they extort by taking their resources, providing little in return, and inflicting violence upon those who refuse to pay them. Even groups that provide real protection facilitate illegal transactions and allow markets for illegal, and frequently harmful, goods and services, to exist [28, pp. 226–244]. They may enforce cartels among businesses, increasing costs and hurting consumers [28, pp. 195–225, 67, p. 5]; businesses that collude with racketeers impose negative externalities on other businesses, initiating a cascade that forces all business owners to associate with them in order to keep up with the competition, which imposes a cost on all. By substituting legal venues, they facilitate tax evasion, depriving the state of revenues and its citizens of their public goods. More diffusely, but no less importantly, their actions may negatively affect the trust in political institutions thus undermining lawful economic transactions [28, pp. 27–28]. Multiple studies find that mafia activity in Italy is associated with a number of negative economic effects among them increased tax evasion, lower employment, and a reduction in economic growth [16,43,53].

Thus, overcoming or at least limiting extortion and protection rackets is a desirable policy objective. Yet, this is a difficult task since the protection provided by some groups is actively sought out by buyers and, if not, the threat of economic or physical violence can dissuade others from cooperating with the police as can norms of secrecy and honour. Ultimately these groups can become deeply entrenched in the societies within which they operate: the

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<sup>1</sup> The model is named Palermo Scenario because most of the empirical data used to develop it was collected in the area of Palermo. Despite its name, it is worth noting that the model is flexible enough to represent the dynamics behind other protection racketeering groups.

Sumiyoshi-kai, a major Yakuza group, has publicly known offices [45], and members of the Italian judiciary, in the past, have argued for a parallel authority and legitimacy of the Sicilian Mafia [28, pp. 4–7]. Extortion and protection rackets often benefit from the support of portions of the society.<sup>2</sup>

An important step to take in countering protection and extortion rackets is to deepen our understanding of them. These groups, however, are notoriously difficult to investigate. Apart from the obvious risks that adventurous empirical researchers face, there is a more fundamental issue. Even those willing to overlook (or able to elude) the potential danger that they face cannot avoid the secretive nature of such groups that hide their criminal activities from prying eyes making it difficult to uncover empirical data about their operations and dynamics. Even the empirical data that are extracted—the judicial documents from the Maxi Trial [2] are one example—capture only a certain proportion of the true levels of the criminal activities, and, in any case, they are not beyond reproach because they may be biased in ways that are difficult to correct for: captured members may not be representative of the group (they are the ‘losers’) or they may have incentives to distort their testimony. Additionally, unlike many other types of crime, the victims often have little incentive to come forward, in part, because of the long term, semi-collusive nature of protection rackets.

Such hindrances can be, in part, alleviated with simulation models. They can function as key tools that provide a data source with which to compare or enrich empirical data, bolstering or conflicting with what has already been found. In this sense, such models can be used as checks for what has been found providing further reassurance in case there is congruence, or as warning flags that highlight questionable data when incongruence occurs.

Ultimately these efforts to model protection racketeering should not only help us to understand how such groups work, but also enrich our knowledge of how to stop them working. Simulation models can and should also be used to test bed anti-racket policies. Two important anti-racket approaches can be called *legal* and *social* norm-based approaches. In the legal norm-based approach, the state uses legal norms, or laws, that are norms issued by legal authorities and enforced by specialised actors [23, p. 357]. In the social norm-based approach, various actors, be it the state, non-governmental organisations, or citizens’ groups, try to change peoples’ actions through non-legal means, targeting social norms in particular by shaping their expectations and beliefs about what is socially appropriate. We can define social norms as socially shared rules that prescribe what individuals ought or ought not to do and that are often spontaneously monitored and enforced by peers [8, 14, 24]. Campaigns, discussions, and information spreading, while all lack the bite of the law, seem to be powerful tools for behaviour change.

Social norms are both a social and a cognitive phenomenon undergoing complex dynamics [14, 15]. They influence people by shaping their mental representations, such as normative beliefs and normative goals, which can subsequently affect their behaviour. Agent-based modelling (ABM) is a computational modelling approach that is particularly suited for the study of dynamics that integrate mental and social aspects as it allows agents’ mental and social dynamics to be explicitly represented. Operationalising complex normative dynamic in ABM requires that agents are endowed with cognitive architectures to recognise, reason upon, and finally decide whether to comply with norms or not.

<sup>2</sup> Another part of this is likely down to a selection effect in that those groups which are not entrenched in their milieu do not survive.

The paper unfolds as follows. In Sect. 2, we present the main characteristics of a powerful racketeering organisation, the Sicilian Mafia. We provide some historical background of the organisation and describe important anti-racket laws introduced by the Italian government to counter it. Next, the Palermo Scenario, with its main actors and dynamics, are described in Sect. 3. The richness of the phenomenon requires that agents are endowed with a complex normative architecture, the justification and description of which are provided in Sect. 4. The architecture of the Entrepreneur, a key actor in the model, is presented in Sect. 5. In Sect. 6, we discuss the Sicilian Mafia case study and some simulations used for analysing the historical perspective of this organisation. In Sect. 7, we describe a methodology for validating models based on a limited amount of data, and finally we provide some conclusions and ideas for future work in Sect. 8.

## 2 The Sicilian Mafia

### 2.1 Powerful protection racketeers

Cosa Nostra, or the Sicilian Mafia, is a confederation of about 150 groups<sup>3</sup> mostly located in the western part of Sicily.<sup>4</sup> It has strict rules of conduct and a strong hierarchical structure [56]. It is arranged in cells, each corresponding to a local territorial entity, typically a district, called *family* or *cosca*. At the base of each family, there are the *men of honour*, also called *soldiers*.

Mafia families exercise a monopoly of illegal violence within their territory, controlling almost all criminal economic activities (e.g., extortion, usury, drug trafficking, and infiltration in public procurement) and affect legal ones [11, 28, 39, 63]. Their typical, and characteristic, criminal activity, however, is the protection racket expressed through the mechanism of protection-extortion [28, 39]: the production and sometimes forced supply of private protection with monetary or other resources in return, under the threat of punishment [28, 39, 59, 61, 62]. Mafias provide protection services [28, 67, 68] to businesses replacing the state in the resolution of many different conflicts. In return, the mafia increases its authority and reputation within the territory, achieving consensus on part of the society that can be used to mobilise citizens against the law enforcement (e.g., non-cooperation with police investigations). Other times the only protection that is provided is from the extorters themselves [68].

This reinforcing mechanism allows mafias to take deep root control of and disseminate within the territory in which they operate.

### 2.2 Historical perspective

The birth of the Sicilian Mafia, one of the most known mafia organisation, can be traced back to the mid-nineteenth century, in the decades following the Italian Unification [28, 53, 57].

In the 1950s and 1960s, the criminal organisation became more visible due to the strength of its relationship with the local political authorities and the consequent increase of its power in Palermo. During the 1970s and 1980s, a family from the Corleone neighbourhood, headed by the bosses Salvatore Riina and Bernardo Provenzano, took power and stressed a top-down

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<sup>3</sup> There is not an exact number of individuals affiliated to the Sicilian Mafia, but according to some official sources [7, p. 16], the number should be considerably lower, perhaps as low as 2000, compared to the 3000 of the mid-1990s.

<sup>4</sup> The provinces of Palermo, Trapani, and Agrigento are particularly involved [7, pp. 28–70].



pyramidal structure by attempting to reconstruct the once existing territorial commission to take strategic decisions and settle disputes [60]. Until the first half of the 1980s, mafia families were primarily committed to drug trafficking. The protection racket was mostly directed to those businesses that could provide significant economic revenue. The cruelty of the Sicilian Mafia in those years was expressed not only in the struggle within the organisation,<sup>5</sup> but also in the fight against the legal institutions and other potentially threatening organisations. In the 1990s, due to the conclusion of the Maxi Trial that resulted in life sentences for almost all the leaders of the dominant families and an exponential increase in the number of collaborators of justice, i.e., *pentiti*<sup>6</sup> or the repentant, the Sicilian Mafia started a strategy of terror meant to “force the institutional partners to negotiate a way out for the men of honour” [17, p. 43].

Following the massacres of Capaci and Via d’Amelio in 1992, however, the population and the state began to challenge the criminal organisation, forcing it to undergo significant changes to keep its power over the local community [56,60]. The Sicilian Mafia changed its extortion strategy in favour of a systematic request, often of a little amount, towards a broader set of entrepreneurs, on the basis of the rule *pay little, but pay all* [4, 18, 40, 59]. Additionally, it began a renewed attempt to expand into other areas trying to re-establish the leading role it had in drug trafficking and money laundering, and to enter the public and private construction business, the leisure industry, and even the renewable energy market.

Other changes emerged with the transition of the leadership to Bernardo Provenzano, who instituted a *strategy of submersion* that led to the end of violent retaliations [17, 21, 52]. This strategy helped to reduce the strong social alarm created around the Sicilian Mafia in the early nineties, allowing mafia families to restore their relations with public administrators, politicians, businessmen, and professionals [3, 20].

The capture of Bernardo Provenzano in 2006, however, created a vacuum at the top leadership of the criminal organisation. Since then, the conviction of its major leaders, except for Matteo Messina Denaro who is still a fugitive, has negatively impacted the organisation. The absence of charismatic leaders, able to hold the decisional power, seems to now be clear. Moreover, the new bosses show a much lower criminal capabilities than their predecessors [55]. Currently, the Sicilian Mafia is undergoing a deep crisis and the image of a fragmented organisation is emerging [41]. Nevertheless, it is not defeated yet and it remains one of the most known, dangerous, and fearsome criminal organisation within Italy and abroad.

