Chapter 12
Calibration and Validation

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12.1 Data Scarcity, Calibration and Validation

The aim of this chapter is to summarise the problems incurred during the phases of calibrating and validating the extortion racket models used by the GLODERS project. The chapter starts with the discussion of the data availability and summarises shortly the contents of Sect. 4.3. It continues with a discussion of what parameterisation, calibration, sensitivity analysis and validation have to do with each other and ends up with a discussion of the validity of the GLODERS models.

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12.1.1 Data Scarcity

As discussed in Sect. 6.3, empirical data about the behaviour of extorters, victims, police and the public are rather scarce, even for countries and regions where extortion is a frequent phenomenon, as is the case particularly in Southern Italy. In Italy extortion rackets are a special category in criminal statistics. The annual report of the Italian National Institute of Statistics for 2010 (published 17 January 2012 (Istituto Nazionale di Statistica, 2012)) reports a total of 5992 extortions all over Italy of which 3271 or 57.3 % had a known offender. The first number reflects, of course, only those extortions which came to police notice and cannot include undetected extortions. Given that in 42.7 % of the detected extortions the offender was not known one can only conclude that victims often report extortions to the police without giving the extorter a name (although they usually know their names). The crime clearance rate of 57.3 % for extortions is high as compared to, for instance, arson (888 out of 9622 or 8.8 %) but low as compared to money laundering (75.0 % of 1344) or unintentional homicide (76.3 % of 1765) or receiving stolen goods (82.9 % of 23,686). And if one takes the dark figure of the mafia part of Italy's gross domestic product—16 % according to Pinotti (2012a, 2012b)—as an estimate of the dark figure for extortions, their total increases to about 7000 per year in Italy, and the clearance rate decreases to about 47 %.

Another source of vagueness lies in the propensity of interviewed persons to refuse answers to questions related with their propensity to report a crime to the police when they were involved in it, particularly when not reporting is a crime in itself—which is the case with corruption (worldwide) and with extortion (in Italy). Unfortunately (as already discussed in Sect. 9.2) extortion does not seem to have ever been the subject of surveys, but one can take the experience from corruption in Eurobarometer 79.1 (European Commission & Brussels, 2013) as a proxy for the response behaviour of interviewees who would have been asked for their readiness to report extortion. The Italian subsample consisted of 1020 interviewees of which 919 said that they had no experience with corruption (and 8 said that they did not know—whatever this means). 93 persons had either refused to answer or witnessed or assisted in an episode of corruption ("assistito" in the sense of "attended" or "participated" in the Italian questionnaire, the English codebook has "experienced", but as "vissuto", "seen", is the alternative what is meant here is that a yes to this question means that the interviewee was actively participating in the corruption, either accepting or requesting a bribe). And out of these 93 as many as 27 (or 29 %) spontaneously refused to answer the question whether they had observed or participated

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in an episode of corruption, and out of the 66 who admitted that they had observed or participated in an episode of corruption six refused to answer whether they had reported this event and ten said that they had reported. Hence we have 50 unreported episodes of corruption out of 66 documented episodes plus 33 supposable and probably also unreported episodes. Although the absolute numbers of corruption episodes in Italy are low, the frequency of unreported episodes and of refused answers is so high that the probability of estimating the clearance rate or the percentage of unreported cases is not reasonable for the crime of corruption, and it would not be reasonable for the crime of extortion either if the respective data were available.

Comparable statistics for other European countries are not much better. In Germany, for instance, extortion racketeering is not even a category in the annual crime statistics published by the Federal Criminal Police Office (Bundeskriminalamt, 2014a, 2014b) as there is either a category of "extortion" at large or a category of "robbery/extortion resembling robbery" of different kinds of businesses such that this statistic cannot be compared to the Italian statistic. Anyway, the German 2013 report mentions two groups mainly involved in extortion rackets in Germany: outlaw motorcycle gangs and mafia-like organisations both of the Italian and the Russian type.

Outlaw motorcycle gangs (Hells Angels, Bandidos, Gremium and Mongols) were reported with 11 cases of extortion (Bundeskriminalamt, 2013); their overall activities (including other kinds of crime) make up for less than 10 % of organised crime in Germany.