### 2.3 Anti-mafia mechanisms

In the 1980s and 1990s, some important innovations in the field of criminal law were launched by the Italian state, starting from the Rognoni-La Torre law (see law n. 646, 1982). Beginning in 1991, the fight against mafias gained greater attention from the Italian state, and an increasing number of measures and legal instruments were created to fight them [41], both directly by police operations or indirectly by the support to their victims (see law n. 8, 1991; law n. 82, 1991; law n. 44, 1999; law n. 512, 1999) [41, 48]. Despite the strong reaction to mafias in the last 30 years [41], the Sicilian Mafia is still heavily affecting the development of Sicily [42, 54].

<sup>5</sup> During the early 1980s, the second mafia war took place. It was driven by the family from Corleone against other families from Palermo.

<sup>6</sup> *Pentiti* designate former members of criminal organisations that, in most cases following their arrest, decide to collaborate with the judicial system to help investigations.

While improvement in legislation has been highly effective at imprisoning mafia members (see law n. 356, 1992), seizing their properties (see law n. 109, 1996; law n. 296, 2006; law n. 92, 2008; law n. 40, 2010), and creating the conditions for the emergence and thriving of civil society organisations, such as *Libera*<sup>7</sup> and *Addiopizzo*,<sup>8</sup> it has been much less successful at changing Sicilians' behaviour and mind-set towards a lawful behaviour. This might be imputed to the enduring existence of the Sicilian cultural context and traditional social norms that lead citizens to accept the presence of the mafia and not report its activities to the police. Such social norms, however, undermine the efforts of the state, creating a situation in which laws fail to motivate citizens to behave in a lawful manner. This suggests that effective anti-racket policies could depend on both legal and social approaches reinforcing each other.

### 3 The Palermo scenario model

#### 3.1 Participatory modelling approach

As already highlighted, the study of protection rackets faces severe data acquisition issues (see Sect. 1). Despite the relative paucity of good empirical data, a lot is known about protection rackets. Yet, this evidence does not reside in survey databases, but in the heads of people working to defeat the mafia; we made use of this knowledge and expertise by developing the Palermo Scenario in an iterative participatory process. Through the development of the Palermo Scenario we engaged in critical discussions with 27 domain experts from 10 countries<sup>9</sup> that helped us to identify the main actors, and validate the models assumptions, dynamics, and outcomes.

#### 3.2 Simulation model

Based on the aforementioned iterative participatory modelling process and evidence that we extracted from a range of sources,<sup>10</sup> five types of actors stand out as occupying key roles in the dynamics of protection rackets: Entrepreneurs, the State, the Mafia, Consumers, and Intermediary Organisations (alternative non-governmental organisations). Here, we briefly describe the main features that characterise each and the links that they have with one another.

*Entrepreneur* actors represent businessmen or liberal professionals. They are the central actors in the model. They (i) sell products to Consumers at a range of prices and receive income. Additionally, they make a number of decisions using a combination of economic and normative reasoning, and decide to (ii) pay *pizzo*,<sup>11</sup> or not, if approached by Mafiosi (i.e., mafia members), (iii) report *pizzo* requests to the State if they decide not to pay *pizzo*, (iv) and report to the State damages that they sustained from the Mafia attacks. They may also following a request by the State (v) collaborate against specific Mafiosi, and finally, can (vi) join the Intermediary Organisation, thereby signalling that they are unwilling to pay *pizzo* and likely to report *pizzo* requests and punishments.

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<sup>7</sup> <http://www.libera.it>.

<sup>8</sup> <http://www.addiopizzo.org>.

<sup>9</sup> These discussions were carried out under the FP7 GLODERS project (<http://www.gloders.eu>, Global Dynamics of Extortion Racket Systems).

<sup>10</sup> These sources are judicial documents, confiscated mafia documents, academic studies, literature, and other sources, such as newspapers and television interviews.

<sup>11</sup> Given the lack of an English word that means extortion money paid to mafia, we employ the Italian term *pizzo* that has this meaning.



The *State* represents the government and its institutions responsible for enforcing anti-racket laws. It is composed of a set of police officers that can (i) imprison Mafiosi based on general or specific investigations. Investigations based on specific evidence are more likely to succeed than those that occur as an everyday matter. After the police capture a Mafioso, it may find information about the Entrepreneurs who paid pizzo to that Mafioso: the Mafioso may provide information or the information may be found in assorted documents such as *Libro Mastro* (i.e., an accounting book kept by some Mafiosi to record various information about pizzo-payers). The State can then use this evidence to elicit collaboration from those Entrepreneurs. If collaboration is obtained, the State uses the collected information to prosecute that Mafioso. The State can also (ii) support Entrepreneurs who have suffered damages at the hands of Mafiosi, who can apply for monetary support to a fund that is set-up specifically for this purpose, the *Fondo di Solidarietà* (i.e., a State-run fund to support Mafia victims),<sup>12</sup> (iii) spread information about successful actions that it has carried out against the Mafia (consider this as the State providing information to journalists who report and propagate the news in newspapers and television programs) and it can work to (iv) change people's attitudes regarding the Mafia by sponsoring and supporting anti-racket festivals, such as the *Festival della Legalità*.

The *Mafia*<sup>13</sup> represents a family covering a neighbourhood and is composed of Mafiosi that (i) request pizzo from Entrepreneurs, (ii) provide benefits, protection, to paying Entrepreneurs, and (iii) punish non-paying and reporting ones. Since they are part of the same family they coordinate their actions—whom they target, how often they request pizzo, how much they request, and how severely they punish. Mafiosi can with a very small probability (iv) turn pentiti and help the State capture other Mafiosi that they know (this is represented as neighbours in a scale-free network).

*Consumers* are multiple agents who do not directly interact with the Mafia. They are connected to other Consumers and Entrepreneurs via a scale-free network and this determines the other agents with which they interact. Consumers have a single decision regarding (i) which Entrepreneur to buy products. This decision is based on a combination of economic (i.e., price of the products) and normative considerations (i.e., relative strength of the norm of avoiding buying from Entrepreneurs paying pizzo). Consumers serve as (ii) *reservoirs* of normative attitudes and behaviours, and (iii) spread information that can influence other Consumers and Entrepreneurs.

The *Intermediary Organisation* represents an anti-racket non-governmental organisation.<sup>14</sup> It (i) promotes lawful behaviour among Consumers and Entrepreneurs through events such as talks in schools, or the organisation and participation in festivals: for instance the civil society organisation Libera is the main organiser for the aforementioned Festival della Legalità. It (ii) serves as an organisation that Entrepreneurs can join if they are not paying pizzo.

Five social norms influence the decisions of consumers and entrepreneurs (summarised in Table 1).

<sup>12</sup> The Fondo di Solidarietà contains resources that depend on a politically determined component and a component derived from the resources confiscated of captured mafiosi.

<sup>13</sup> This model is not aimed at analysing the internal structure of the mafia and other important dynamics, such as fights between different mafia groups for the domain on the territory. For an analysis on this aspect of the mafia, please refer to [50].

<sup>14</sup> The main features of the Intermediary Organisation actor have been extracted from discussions and interviews with Daniele Marannano, one of the leaders of Addiopizzo.

**Table 1** Summary of the social norms in the Palermo scenario

Actor	Id	Social norm
Entrepreneur	$N_1$	Pay pizzo request
	$N_2$	Do not pay pizzo request
	$N_3$	Report pizzo request
	$N_4$	Do not report pizzo request
Consumer	$N_5$	Avoid paying pizzo entrepreneurs

#### 4 Why complex normative agents?

Norms are a fundamental feature of human social interaction [8,13,14,24,27]. Myriad qualitative and quantitative, both observational and experimental, sources demonstrate how important norms are in shaping human's behaviour [9,12,22,26,38]. Consider, for instance, the cross-cultural work of Henrich and co-authors who show that fair behaviour and arguably norms are related to group-level differences in economic organisation, market integration, and participation in world religions [31–33]. There is no good reason to think that this particular domain of social interaction would be exempt from the reach of norms.

Indeed, there are some good reasons to suspect that norms come into play from different angles. Most obviously *omertà*, which prescribes the maintenance of secrecy, is arguably a norm that is socially enforced and may reduce collaboration with the authorities. After one shopkeeper reported pizzo requests to the police citizens boycotted his shop [19]. Norms over *fairness*, concerning what is acceptable to pay and request may regulate pizzo pricing; as some authors report the payment for protection is, in some cases, more reasonable than would be expected [67]. Norms of in-group favouritism have been found to be stronger in areas with higher mafia presence [47]. On a different side, much of the work carried out by anti-racket non-governmental organisations in Italy is predicated on the assumption that some consumers will find it reprehensible to buy goods from shops that pay pizzo. None of this is to argue that norms always play a role, but that in some cases they arguably do; thus there is a need to include normative considerations in agents' behaviours.

Our proposed agent-based model emphasises how social processes, consisting mainly of the spreading of social norms that promote lawful behaviour, may sustain legal processes, enacted by the state, in counteracting the mafia and its protection activities. In our perspective, social norms are both a social and a cognitive phenomenon undergoing complex dynamics, in which the macro, social process of norm emergence and spreading, and the micro, mental process of immergence<sup>15</sup> are intertwined in a circular fashion [14]. The interplay between the mental and the social dynamics allows norms to emerge, spread, and change. Only when the prescriptive character of a request is recognised by an agent and generates the corresponding representations in its mind (i.e., normative beliefs, goals, and intentions), does a norm give rise to a normative behaviour of that agent. By including normative architecture, we can inspect agents mind and understand how norms affect their decisions instead of relying only on the analysis of their behaviours.