Italian mafia groups were reported with 11 cases, where in most of these cases extortion was not even reported.

Russian-language organised crime groups were reported for 30 cases, making up for less than 5 % of organised crime in Germany (Bundeskriminalamt, 2013). The most recent report (Bundeskriminalamt, 2014a, 2014b) mentions only outlaw motorcycle gangs in the context of violent extortions, but the total number of this kind of crime investigations was still low (with 23).

Thus it is not a surprise that for European Union (EU) regions other than Southern Italy reliable statistics are missing, and—as discussed above—even for this part of the EU where such statistics could be meaningful, they are of restricted reliability.

12.1.2 Parameterisation, Sensitivity Analysis, Calibration and Validation

The simulation models described in this book were more or less generated from anecdotal knowledge about extortion racket systems typical for Southern Italy. As such they originated as mental models that were formalised into computer simulation models. If one considers these computer simulation models as models of a theory in the sense of the "non-statement view" of contemporary philosophy of science (also known as the "structuralist program" (Balzer, Ulises, & Sneed, 1987)) the computer simulation model of a theory of extortion racket systems (as of any theory, see for

instance (Troitzsch, 1994)) can be used as a proxy for the state-of-the-art definition of a model of this theory, containing all terms necessary to formulate the theory, namely sets of objects, functions yielding measurable features of objects and relations defined over Cartesian products of sets of objects and formulas expressing conditions that have to be satisfied ("laws"). Sets of objects are defined as agent types in agent-based modelling, functions yielding measurable features are the instance variables defined for these agent types, relations are defined as additional object types or as additional instance variables and laws are defined as programme invariants. For any theory, according to the "non-statement view", a set of intended applications needs to be defined which in the case of the theory of extortion racket systems is the set of observable extortion racket systems in different parts of the world. It goes without saying that not all terms of the theory are observable or measurable before the theory has been provisionally accepted—as the discussion of undetected cases showed there might be some terms which only become measurable with the help of the theory in a way that a certain intended application—a province in Southern Italy—satisfies the theory only under the condition that the percentage of undetected cases has a certain value or lies within a certain range of values. From what was already seen in Sect. 8.4 the province of Trapani at the western coast of Sicily is a candidate for an intended applications of the theory behind the event-oriented NetLogo model, as is the neighbouring province of Palermo for the GLODERS-S model.

This anticipated, we can give the terms in the headline of this section a more precise meaning:

Parameterisation is the act of assigning values to what one usually calls global variables in a computer programme when these are used as parameters in functions.

Sensitivity analysis is the process of finding out which of these parameters matter, i.e. which parameters influence the output metrics of a simulation run. Sensitivity analysis is only necessary and reasonable in stochastic models, as in deterministic models every change in every parameter will lead to differing output metrics.

Calibration is then the selection of parameter combinations which lead to output metrics which match the respective metrics of intended applications.

Validation is the task of finding out whether at least one or few parameter combinations lead to output metrics with the available intended applications—whose set will usually be finite whereas the set of possible parameter combinations might be infinite (in theory, not in practice as only a finite number of simulation runs can be produced and as the set of "real" numbers in a computer is also finite).

The theory of extortion racket systems described in this book is a stochastic theory which uses stochastic functions to describe the relations between agents. Hence the output metrics mentioned in the above definition are distributions rather than distinct values. This makes it necessary to discuss what the meaning of a match between the output metrics of a simulation run (a distribution function defined over the space spanned by some instance variables of the agents) and the empirical statistic of a certain regional extortion racket system is. The theory, formalised in the simulation model, states that given its parameterisation a certain output metric is distributed according to certain distribution, and the question to be answered for the

sake of validation is whether the feature measured for a certain regional extortion racket system lies within an appropriate confidence interval of this distribution.

An additional problem arises from computer simulations in so far as these—other than analytical mathematical derivations—do not yield a closed formula of a distribution function but only a list of values drawn from a hopefully large sample of simulation runs which in turn allows for an approximate formula for a probability density function or for a cumulative density function such that a statistical test becomes possible.

12.1.3 Validity of the Norm-Oriented ERS Simulation Models

The validity of the GLODERS-S model has already been discussed by Nardin et al. (2016) with the result that this version yielded a precise replication of the empirical data of the province of Palermo. For the model discussed in Sect. 8.4 with its high number of 1280 runs a more detailed analysis of the validity is possible. Section 8.4 already showed a diagram with representations of all runs and of the empirical findings of the seven provinces covered by the Sicily and Calabria database (Frazzica et al., 2015). To be able to analyse the distribution of the simulation runs in more depth, the data were normalised with the help of a linear transformation in order to have the mean of both transformed variables at 0.0 and to have their variances as 1.0. Moreover the runs were weighted with the natural logarithms of the numbers of extortions that were counted per run. These numbers ranged from one to more than a thousand, and these numbers are distributed according to a lognormal distribution with mean about 80; the input parameters explain slightly more than one-half of their variance and the influence of most individual input parameters on the number of extortions is highly significant on a 0.005 level. Nevertheless this output metric was not used for the analysis proper, as its empirical counterpart is very dubious due to the high dark figure.

The resulting approximate probability density function (an exponential function of a polynomial of the two transformed variables up to fourth order[1]—a normal distribution would have had a PDF as an exponential function of a polynomial of the two transformed variables up to second order) can be seen in Fig. 12.1.

[1]The algorithm used for the approximate calculation of the probability density function was first described by Cobb (1978), extended by Herlitzius (1990) to multivariate distributions and, for instance, used by Troitzsch (1998). The algorithm works only for standardised variables and yields the best possible approximation between the empirical moments up to fourth order and the same moments of a probability distribution described with a density function which is an exponential function of a polynomial in two variables up to fourth order. Hence the diagram in Fig. 1 does not show the "true" distribution but a quite good approximation as the comparison between colour shades, contours and scattergram shows. Contours are for values of the probability density function which are multiples of 0.015; its maximum is 0.307, and the value of the cumulated density function within the outermost contour line is 0.95 which means that Trapani, Reggio ID="ITerm239"Calabria and Palermo lie within the 95 % confidence region.

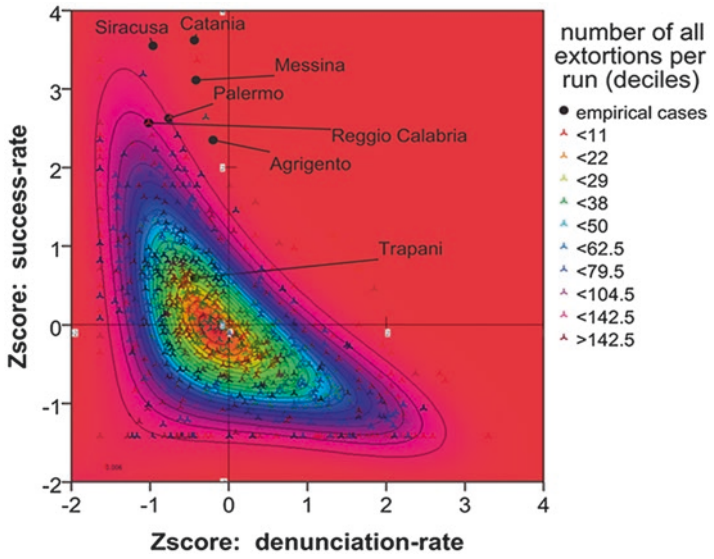

Fig. 12.1 Distribution of a Z transformation of the two main output metrics of the event-oriented NetLogo ERS model (contour curves for multiples of 0.015, coloured marks for the individual runs, *black dots* for the empirical data of the seven provinces covered by the Sicily and Calabria database)

This probability density function is far from normal. The province of Trapani is represented at a position where the PDF is approximately 0.25, the provinces of Reggio Calabria and Palermo are represented at a position where the PDF is approximately 0.030 and 0.015, respectively, whereas the other four provinces lie outside the 0.015 contour curve, but—with the exception of Catania—still near the positions of simulated runs.