ABM, in particular, has a number of characteristics that makes it ideal for studying protection racket dynamics. First, unlike traditional equation-based simulations, in which

<sup>15</sup> Immergence refers to a gradual process in which the emergent effects determine new mental mechanisms in the agents involved, who are not necessarily aware of the effects produced [14].

the phenomenon is represented assuming interactions among a homogeneous population of agents, ABMS allow for the interaction of autonomous, heterogeneous, and adaptive agents. In ABM, an agent is a self-contained program that is able to act according to its perception of the surrounding environment and its internal state. It takes advantage of the syntactic and semantic flexibility of computer languages, which allows richer models to be created than those allowed by mathematical languages.

Second, ABM is particularly suitable for studying dynamics that integrate mental and social aspects [1]. This is because it allows the explicit representation and generation of agents' mental states and their dynamics, and the interaction with the social dynamics in which they are involved.

Third, ABM allows to represent the spatio-temporal evolution of systems and to analyse the implications of the adaptive responses of the different agents.

Fourth, ABM is specially recommended when a social mining approach—i.e., use of data mining techniques to extract socially relevant information—is inapplicable. Of late, social mining has proved to be an invaluable research method in understanding social phenomena [30]. Often agent-based simulation is fed with real-data, extracted from social mining [69]. In such cases, learning mechanisms are defined based on data rather than generated within the simulation. When large datasets are not available or when the purpose of the modelling is to generate the behaviour observed, simulation needs more complex agent models.

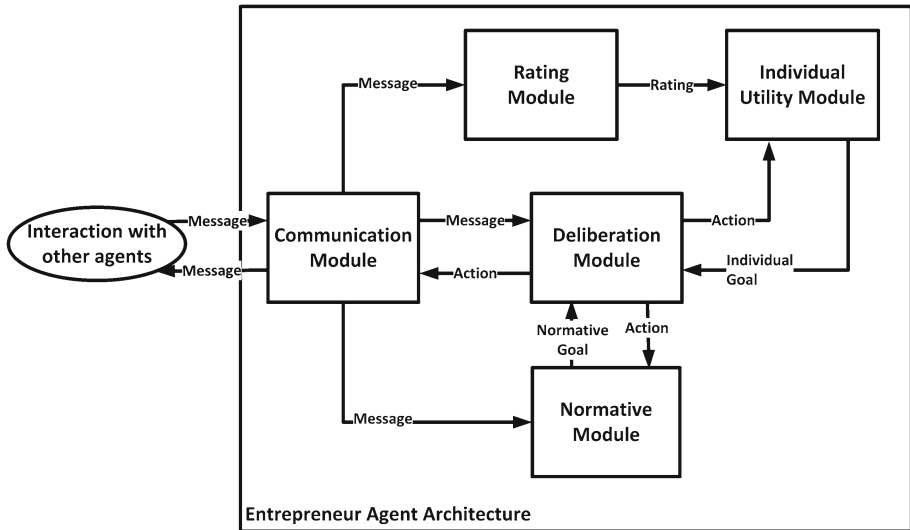
As already mentioned, we believe that it is important to include norms in the deliberation of our agents. This requires that agents be endowed with an architecture allowing them to recognise norms and be influenced by them. The normative architecture *EMIL- A* is a good candidate for this undertaking [5, 14]. *EMIL- A* is an agent normative architecture specifically developed for the simulation of norm emergence, innovation, and spread. It is endowed with modules that allow (i) the recognition of norms and the generation of the corresponding norm-based mental representations, (ii) the detection and the dynamic updating of the salience of norms, which corresponds to the perceived prominence of a norm within a relevant reference group, and (iii) the decisions to comply with and (iv) enforce norms.

Normative agents endowed with normative architectures are not new to the field of agents and multi-agent systems [44]. One of the first proposed was the *BOID* (beliefs-obligations-intentions-desires) architecture [10]. *BOID* is a *BDI* (belief-desire-intention) architecture that includes four components responsible respectively, for dealing with beliefs, obligations, intentions, and desires. It is based on a feedback mechanism that considers the effects of actions before committing to them. Obligations are introduced to constrain individual's intentions and desires on one hand, while preserving individual autonomy on the other. Agents are enabled to violate normative prescriptions based on their capacity of normative reasoning.

Nonetheless, *EMIL- A* is the only norm architecture with the particular feature for detecting how important, or salient, a norm is within a group and dynamically update this belief on the basis of the interactions with other agents. The ability to monitor variations in a norm's salience allows individuals to detect norm change and dynamically predict the actions, expectations, and willingness of others to react to violations, and in turn adapt their own behaviour to others' conduct.

## 5 Agent architecture

We now describe in detail the agent architecture of one of our agent types: the Entrepreneur as they are the central and most complex actor in the model. Figure 1 shows the Entrepreneur



**Fig. 1** Entrepreneur agent architecture. The *rectangles* represent the internal processes and the *arrows* the flow of information and control among them

agent's architecture and its five components: the *Communication Module*, the *Rating Module*, the *Individual Utility Module*, the *Normative Module*, and the *Deliberation Module*.

## 5.1 Communication module

The communication module is the entrepreneurs' interface that allows them to exchange messages with other agents. It is responsible for checking the content of messages that it receives and redirecting them to the other appropriate modules that handle them, and for sending messages to other agents. A message contains information about the occurrence of an event in the simulation environment.

## 5.2 Rating module

The rating module allows Entrepreneurs to generate subjective evaluations, or ratings, about other agents' capabilities based on the information that they receive from other agents or events that they observe in the environment. These ratings are considered as instrumental factors by Entrepreneurs when deciding how to act (see Sect. 5.3 for more details). Entrepreneurs generate ratings for the State and the Mafia: the State is evaluated as a *Protector* and an *Investigator*, while the Mafia is evaluated as a *Punisher*.

The rating of the State as a protector represents the belief Entrepreneurs have about the ability of the state to protect them from the Mafia. The evaluation depends on the State's preventive and reactive anti-racket actions. The preventive aspect of the State is measured by evaluating how effective the State is in capturing Mafiosi after Entrepreneurs report that they have been approached for pizzo. The reactive aspect is measured by the State's ability to financially compensate victims of Mafia damage. Since we do not have clear empirical evidence regarding the prevalence of one aspect over the other, we assume that both contribute equally to the rate. Concretely, the State as a protector is calculated as the fraction of reports (*numReports*) that resulted in Mafiosi imprisonment (*numImprisonments*) and the fraction of

reports of harmful actions of the Mafia ( $numPunishReports$ ) for which the Entrepreneur was economically compensated by the State ( $numStateCompensations$ ).

$$stateProtRate = \frac{1}{2} \times \left( \frac{numImprisonments}{numReports} + \frac{numStateCompensations}{numPunishReports} \right) \quad (1)$$

The State as an investigator represents the belief that Entrepreneurs have about the State's ability to identifying pizzo-paying Entrepreneurs and obtain their collaboration against Mafiosi. This rating is calculated as the fraction of the number of times the State requests that pizzo-paying Entrepreneurs collaborate ( $numCollaborations$ ) and the total number of payments observed ( $numPayments$ ).

$$stateInvRate = \frac{numCollaborations}{numPayments} \quad (2)$$

The intuition behind this rating is that an Entrepreneur identifies that it would be detected by the State as pizzo-payer by considering how many of the observable payers were previously identified as payers and requested to collaborate in prosecuting a Mafioso.

The rating of the Mafia as a Punisher indicates the belief that an Entrepreneur has about how punitive the Mafia is. It is calculated as the fraction of the total number of punishments inflicted by the Mafia ( $numPunishments$ ) divided by the total number of known non-paid pizzo requests ( $numNoPayments$ ).

$$mafiaPunRate = \frac{numPunishments}{numNoPayments} \quad (3)$$

Thus, it represents the Mafia's willingness to punish due to the lack of compliance with pizzo requests.

### 5.3 Individual utility module

This module calculates the material costs and benefits associated with a potential action and generates the Entrepreneur's *Individual Goal* that combines the relevant information. It motivates Entrepreneurs to take decisions that maximise their own material utility and it is one of the key inputs used in the deliberation module. Entrepreneurs have two separate individual goals, one concerning the pay pizzo decision (Sect. 5.3.1) and another for the report pizzo request decision (Sect. 5.3.2).

#### 5.3.1 Pay pizzo

The individual goal associated with the pay pizzo decision balances the costs and benefits of paying (Eq. 4) and not paying (Eq. 5) pizzo.