Figure 12.1 shows the distribution of the two output metrics for all parameter combinations generated by the pseudorandom number generator within the intervals given in Sect. 8.4, Table 8.3, but it also gives a hint at which parameter combinations should be analysed in more detail. If it is the case that the provinces of Palermo and of Trapani are the first candidates for intended applications of the theory behind the event-oriented NetLogo model, the parameter combinations of the runs whose output metrics turned out to be most similar to the empirical data should be used to find out what the distribution of the output metrics is like for exactly these two input parameter combinations. This is what is shown in Fig. 12.2. The runs with the parameterisation of the run from Sect. 8.4, Figs. 8.1 and 8.2, matching the province of Trapani are marked in green and form a distribution with a fairly small variance whereas the runs with the parameterisation of the run matching the province of Palermo are marked in red and form a distribution with a much larger variance. The main difference between the two parameterisations can be found in Table 12.1; the other input parameter values of the two original runs resembling these two provinces did not differ much; hence the means between these runs were taken (for a detailed explanation of these parameters see Sect. 8.4, Table 8.3).

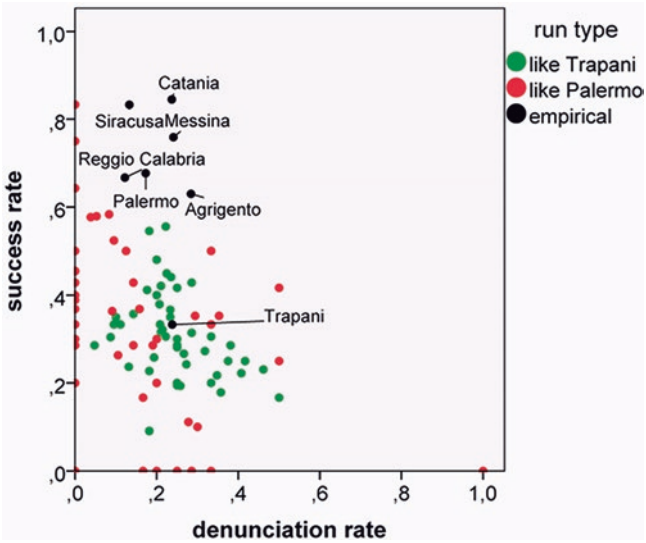

Fig. 12.2 Runs resembling empirical data

Table 12.1 Difference in the parameterisation for Reggio Calabria- and Trapani-like simulation runs

Input parameters of the two runs next to provinces	Reggio Calabria-like	Trapani-like
Cultural background	−7.25	−13.2
Communication range	2.95	5.94
Forgetfulness	0.907	0.831
Weight of the normative drive; the weight of the individual drive is 1–NDW	0.5227	0.4925
Benefit for victims	119	80
Conviction probability	.561	.331
Vision range of police	37	51
Punishment severity	22	28
Probability that a shop publishes its readiness not to denounce an extortion attempt	.061	0.074
Escape chance	0.270	0.144
Extortion radius extension	1.056	1.043

Parameterising the model with these values means calibrating it at least for these two provinces. At the same time the parameter values in Table 12.1 and the ones mentioned above are theory-supported measurements of these 11 "T-theoretical terms" (as the "non-statement view" calls these terms (Balzer et al., 1987)) for these two provinces. With even more simulation runs measuring these nine terms for the other five provinces should also be possible (the provinces of Palermo, Messina and Agrigento already found their matching simulation runs—see the red dot near the black dot for this province, better visible in Sect. 8.2, Fig. 8.2).

Putting everything together, one can conclude that the validation of the theory behind the event-oriented NetLogo model was fairly successful. It goes without saying that many other regions for which data are not available for reasons discussed in the first paragraphs of this section also qualify as successful intended applications of the theory.

12.2 Narratives and Stylised Facts[2]

The Sicilian mafia, or *Cosa Nostra*, is one of the oldest and most important Italian mafia (Santino, 1995). It is a confederation of about 150 groups[3], mostly located in the western part of Sicily.[4] This criminal organisation adopts a hierarchical structure with strict rules of conduct (Punzo, 2013a, 2013b) and is organised in cells, each one corresponding to a local territorial entity, typically a district, called *family* or *cosca*. At the basis of each *family*, you find the *men of honour*, also called *soldiers*. Each family exercises monopoly of illegal violence within their territory, checking the almost overall criminal activities (e.g. extortion, usury, drug trafficking, infiltration in public procurement) and affecting the legal economic ones (Catanzaro, 1988; Gambetta, 1993; La Spina, 2005; Sciarrone, 2009).