The pay function is given by the cost in paying pizzo ( $mafiaExtortion$ ) plus the possibility of receiving a fine by the State ( $stateFine$ ) in case the later identifies the Entrepreneur as a pizzo payer ( $stateInvRate$ ) and subtracted from the possible benefit provided by the Mafia ( $mafiaBenefit$ ).

$$pay = mafiaBenefit - (mafiaExtortion + (stateFine \times stateInvRate)) \quad (4)$$

The not pay function evaluates the severity of the punishment inflicted by the Mafia ( $mafiaPun$ ) considering the expected probability of being punished in case of non-payment ( $mafiaPunRate$ ).

$$notPay = - (mafiaPun \times mafiaPunRate) \quad (5)$$

Because these resulting values have different scales, they need to be converted into values that can be compared and used for calculating the individual goal for paying. Such a conversion is done by transforming both values into a circumference degree between 0 and 360 according to Eqs. 6 and 7.

$$convPay = \frac{0.5 \times \arctan (pay)}{\frac{\pi}{2}} + 0.5 \quad (6)$$

$$convNotPay = \frac{0.5 \times \arctan (notPay)}{\frac{\pi}{2}} + 0.5 \quad (7)$$

Following transformation, the proportionality between both values defines the individual goal of the Entrepreneur to pay pizzo ( $IG_{pay}$ ).

$$IG_{pay} = \frac{convPay}{convPay + convNotPay} \quad (8)$$

### 5.3.2 Report pizzo request

The Individual Goal associated with this decision balances the probability of being punished by the Mafia and the probability of being protected by the State.

Entrepreneurs weight the ratings of Mafia as a punisher ( $mafiaPunRate$ ) and the State as a protector ( $stateProtRate$ ) in order to determine the risk of reporting pizzo requests and being punished by the Mafia. The calculation of the individual goal of reporting ( $IG_{report}$ ) is shown in Eq. 9.

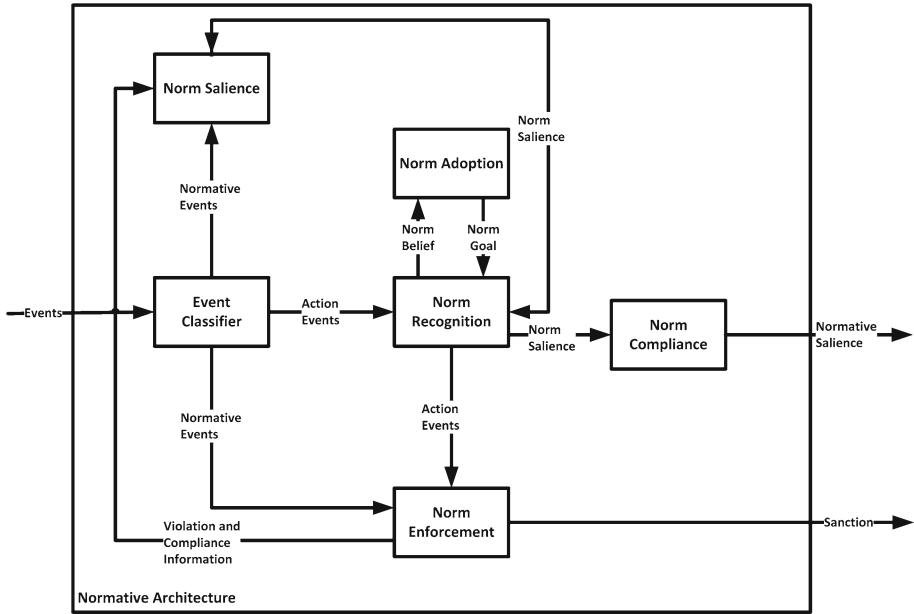
$$IG_{report} = ((1 - mafiaPunRate) \times stateProtRate) \quad (9)$$

## 5.4 Normative module

Like the individual utility module, the *Normative Module* is a key part of Entrepreneurs' deliberations and its output feeds the Deliberation Module. In contrast to the former, this module is concerned with the normative aspects of decision making whether an action is the socially appropriate one to take. It enables Entrepreneurs to learn the social norms governing their environment, generate their corresponding mental representations, and recognise and dynamically update the relative degree of salience of each social norm (capturing the fact that some norms exist but are deemed to be relatively unimportant while others are deeply entrenched and unthinkable to break). This module uses the EMIL- A architecture<sup>16</sup> [5] (see Fig. 2).

EMIL- A endows agents with a number of different modules that allow them to deal with the complexity of social norms. The *Event Classifier* module enables agents to receive, classify, and redirect events to other EMIL- A specific modules. Agents infer new social norms, and generate the corresponding normative beliefs, through observations and interactions with other agents using the *Norm Recognition* module. The *Norm Adoption* module allows agents to decide whether to adopt or not the identified social norms as normative goals. The *Norm Compliance* module determines whether or not to have the intent to comply with the adopted

<sup>16</sup> The implementation of the EMIL- A used in this work can be downloaded at <https://www.github.com/gnardin/emilia>.



**Fig. 2** EMIL- A normative architecture. The *rectangles* represent the normative processes and the *arrows* the flow of information and control among the processes

normative goals and convert them into normative intentions. The *Norm Enforcement* module allows agents to determine the most appropriate sanctions to apply to other agents that violate a norm.

These modules' operations are influenced by the final module, the *Norm Saliency* module, in which the importance of the norm, which plays a major role in that norm's acceptance or rejection, is calculated. Formally,

$$\sigma_n = \frac{1}{\alpha} \times \left( \beta + \left( \frac{C - V}{C + V} \times w_c + \frac{O_c - O_v}{O_c + O_v} \times w_o + \frac{\max(0, (O_v + V) - P - S)}{O_v + V} \times w_{npv} + \frac{P \times w_p + S \times w_s}{\max(P + S, O_v + V)} + \frac{E_c - E_v}{E_c + E_v} \times w_e \right) \right) \quad (10)$$

where  $\sigma_n$  is the saliency of the norm  $n$ ,  $\alpha$  is a normaliser that renders the saliency into a value in the range  $[0, 1]$ ,  $C$  is the number of times the agent complied with the norm  $n$ ,  $V$  is the number of times the agent violated the norm  $n$ ,  $O_c$  is the number of times the agent observed other agents complying with the norm  $n$ ,  $O_v$  is the number of times the agent observed other agents violating the norm  $n$ ,  $P$  is the number of punishments received, applied or observed due to the violation of norm  $n$ ,  $S$  is the number of sanctions,<sup>17</sup> received, applied or observed due to the violation of norm  $n$ , and  $E_c$  and  $E_v$  are the number of messages received demanding, respectively, the compliance with or violation of the norm  $n$ .

<sup>17</sup> In previous work [5] we distinguish between two enforcement mechanisms, punishment and sanction, which have different capacities to convey normative information. Punishment works only by imposing a cost on the wrongdoer, reducing his or her material payoffs. In addition to inflicting a cost, sanction also communicates that the sanctioned behaviour is not approved of because it violated a norm. Sanctions convey a great deal of norm-relevant information that has the effect of making norms explicit and increasing their saliency.



**Table 2** Social cues and weights for the norm salience updating[6]

Cue	Description	Weight
C	Norm compliance	$w_c = +0.99$
V	Norm violation	$w_c = -0.99$
O	Observed norm compliance	$w_o = +0.33$
NPV	Non-punished violators	$w_{npv} = -0.66$
P	Observed/applied/received punishment	$w_p = +0.33$
S	Observed/applied/received sanction	$w_s = +0.99$
E	Observed/applied/received norm invocation	$w_e = +0.99$

Each term of the norm salience equation has a weight value associated with it. They are used to give different significance to each of the terms. In Table 2, the weight associated with each term is presented, which are based on empirical work by Cialdini et al. [12]. It is important to stress that the essential aspect of these weights is the proportionality among them and not their actual value.

As already described in Table 1, Entrepreneurs' decisions are influenced by four different social norms:

$N_1$  Pay pizzo request

$N_2$  Do not pay pizzo request

$N_3$  Report pizzo request

$N_4$  Do not report pizzo request

whose initial norm salience may vary. Record that the more salient a norm is perceived to be, the higher its strength, and consequently the Entrepreneur is more inclined to comply with the norm. We consider that the Normative Goal of each of these norms corresponds to the salience of the norms. Thus,  $NG_{pay} = \sigma_{N_1}$ ,  $NG_{not-pay} = \sigma_{N_2}$ ,  $NG_{report} = \sigma_{N_3}$  and  $NG_{not-report} = \sigma_{N_4}$ .

$N_1$  and  $N_2$  are social norms associated with the Entrepreneurs' decision to pay pizzo requests, while  $N_3$  and  $N_4$  are social norms associated with their decision to report pizzo requests. These Entrepreneurs' social norms are grouped into two sets of norms: the TRADITIONAL and the NEW. The TRADITIONAL set of norms groups the norms  $N_1$  and  $N_4$  that correspond to the traditional mind-set of some individuals that pizzo requests should be paid and not reported to the police. An Entrepreneur is assumed to be in the TRADITIONAL set, if the salience of the  $N_1$  and  $N_4$  norms are greater than the salience of the  $N_2$  and  $N_3$  norms, respectively. Conversely, the NEW set of norms groups the norms  $N_2$  and  $N_3$  that correspond to a hoped-for recent understanding of the social and economic harm caused by the Mafia. An Entrepreneur is assumed to be in the NEW set, if the norm salience of the  $N_2$  and  $N_3$  norms are greater than the salience of the  $N_1$  and  $N_4$  norms, respectively.

## 5.5 Deliberation module

Finally, the deliberation module incorporates all the decisions the Entrepreneur may perform. The decisions taken in this module are influenced by the individual goal (see Sect. 5.3), the normative goal (see Sect. 5.4), the individual weight ( $IW$ ), and the normative weight ( $NW$ ). We have already discussed the individual goal and normative goal—the former is the result of material cost-benefit calculation while the latter is the outcome of normative considerations—so we now briefly turn to their respective weights; the individual weight and normative weight

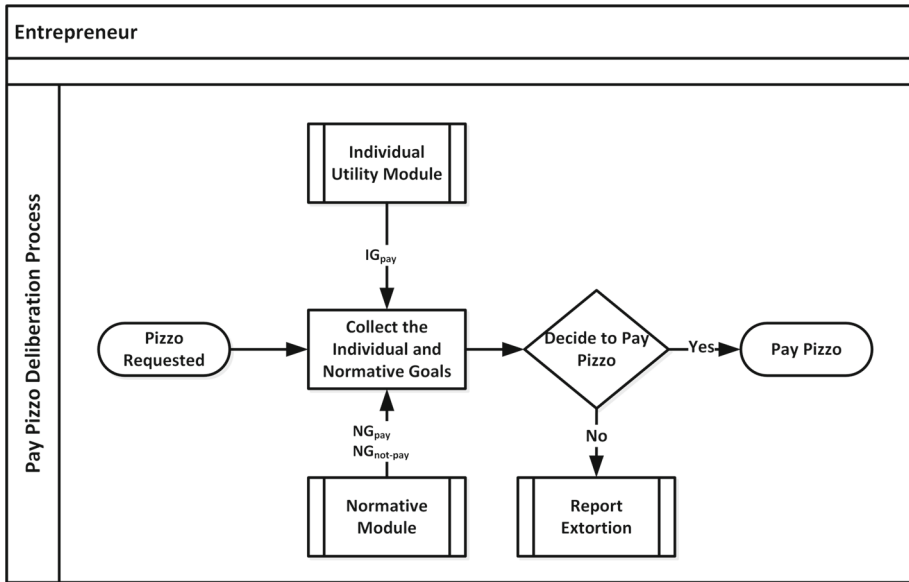


Fig. 3 Pay pizzo deliberation process

represent the weights given to each of the goals in the decision. By varying these parameters it is possible to represent different individual profiles, such as more normative or selfish.

Entrepreneurs have two main deliberations to make to pay pizzo (see Sect. 5.3.1) and to report pizzo request (see Sect. 5.3.2). We go through both in turn.

### 5.5.1 Pay pizzo deliberation process

Figure 3 illustrates the deliberation process Entrepreneurs perform to decide whether or not to pay a pizzo request.

Every time an Entrepreneur receives a pizzo request, it collects information about the normative goal of the *Pay pizzo request* ( $NG_{pay}$ ) and *Do not pay pizzo request* ( $NG_{not-pay}$ ) norms from the normative module as well as the individual goal of paying pizzo ( $IG_{pay}$ ) from the individual utility module and it decides whether or not to pay the pizzo request according to the Algorithm 1.

Put verbally, the decision by Entrepreneurs to pay pizzo is a probabilistic one that is based on weighting its dynamically updated individual goal (see Sect. 5.3.1) and normative goal concerning the decision (see Sect. 5.4). This probability indicates how inclined the entrepreneur is to pay pizzo based on how much it would benefit, or lose, from doing so, and how much it observes its social group acting in certain way. Once the probability is calculated we include uncertainty in the decision by comparing whether the calculated probability is greater than a randomly picked number from a uniform distribution between 0 and 1. This realistic uncertainty may lead Entrepreneurs to pay pizzo even when they are inclined not to do so and vice-versa.

If the Entrepreneur decides to pay, it performs the action and the process is finished. Otherwise, the Entrepreneur has to decide whether to report the pizzo request to the State.

**Algorithm 1** Entrepreneur’s decision whether to pay or not a pizzo request.

```

Require:  $IG_{pay}$  Individual Goal Pay pizzo request
Require:  $IW$  Individual Weight
Require:  $NG_{pay}$  Norm Saliency of Pay pizzo request
Require:  $NG_{not-pay}$  Norm Saliency of Do not pay pizzo request
Require:  $NW$  Normative Weight
1:  $NG \leftarrow 0$ 
2:  $probPay \leftarrow 0$ 
3: if ( $NG_{pay} > NG_{not-pay}$ ) then
4:    $NG \leftarrow NG_{pay}$ 
5: else
6:    $NG \leftarrow 1 - NG_{not-pay}$ 
7: end if
8:  $probPay \leftarrow (IG_{pay} \times IW) + (NG \times NW)$ 
9: if ( $random(0, 1) < probPay$ ) then
10:  // Decide to pay the pizzo request
11:  return true
12: else
13:  // Decide to not pay the pizzo request
14:  return false
15: end if
    
```

5.5.2 Report pizzo request deliberation process

Every time an Entrepreneur decides not to pay a pizzo request, it also needs to decide whether to report it to the State. This subset restriction, that only non-payers can report, is supported by empirical data that indicates that the overwhelming majority of those that report mafiosi to the state are businesspeople who have refused to pay pizzo.

Figure 4 illustrates the deliberation process that Entrepreneurs perform when deciding whether to report or not pizzo request.

To decide whether or not to report, first, the Entrepreneur collects information about the normative goal of the *Report pizzo request* ( $NG_{report}$ ) and *Do not report pizzo request*

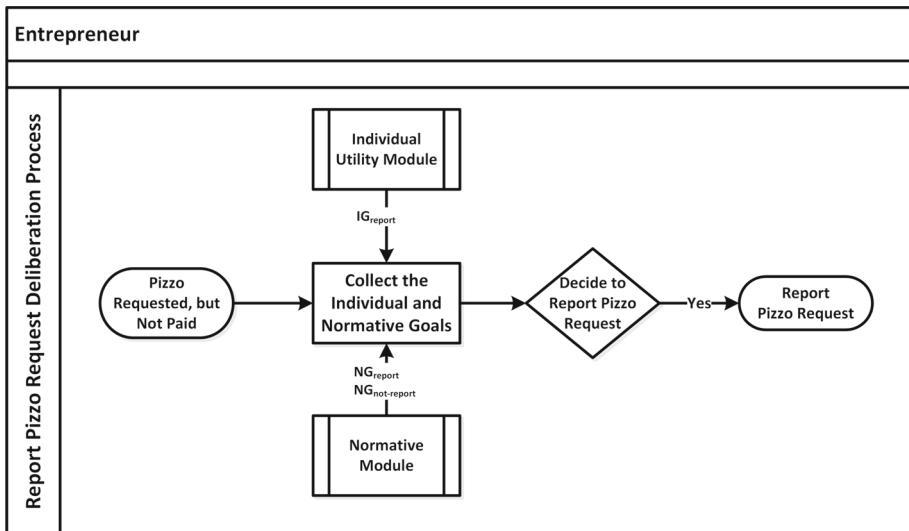


Fig. 4 Report pizzo request deliberation process

( $NG_{not-report}$ ) norms from the normative module as well as the individual goal of report pizzo request ( $IG_{report}$ ) from the individual utility module. Then using the Algorithm 2, it decides whether or not to report.

---

**Algorithm 2** Entrepreneur's decision whether or not to report a pizzo request.
 

---

**Require:**  $IG_{report}$  Individual Goal Report pizzo request  
**Require:**  $IW$  Individual Weight  
**Require:**  $NG_{report}$  Norm Saliency Report pizzo request  
**Require:**  $NG_{not-report}$  Norm Saliency Do not report pizzo request  
**Require:**  $NW$  Normative Weight

```

1:  $NG \leftarrow 0$ 
2:  $probReport \leftarrow 0$ 
3: if ( $NG_{report} > NG_{not-report}$ ) then
4:    $NG \leftarrow NG_{report}$ 
5: else
6:    $NG \leftarrow 1 - NG_{not-report}$ 
7: end if
8:  $probReport \leftarrow (IG_{report} \times IW) + (NG \times NW)$ 
9: if ( $random(0, 1) < probReport$ ) then
10:  // Decide to report the pizzo request
11:  return true
12: else
13:  // Decide not to report the pizzo request
14:  return false
15: end if

```

---

Similarly to the previous decision, the decision to report is based on a probability that is calculated by weighting the relevant (dynamically updated) individual goal (see Sect. 5.3.2) and normative goal about (see Sect. 5.4). This probability indicates how inclined Entrepreneurs are to report to the State. Once the probability is calculated, we include some uncertainty in the Entrepreneur's decision by comparing whether the calculated probability is greater than a uniform random number generated between 0 and 1. This uncertainty aspect may lead the Entrepreneur to report pizzo request even when it has a low probability value and vice-versa. If the Entrepreneur decides to report, it performs the action. Otherwise, it does nothing.

## 5.6 Other agents

Consumers, like Entrepreneurs, have sophisticated architectures that enable them to take decisions combining both economic and norm-based reasoning. The remaining agents, the State, the Mafia, and the Intermediary Organisation, are simpler and are represented as reactive agents.

While in reality the State, the Mafia, and the Intermediary Organisation are also complex entities, we decided to represent them as reactive agents for a number of different reasons. Fundamentally, increasing the complexity of the State agent would have made the model even more complex and potentially harder to analyse. Nevertheless, we believe that representing the state as a primarily rule-following entity is defensible. Relative to consumers and entrepreneurs, actors associated with states in developed contexts are typically more driven by legal codes, and these legal codes take longer to adapt than the strategies of consumers and entrepreneurs. Thus, the actions of state associated individuals are more predictable and also more stable over time. Similarly to states, the intermediary organisations have relatively stable strategies and goals: to promote lawful behaviour among the population mainly using

strategies to change people's attitudes toward the mafia. The mafia, however, is a highly adaptable and dynamic organisation, but due to the difficulty in obtaining information about the mechanisms influencing its behaviour, we decided to represent it as a reactive actor that has a user-configured strategy. Although these agents are reactive, they are highly configurable.