The Sicilian mafia is deeply rooted in society and it tends to reproduce itself over time (Gambetta, 1993; La Spina, 2008; Neumann, Frazzica, & Punzo, 2016; Sciarrone, 2009). It also provides actual protection services (Gambetta, 1993; La Spina, 2008), usually by replacing the state in the resolution of different problems. In return, the mafia increases its authority and reputation, achieving consensus on the part of society that can be even spent to mobilise the entire community against law enforcement (Punzo, 2016).

The embeddedness of the Sicilian mafia dates back to the decade between the 1950s and 1960s, when the relationship between the criminal organisation and the local political authorities strengthened. In this period, the Palermo families began to acquire increasingly more power and to infiltrate into urban development programmes.

During the 1970s and 1980s a family from the neighbourhood of Corleone and headed by the bosses Salvatore Riina and Bernardo Provenzano took power and stressed a top-down pyramidal structure, characterised by a "structure rigidly hierarchical and organised according to specific administrative models whose top positions are reached through complex selective recruitment policies […]"

[2] Part of this chapter was published in NardinID="ITerm240" et al. (2016) "Reprinted with permission of the Journal of Autonomous Agents and Multi-Agent Systems.

[3] There is no exact number of members affiliated to the Sicilian mafia, but according to official reports, the number should be considerably lower than the estimated 3000 of the mid-1990s, perhaps as low as 2000ID="ITerm250" (see Paoli, 2014).

[4] The provinces of Palermo (the capital of ID="ITerm251"Sicily), Trapani and AgrigentoID="ITerm252" (Paoli, 2014) are particularly influenced by the Sicilian mafia.

(Di Cagno & Natoli, 2004, p. 19). Still during this period, the mafia bosses attempted to reconstruct the Territorial Commission to discuss strategic decisions and settle disputes, the so-called *Cupola* (Di Cagno & Natoli, 2004; Punzo, 2013a, 2013b; Scaglione, 2011). In contrast, especially in the 1980s and the 1990s, the state launched some important innovations in the field of criminal law, starting with the Rognoni-La Torre law.

Until the first half of the eighties, the mafia families were primarily committed to drug trafficking. The protection racket was mostly directed to those businesses that could provide significant economic revenue. Moreover, the cruelty of the Sicilian mafia in those years was expressed not only in the struggle within the organisation,[5] but also in the fight against the institutions and all the potential dangers to the organisation. In the period following the late 1980s, due to the conclusion of the Maxi Trial (Alfonso, 2011) that resulted in life sentences for almost all the heads of the leading families and an exponential increase in the number of collaborators of justice, the Sicilian mafia started a terror strategy meant to "force the institutional partners to negotiate a way out for the men of honours" (Di Cagno & Natoli, 2004, p. 43).

Directly after the massacres of Capaci and Via d'Amelio, in 1992, the fight against the mafia has gained more attention, which endured over time. The declared trend is toward increasing efforts, creating a *system* of anti-mafia measures and instruments (La Spina, 2014; La Spina & Militello, 2016), both directly by police operation or indirectly through the support to mafia's victims (La Spina, 2014; La Spina & Militello, 2016; Militello, 2013). In contrast, the criminal organisation underwent significant changes in order to identify alternative ways of penetrating the local environment (Punzo, 2013a, 2013b). The strategy of the Sicilian mafia in the management of extortions changed in favour of a systematic request, often of only small amounts, towards all the entrepreneurs, on the basis of the rule of the "*pay little, but pay all*" (Amadore & Uccello, 2009; Di Gennaro & La Spina, 2010; La Spina, 2008; Scaglione, 2008). In addition, they began a renewed attempt to expand into other areas, until then considered difficult to enter, such as to get back the leading role in drug trafficking and money laundering, and to enter the public and private construction and leisure industries and 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 striking criminal manifestations (Di Cagno & Natoli, 2004; Dino, 2011; Palazzolo & Prestipino, 2007). This strategy has helped to reduce the strong social alarm created around the Sicilian mafia after the early 1990s, allowing the criminal group to restore its relationships with public administrators, politicians, businesspersons and professionals (Amadore, 2007; Dino, 2006).