Despite our effort to collect evidence and data to support all of our modelling representations, some of these representations inevitably have a level of arbitrariness. As we mentioned earlier however (Sect. 3.1), the agents and dynamics were discussed and created with the help of experts active in this domain, and as we discuss later (Sect. 7), we conduct some validation procedures with the available data.

## 6 A Sicilian Mafia case study

We now describe a simulation experiment and results derived from it to demonstrate the usefulness of the Palermo Scenario and the benefits of using complex normative agents in policy-directed simulations.

### 6.1 Description

In this experiment, we explore and analyse five historical periods of the Sicilian Mafia. Each historical period can be broadly characterised by certain strategies of the different agents, for instance before about 1992 the Mafia employed a violent strategy while following this period it undertook a more hidden strategy. Agents' strategies are linked to the simulation model via specific input parameters. In Table 3 we display the agents, the main strategies that they use, and the possible values of the strategies that we consider here. In Table 4 we display the parameters of the model through which the strategies are implemented along with their description.

We characterise the evolution of the Sicilian Mafia and the relevant agents (see also Sect. 2) in the following way:

P1 This period represents the situation before 1980, in which the State has few specific legal mechanisms to fight the Mafia (weak legal norms and no social norms). The Mafia

**Table 3** Description of the possible strategies of the agents

Agent	Strategy	Value
State	Legal norms	<i>Weak legal norms</i> : the State lacks legal mechanisms for countering the Mafia or only does so weakly
		<i>Strong legal norms</i> : the State has legal mechanisms and uses them effectively against the Mafia
State and Intermediary Organisation	Social norms	<i>No social norms</i> : agent cannot spread lawful social norms <i>Social norms</i> : agents can spread lawful social norms
Mafia	Racketeering	<i>Violent racketeering</i> : characterised by the high amount of pizzo requested and strong and likely punishment for refusal
		<i>Hidden racketeering</i> : characterised by low amount pizzo requests from a greater proportion of Entrepreneurs and rare and mild punishment for refusal

**Table 4** Input parameters of the strategies

Strategy	Input parameter	Description
Legal norms	numPoliceOfficers	Number of police officers
	captureProb	Probability of capturing a Mafioso if the police observes an pizzo request or punishment
	convictionProb	Probability of convicting a Mafioso after capture
	percTransferFondo	Percentage of Mafia's resources allocated into victim-support fund
Social Norms	propCitizens	Proportion of the population who receive a message invoking the NEW set of norms
Racketeering	extortLevel	The proportion of Entrepreneurs' endowment requested as pizzo
	punishSeverity	The amount of punishment inflicted by Mafiosi on Entrepreneurs
	punishProb	Probability of punishing a non-payer Entrepreneur

demands a high amount of pizzo from Entrepreneurs. Those who do not acquiesce have a high probability of being strongly punished (violent racketeering). Additionally, much of the Palermitan population, the Entrepreneurs and Consumers, still hold a traditional view on the Mafia, in which pizzo is broadly perceived as a 'legitimate' payment for protection services [28,67].

- P2 This period represents the situation between 1980 and 1992, in which the State institutes several new coercive anti-racket laws in order to counter the Mafia (see Sect. 2.3). These new anti-racket laws allow the police and judiciary to more effectively counter the Mafia and also allow the State to provide support to Mafia victims (strong legal norms). However, the State does not promote lawful behaviour among the population through non-legal means, such as invoking social norms (social norms).
- P3 In the early 1990s, however, due to the effectiveness of the state strategy (strong legal norms), the Mafia changes its violent and combative strategy (violent racketeering) into a more moderate strategy in order to operate hidden from the law enforcement (hidden racketeering). Concretely, this strategy stipulates a reduced amount of pizzo demanded of Entrepreneurs but from a larger number of them. In addition, it inflicts a lower punishment on those that do not pay.
- P4 In the mid-1990s, these changes, especially the State policies, pave the way for the emergence of civil society organisations (represented as the Intermediary Organisations) responsible for promoting lawful behaviour by aligning social norms with the legal norms among the population.
- P5 After 2000, the State realises that to counter the Mafia the use of legal mechanisms alone are not enough and began to act in order to explicitly promote lawful behaviour through non-legal means (social norms). This is reflected in the support and encouragement of initiatives that transmit these values in schools and among the general public (e.g., Festival della Legalità).

The input parameter values that we use to define the policies and characterise the periods, along with the agents and their strategies, are shown in Table 5. These values are informed by qualitative data extracted from empirical data analysis conducted by the University of Palermo in Sicily [41,49]. These data were collected through interviews with shopkeepers

**Table 5** Agent's strategies and parameter values according to each historical period

Period	Agent and configuration		Intermediary organisation
	State	No Social Norms	No Social Norms
P1 Pre-1980	<i>Weak Legal Norms</i>		<i>Mafia Violent</i>
	numPoliceOfficers = 5	propCitizens = 0.0	extortLevel = 0.1
	captureProb = 0.2		punishSeverity = 0.75
	convictionProb = 0.1		punishProb = 0.9
	percTransferFondo = 0.0		
	State		Intermediary Organisation
	<i>Strong Legal Norms</i>	<i>No Social Norms</i>	<i>No Social Norms</i>
P2 1980–1992	numPoliceOfficers = 20	propCitizens = 0.0	extortLevel = 0.1
	captureProb = 0.8		punishSeverity = 0.75
	convictionProb = 0.6		punishProb = 0.9
	percTransferFondo = 0.5		
	State		Intermediary organisation
	<i>Strong Legal Norms</i>	<i>No Social Norms</i>	<i>Hidden</i>
P3 1992–1995	numPoliceOfficers = 20	propCitizens = 0.0	extortLevel = 0.03
	captureProb = 0.8		punishSeverity = 0.5
	convictionProb = 0.6		punishProb = 0.5
	percTransferFondo = 0.5		



Table 5 continued

State	Strong Legal Norms	No Social Norms	Mafia	Intermediary Organisation
P4 1995-2000	numPoliceOfficers = 20	propCitizens = 0.0	<i>Hidden</i>	<i>Social Norms</i>
	captureProb = 0.8		extortLevel = 0.03	propCitizens = 0.1
	convictionProb = 0.6		punishSeverity = 0.5	
	percTransferFondo = 0.5		punishProb = 0.5	
	State		Mafia	Intermediary Organisation
P5 Post-2000	Strong Legal Norms	Social Norms	<i>Hidden</i>	<i>Social Norms</i>
	numPoliceOfficers = 20	propCitizens = 0.05	extortLevel = 0.03	propCitizens = 0.1
	captureProb = 0.8		punishSeverity = 0.5	
	convictionProb = 0.6		punishProb = 0.5	
	percTransferFondo = 0.5			

**Table 6** Behavioural output metrics

Metric	Description
Number of pizzo requests	Total number of pizzo requests made
Proportion of pizzo paid	Proportion of pizzo requests paid by Entrepreneurs
Proportion of reports	Proportion of non-paid pizzo requests that are reported to the State
Proportion of imprisonments	Proportion of Mafiosi incarcerated

who had paid or been requested to pay pizzo, and analyses of judicial trials and confiscated mafia documents.

## 6.2 Results

The simulation experiment was conducted using the simulator GLODERS-S<sup>18</sup> developed under the project GLODERS. The experiment was run with 200 Consumers, 100 Entrepreneurs, 1 State, 1 Mafia, 1 Intermediary Organisation, and 20 Mafiosi. The number of Police Officers varies depending on the strategy adopted by the State (weak or strong legal norms, see Table 5).<sup>19</sup>

The simulation corresponds to a continuous run of the model for 50,000 time units with configurations exogenously changing at run-time every 10,000 time units. These configuration changes correspond to the sequence of periods from P1 to P5 and cumulatively take into account the results of the former periods carry them over to the next.

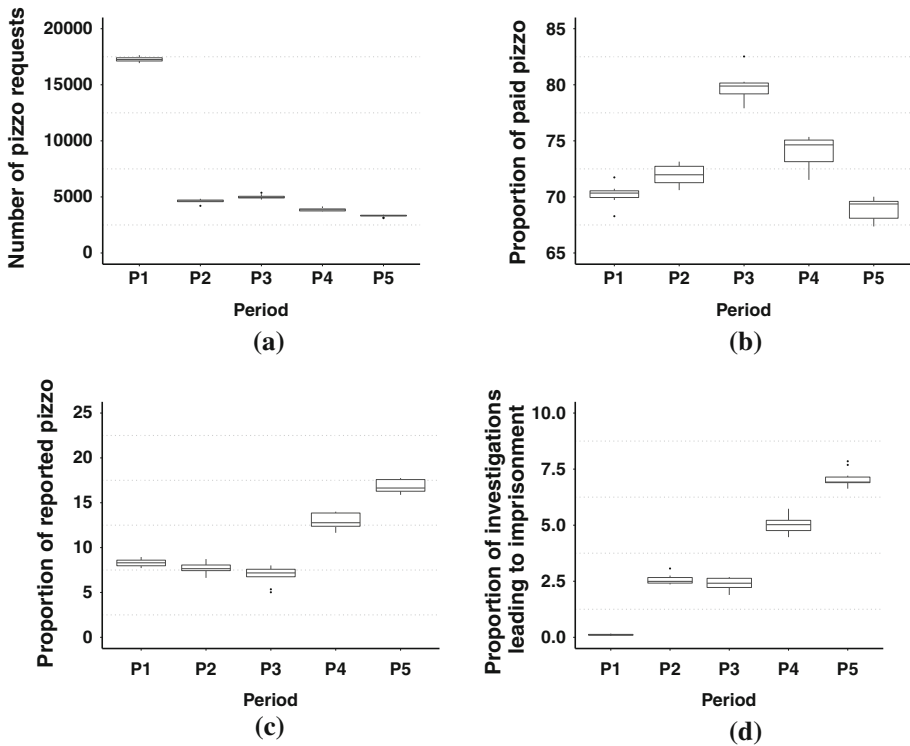
We repeated the simulation 10 times and the results were analysed based on the arithmetic mean value of the behavioural output metrics shown in Table 6 and the saliences of the output metrics concerning the norms.