The capture of Bernardo Provenzano in 2006 created a vacuum at the top of the criminal organisation. Since then, many convictions of its major leaders, except for Matteo Messina Denaro, who is still fugitive, have had decisive consequences. The absence of charismatic leaders, able to hold the decisional power, seems to now be

[5] During the early 1980s, the second mafia war took place. It was driven by the *family* from Corleone against other *families* from Palermo.

clear. Moreover, the new bosses show a much lower criminal capabilities than their predecessors (Punzo, 2013b).

The Sicilian mafia is currently undergoing a deep crisis and the image of a fragmented organisation is emerging. Nevertheless, it is not defeated. In fact, the Sicilian mafia remains one of the most dangerous and fearsome criminal organisations over the Italian territory and abroad. Despite the strong reaction of the state over the last 30 years against the mafia (see La Spina, 2014), the Sicilian mafia is still heavily affecting the development of Sicily (La Spina, Avitabile, Frazzica, Punzo, & Scaglione, 2013; Pinotti, 2012a, 2012b; Scaglione, 2015). This might be imputed to the fact that while 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 intermediary organisations, such as Addio Pizzo[6] and Libera[7] (law n. 44, 1999), it has been much less successful at changing citizens' behaviour and motivating them to collaborate with the state. This may be the consequence of the enduring existence of the Sicilian cultural context and some social norms that lead people to accept the presence of mafia and not to report its activity. Such social norms would then undermine the efforts of the state, creating a context in which laws fail to motivate citizens.

Here we analyse five historical periods from 1980s to 2000s of the Sicilian mafia broadly characterised by certain strategies of the different actors involved in the dynamics of the phenomenon as described above using the Palermo Scenario simulation model presented in Sect. 5.1. In particular, we describe a simulation experiment aimed at understanding the dynamics of protection rackets 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.

In Sect. 12.2.1, we describe the experiment we performed to explore the five historical periods of the Sicilian mafia. Next, we discuss the results of some simulations used for analysing the historical perspective of this organisation in Sect. 12.2.2.

12.2.1 Experiment

In this experiment, we explore and analyse five historical periods of the Sicilian mafia described below. 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 12.2 we display the agents, the main strategies that they use

[6] http://www.addiopizo.org.

[7] http://www.libera.it.

and the possible values of the strategies that we consider here. In Table 12.3 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 Chap. 5) in the following way:

P1: This period represents the situation before 1980, in which the state had few specific legal mechanisms to fight the mafia (weak legal norms and no social norms). The mafia demanded a high amount of pizzo from entrepreneurs. Those who did not acquiesce had a high probability of being strongly punished (violent

Table 12.2 Description of the possible strategies of the agents

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

Table 12.3 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 a 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

mafia). Additionally, much of the Palermitan population, the entrepreneurs and consumers, still held a traditional view on the mafia, in which pizzo is broadly perceived as a *legitimate* payment for protection services (Gambetta, 1993; Varese, 2013).

P2: This period represents the situation between 1980 and 1992, in which the state instituted several new coercive anti-racket laws in order to counter the mafia. These new anti-racket laws allowed the police and judiciary to more effectively counter the mafia and also allowed the state to provide support to mafia victims (strong legal norms). However, the state did not promote lawful behaviour among the population through non-legal means, such as invoking social norms.

P3: In the early 1990s, however, due to the effectiveness of the state strategy (strong legal norms), the mafia changed its violent and combative strategy (violent mafia) into a more moderate strategy in order to operate hidden from the law enforcement (hidden mafia). Concretely, this strategy stipulated a reduced amount of pizzo demanded of entrepreneurs but from a larger number of them. In addition, it inflicted a lower punishment on those that did not pay.

P4: In the mid-1990s, these changes, especially the state policies, paved 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 realised that to counter the mafia the use of legal mechanisms alone is 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, shown in Tables 12.2 and 12.3, are informed by qualitative data extracted from empirical data analysis conducted by the University of Palermo in Sicily during the GLODERS[8] project (La Spina, 2014; Militello, La Spina, Frazzica, Punzo, & Scaglione, 2014). These data were collected through interviews with shopkeepers who had paid or been requested to pay pizzo, and analyses of judicial trials and confiscated mafia documents.

Additionally, we assume that entrepreneurs and consumers have five specific social norms. Entrepreneurs have social norms (N1) Pay pizzo request, (N2) Do not pay pizzo request, (N3) Report pizzo request and (N4) Do not report pizzo request. Consumers have the social norm (N5) Avoid paying pizzo Entrepreneurs. Norms N1 and N4 (TRADITIONAL set of norms) are part of the set of norms that are associated with the traditional mentality of the individuals regarding the mafia, in which pizzo should be paid and not reported to the police (omertà). Conversely, norms N2 and N3 (NEW set of norms) represent the set of norms that correspond to a recent emerging anti-racket sentiment that is based on the

[8] http://www.gloders.eu/.

understanding of the social and economic harm caused by the mafia. Differently to these, norm N5 is one factor that is used by Consumers to rank the different Entrepreneurs that may buy a product from.

The simulation experiment was conducted using the simulator GLODERS-S[9] developed under the project GLODERS. The experiment was run with 200 consumers, 100 entrepreneurs, 1 state, 1 mafia and 20 mafiosi. The number of police officers varies depending on the strategy adopted by the state (weak or strong legal norms, see Table 12.4).[10]

The simulation corresponds to a continuous run of the model for 50,000 time units with configurations exogenously changing at runtime 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 carried over to the next.

We repeated the simulation ten times and the results were analysed based on the arithmetic mean value of the behavioural output metrics shown in Table 12.5 and the saliences of the output metrics concerning the norms.

12.2.2 Analysis

The results, displayed in Fig. 12.3, 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 ($p = 1.082 \times 10^{-05}$)[11] (Fig. 12.3a). This reduction in payment can be attributed to an increase in the state's efficiency leading to a greater proportion of imprisonment ($p = 1.082 \times 10^{-05}$) (Fig. 12.3d) and consequently larger number of imprisoned mafiosi. Nonetheless, the proportion of paid pizzo increases ($p = 1.299 \times 10^{-04}$) (Fig. 12.3b), 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. 12.4). 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. 12.4). This can be observed in Table 12.6 and Table 12.7.

[9] Simulator available for download at https://github.com/gnardin/GLODERSs/.

[10] The numbers of ID="ITerm253"agents of each type are arbitrary. However, we assume that five entrepreneurs per mafioso is a reasonable number to be handled by an individual. Moreover, the number of police officers ranges from 5 to 20, meaning that in an extreme case there is the same number of police officers as mafiosi.

[11] All statistical significance tests shown in this chapter are performed using the Wilcoxon rank sum test with $\alpha = 0.05$ (Hollander & Wolfe, 1973, pp. 68–75). We chose this test due to the fact that our data cannot be assumed normally distributed under the Shapiro-Wilk test (Shapiro & Wilk, 1965).

Table 12.4 Agent's strategies and parameter values according to each historical period

Period	Agent and configuration			
P1: Pre-1980	**State**		**Mafia**	**Intermediary Organisation**
	Weak legal norms	*No social norms*	*Violent*	*No social norms*

	`numPoliceOfficers=5`
	`captureProb=0.2`
	`convictionProb=0.1`
	`percTransferFondo=0.0`
		`propCitizens=0`	`extortLevel=0.1`
			`punishSeverity=0.75`
			`punishProb=0.9`
				`propCitizens=0.0`

P2: 1980–1992	**State**		**Mafia**	**Intermediary Organisation**
	Strong legal norms	*No social norms*	*Violent*	*No social norms*

	`numPoliceOfficers=20`
	`captureProb=0.8`
	`convictionProb=0.6`
	`percTransferFondo=0.5`
		`propCitizens=0`	`extortLevel=0.1`
			`punishSeverity=0.75`
			`punishProb=0.9`
				`propCitizens=0.0`

P3: 1992–1995	**State**		**Mafia**	**Intermediary Organisation**
	Strong legal norms	*No social norms*	*Hidden*	*No social norms*