The results, displayed in Fig. 5, demonstrate that the introduction of anti-racket laws—between period P1 (weak legal norms State) and P2 (strong legal norms State)—drastically reduces the total number of pizzo requests ( $p = 1.082 \times e^{-05}$ ).<sup>20</sup> (Fig. 5a). This reduction in payment can be attributed to an increase in the State's efficiency leading to a greater proportion of imprisonment ( $p = 1.082 \times e^{-05}$ ) (Fig. 5d) and consequently larger number of imprisoned Mafiosi. Nonetheless, the proportion of paid pizzo increases ( $p = 1.299 \times e^{-04}$ ) (Fig. 5b), meaning that among those (fewer) Entrepreneurs who are approached a greater proportion decide to pay. This can be attributed to the increase in the salience of the set of TRADITIONAL norms that occurs during P1 and that remains stable during P2 (see Fig. 6). The strong legal approach undertaken during P2 is completely ineffective at reducing the salience of TRADITIONAL norms. Hence, even though, in period P2, the State becomes effective capturing and convicting Mafiosi, it is not successful in making the NEW set of norms more salient than the TRADITIONAL ones in the Entrepreneurs' mind (Fig. 6). This can be observed in Tables 7 and 8.

<sup>18</sup> Available for download at <https://www.github.com/gnardin/gloderss>.

<sup>19</sup> The numbers of agents of each type are arbitrary. However, we assume that 5 Entrepreneurs per Mafioso is a reasonable number to be handled by an individual. Moreover, the number of Police Officers range from 5 to 20, meaning that in an extreme case there is the same number of Police Officers as Mafiosi.

<sup>20</sup> All statistical significance tests shown in this paper are performed using the Wilcoxon Rank Sum Test with  $\alpha = 0.05$  [35, pp. 68–75]. We chose this test due to the fact that our data cannot be assumed normally distributed under the Shapiro-Wilk test [64].



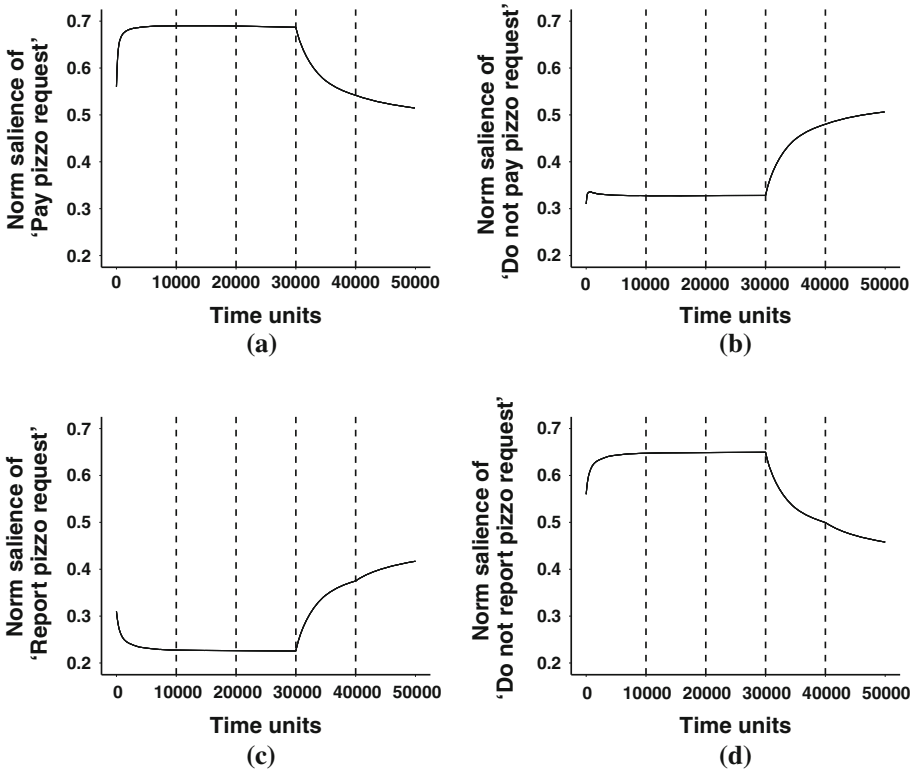
**Fig. 5** Results of the simulation of the periods shown in Table 5 according to the output metrics shown in Table 6. **a** Total number of pizza requests. **b** Proportion of paid pizza requests. **c** Proportion of reported pizza requests. **d** Proportion of imprisonments

In period P3, the Mafia responds to the State’s strong approach and changes its strategy from violent to hidden characterised by requesting lower amounts of pizza and inflicting softer punishments. As a result, the Mafia successfully increases the proportion of Entrepreneurs that pay pizza ( $p = 1.082 \times 10^{-05}$ ) (Fig. 5b); a reduction in the threat of punishment and in its severity actually allows the Mafia to obtain a greater proportion of payments. The success of the hidden Mafia strategy may be partially imputed to the fact that the TRADITIONAL set of norms is still highly salient among the Entrepreneurs indicating the inadequacy of the State actions in favouring a greater change on the Entrepreneurs mind-set towards the NEW set of norms.<sup>21</sup> This impact is presented in Table 8, in which the salience of the TRADITIONAL and NEW set of norms remains relatively unchanged in period P3 compared to P2.

The inclusion of the Intermediary Organisation in period P4, whose main activity is to promote the NEW set of norms through the social norm-based approach, however, changes the situation. As a result, we observe a reasonable decrease in the proportion of paid pizza ( $p = 1.082 \times 10^{-05}$ ) (Fig. 5b) and an increase in both the proportion of reported pizza (Fig. 5c) and imprisonments (Fig. 5d).

Additionally, a group of Entrepreneurs (about 0.3%) shifted their dominant norm regarding the payment of pizza from a situation in which the salience of *Pay pizza request* norm is

<sup>21</sup> We are aware that several other factors may have influenced this change; however, here we model only the normative aspect.



**Fig. 6** Mean value of the Entrepreneur norms salience. The y-axis show the mean strength of the norms and the x-axis represent the elapsed simulation time measured in time units. The dashed lines indicates the moment in which the periods' configuration is changed beginning with period P1's to P5's configuration. **a** *Pay pizzo request* norm. **b** *Do not pay pizzo request* norm. **c** *Report pizzo request* norm. **d** *Do not report pizzo request* norm

**Table 7** Entrepreneurs' norm salience mean and standard deviation value at the end of each period

Norm	Periods				
	P1	P2	P3	P4	P5
$N_1$	$0.689 \pm 0.02$	$0.689 \pm 0.01$	$0.687 \pm 0.02$	$0.542 \pm 0.02$	$0.514 \pm 0.02$
$N_2$	$0.327 \pm 0.02$	$0.327 \pm 0.01$	$0.328 \pm 0.01$	$0.479 \pm 0.02$	$0.506 \pm 0.01$
$N_3$	$0.227 \pm 0.01$	$0.226 \pm 0.01$	$0.225 \pm 0.01$	$0.374 \pm 0.02$	$0.416 \pm 0.04$
$N_4$	$0.647 \pm 0.01$	$0.648 \pm 0.01$	$0.649 \pm 0.01$	$0.499 \pm 0.02$	$0.485 \pm 0.04$

higher to one in which the salience of *Do not pay pizzo request* norm is higher. Thus the promotion of lawful behaviour performed by the Intermediary Organisation leads to some change in the Entrepreneurs' normative mind-set, which is also reflected in both the increase in reported pizzo (Fig. 5c) and Mafiosi imprisonment (Fig. 5d).

Finally, in period P5, the State begins an activity that complements the action of the Intermediary Organisation. It starts promoting lawful behaviour among the population by

**Table 8** Proportion of entrepreneurs associated with each set of norms at the end of the simulation

Period	Traditional (%)	<i>Do not pay</i> only (%)	<i>Report</i> only (%)	New (%)
P1	100.0	0.0	0.0	0.0
P2	100.0	0.0	0.0	0.0
P3	100.0	0.0	0.0	0.0
P4	97.0	0.3	0.0	0.0
P5	56.4	25.6	3.4	14.6

encouraging the adoption of the NEW set of norms and giving more visibility to its actions and results obtained in countering the Mafia. Looking at Figs. 5 and 6, we note a significant change in the proportion of paid *pizzo* requests with respect to period P4 ( $p = 1.082 \times 10^{-05}$ ) (Fig. 5b). Analysing the transitions shown in Table 8, we note that complementing the action of the Intermediary Organisation in spreading the NEW set of norms, the State improves significantly the transition of the Entrepreneurs' mind-set from the TRADITIONAL to the NEW set of norms (about 14.6%). Another 25.6% of Entrepreneurs make a partial transition and have *Do not payizzo request* as their dominant norm, and an additional 3.4% shifted to the *Reportizzo request* norm.

This suggests that the social norm-based approach, such as the promotion of lawful behaviour, is complementary to a legal norm-based approach. The analyses of the way in which these two policies complement each other has been made possible by the use of agents endowed with complex architectures. These type of architectures allowed us to inspect agents' mind and understand how norms affected their decisions instead of relying only on the analysis of their behaviours.

## 7 Validation

In this section, we describe a simulation model validation methodology that uses empirical data that is reduced in quantity and only pertains to the output of the phenomenon being analysed. We also demonstrate the application of this methodology in the validation of the Palermo Scenario with the empirical data collected in the area of Palermo.

### 7.1 Methodology

As argued at length in [36, p. 103], “simulation sometimes is the only possibility to generate deductions from theoretical assumptions” and any direct link between empirical data and mental models derived from these assumptions, on one hand, and from simulation on the other, is only a short-cut [36, p. 102]. Hence, the interface between data and simulation needs some additional theoretical grounding.

Any kind of interface has to take into account that the link between data and simulation is the theory behind the simulation—as simulation is only the implementation of theory in a programming language (instead of natural language and mathematics, see [51]). A theory and the corresponding simulation model can be used to develop ideas of how to operationalise theoretical concepts in order to make these theoretical concepts measurable—which is, of course, not a trivial problem when features of individuals are at stake, particularly when these individuals are in a situation in which they are reluctant to communicate about their

motivations and behaviour propensities. The theoretical concepts summarised in Sect. 5 are mainly about individual normative goals and behaviours which can—in principle—be measured in questionnaires (quite successfully in marketing research and in election research, but not in our field—for the reasons see Sect. 7.2) or in laboratory or field experiments (also quite successfully in the fields mentioned, but not in our field). On the other hand, we have theoretical concepts at the macro level which are obviously related to the theoretical concepts at the micro level discussed in the preceding sentence and formalised, for instance, in Eq. 10. And these macro concepts can easily be measured as they leave their traces in publicly available documents (quite easily found in election research, less easily in marketing as firms want to keep data like these secret, and also easily, but less reliably found in criminal statistics and our data base on extortion cases in Sicily and Calabria). Where theoretical concepts at the micro level cannot easily be measured, theory (and, hence, simulation) can help to link the theoretical concepts between the two levels, assuming certain behavioural traits at the micro level and deriving time series and distributions at the macro level, which then can be compared to the available data at the macro level. This is certainly not a proof that the micro level assumptions about the empirical (but unmeasurable) behaviour at the micro level actually leads to the predicted and measured macro behaviour—but proofs are never available in empirical sciences. Instead one has to discuss three aspects of model validation in terms of Zeigler [70], according to whom we should distinguish between three types of validity and three different stages of model validation (and development):

- *Replicative validity* the model matches data already acquired from the real system (also known as retrodiction).
- *Predictive validity* the model matches data before the data are acquired from the real system.
- *Structural validity* the model “not only reproduces the observed real system behaviour, but truly reflects the way in which the real system operates to produce this behaviour”—this stage of validity can almost never be accomplished, especially in models representing individuals, as one will never find out in sufficient detail how real people “operate to produce [their] behaviour” even if this behaviour consists of deliberate action.

At least part of the methods and procedures of the Palermo Scenario model are shaped after empirical evidence (see Sects. 2 and 3). If we succeed in finding simulation output which is in line with criminal statistics, we can claim that our model is replicatively valid—but this has no direct consequences for its predictive and, more so, for its structural validity (historical solar eclipses validated the pre-Copernican astronomical models with high precision, both replicatively and predictively, but these models were structurally wrong). We can only claim structural validity to the extent to which our micro theory is in line with empirical research.

## 7.2 Empirical data

Finding empirical data that are appropriate for validating a simulation model of protection rackets is difficult for several reasons:

- There are surveys whose results can be used to study attitudes towards crimes similar to extortion and to study the prevalence of such crimes, such as the Eurobarometer 79.1 [25] that asked people for their attitudes towards corruption, the European Values Study [29] that asked people for their norm-related attitudes, or the *Sicurezza dei Cittadini* survey [37] that asked people for their experience with different kinds of criminality,

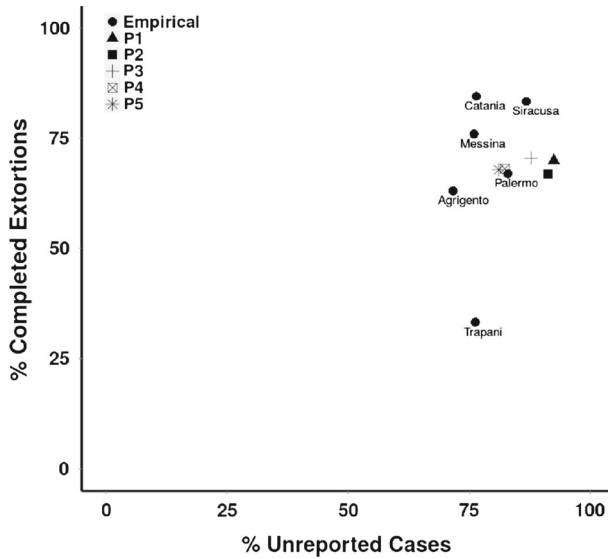
- among them menace and aggression. They do not address the problem of protection rackets directly but only allow inferences from related types of crime.
- In spite of the high number of interviewees in these surveys (Eurobarometer and European Values Study with 27,786 and 67,492 interviewees respectively, of which 1020 and 1519 in Italy, *Sicurezza dei Cittadini* with 60,001 interviewees in Italy), the numbers of usable cases—persons with experience in corruption or explicit attitudes toward corruption, persons who were victims of menace or aggression—are so small that they do not allow for reliable estimates and for validating stochastic simulations. Anyway they allow for some hints at correlations between variables which are output metrics of the simulation.
  - Even if one had surveys of an adequate size, one has to consider that obviously a majority of interviewees refuse to answer questions related to observed or experienced criminal offences. In the *Sicurezza dei Cittadini* survey, for instance, the percentage of refused answers to the question whether they had reported a menace to the police was 57% (out of 1,280 cases where they had suffered from such a crime). This means that even the answers that were given cannot be used for a reliable estimate of the percentage of reported menaces. Unlike in marketing research and in election research the percentage of interviewees who have experienced the issue relevant for a survey is—at slightly above 2%—so small that it is difficult to draw reliable conclusions in our field.
  - Even the European Values Study cannot give reliable answers to the question what are the weights of utility and norm related reasons for an individual's decision making such that analysis results of this study allow only for the differences in normative backgrounds in different regions of Europe and Italy. This might be interesting for a general discussion of causes for different prevalences of extortion in different parts of Europe or Italy, but is not sufficient for comparing the simulation results about the salience of norms in agents with information about the salience of norms in real human actors.

In addition to the qualitative data extracted from the participatory modelling process (see Sect. 3.1), the only source of reliable empirical data so far is a database of more than 600 cases of extortion in Sicily and Calabria during the past decade. The entries in this database were extracted from police reports and court trials by the GLODERS team at the University of Palermo and in most cases allow a precise description of what happened: Was the extortion completed or only attempted? Was it reported to the police by the victim, or did the police detect it in their own observations? Were the extorters put to jail, were they convicted and was their money confiscated? But even this detailed database cannot answer the question of how many extortions ever remained undocumented—as there must be an unknown number of extortion attempts and completed extortions which were kept secret by victims and offenders.

### 7.3 Application

For the validation attempts reported here the percentages of unreported cases (i.e., cases where the police got to know about an extortion without the help of the victim) and the percentages of completed extortions (i.e., not only attempted, but also unsuccessful) that took place in the area of Palermo were calculated. Each simulation run yields a file which in its structure and contents is similar to the empirical database: for each extortion that ever happened in a simulation run there is a record documented whether the extortion was kept secret between victim and offender, or whether it became known to the police, whether it was completed or only attempted, whether the victim reported it, whether the police was successful and the court convicted the extorter. First results of such a comparison are shown in Fig. 7 for the percentages of unreported cases and completed extortions. The empirical data plots are very heterogeneous regarding the percentage of completed extortions. The Palermo





**Fig. 7** Comparison between empirical data and simulation results. The *solid circles* represent the empirical data, whose correspondent province name is labelled adjacent to it. The other *symbols* represent the simulation results of the periods shown in Table 5

empirical data plot, however, matches well with the P4 and P5 plots, which suggests that the model is replicatively validated considering the current Palermo situation represented in the empirical data.

## 8 Conclusions

This paper proposes an agent-based simulation model of protection rackets that was built in an iterative participatory process with domain experts who are active on a day-to-day basis in the fight against crime. It can be used to further our understanding of how protection rackets work and explore the consequences that various policies, specifically a legal approach, typically pursued by states, and a social norm approach, have on the mafia and citizens in this complex social system. We find that an approach in which legal and social approaches are combined brings about a weakening in the mafia as well as robust changes in citizens' behaviours and minds. Analyses concerning how these two policies complement each other has been made possible by the use of agents endowed with a complex normative architecture. This type of architecture allowed us to analyse not only agents' behaviour but also inspect their minds to understand how norms affected their decisions.

Future avenues may consist of (1) deepening the representation of the internal structure of the protection racketeers and in particular of those factors that contribute to their success and stability (e.g., social norms, group reputation, etc.), (2) studying the dynamics occurring between different protection rackets for the domain over a territory, and (3) facilitating the use of the model for domain experts interested in policy-directed simulations.

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