	`numPoliceOfficers=20`
	`captureProb=0.8`
	`convictionProb=0.6`
	`percTransferFondo=0.5`
		`propCitizens=0`	`extortLevel=0.03`
			`punishSeverity=0.5`
			`punishProb=0.5`
				`propCitizens=0.0`

P4: 1995–2000	**State**		**Mafia**	**Intermediary Organisation**
	Strong legal norms	*No social norms*	*Hidden*	*Social norms*

	`numPoliceOfficers=20`
	`captureProb=0.8`
	`convictionProb=0.6`
	`percTransferFondo=0.5`
		`propCitizens=0`	`extortLevel=0.03`
			`punishSeverity=0.5`
			`punishProb=0.5`
				`propCitizens=0.1`

P5: Post-2000	**State**		**Mafia**	**Intermediary Organisation**
	Strong legal norms	*Social norms*	*Hidden*	*Social norms*

	`numPoliceOfficers=20`
	`captureProb=0.8`
	`convictionProb=0.6`
	`percTransferFondo=0.5`
		`propCitizens=0.05`	`extortLevel=0.03`
			`punishSeverity=0.5`
			`punishProb=0.5`
				`propCitizens=0.1`

Table 12.5 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

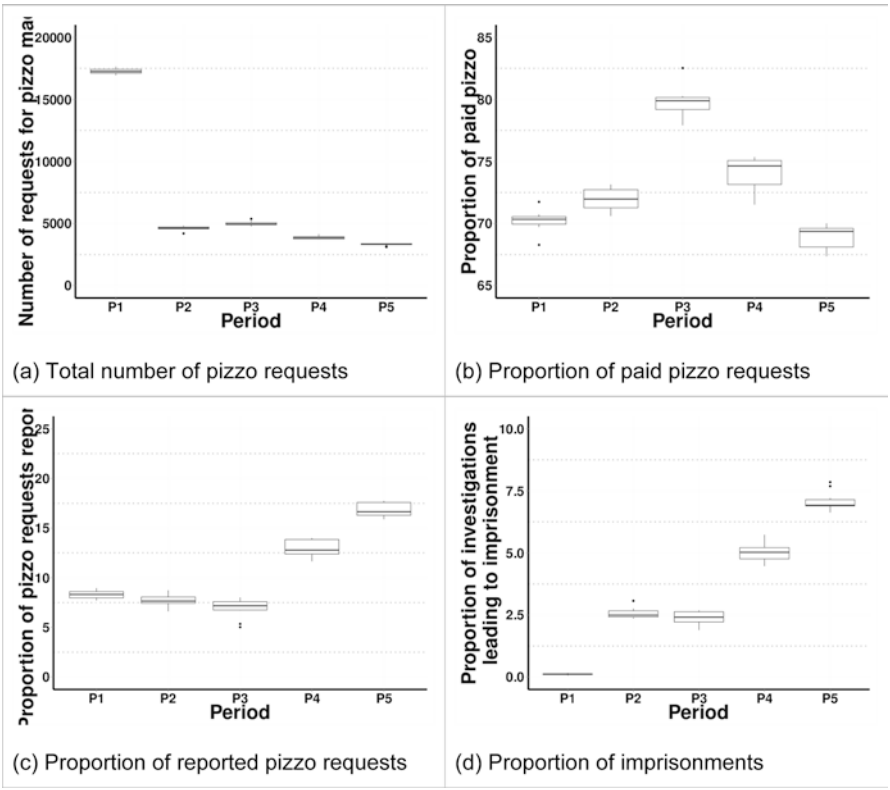

Fig. 12.3 Results of the simulation of the periods shown in Table 12.4 according to the output metrics shown in Table 12.5. (**a**) Total number of pizzo requests; (**b**) proportion of paid pizzo requests; (**c**) proportion of reported pizzo requests; (**d**) proportion of imprisonments

In period P3, the mafia responds to the state' strong approach and changes its strategy from violent to hidden characterised by requesting lower amounts of pizzo and inflicting softer punishments. As a result, the mafia successfully increases the proportion of entrepreneurs that pay pizzo ($p = 1.082 \times 10^{-05}$) (Fig. 12.3b); a reduction in the threat of punishment and in its severity actually allows the mafia to obtain

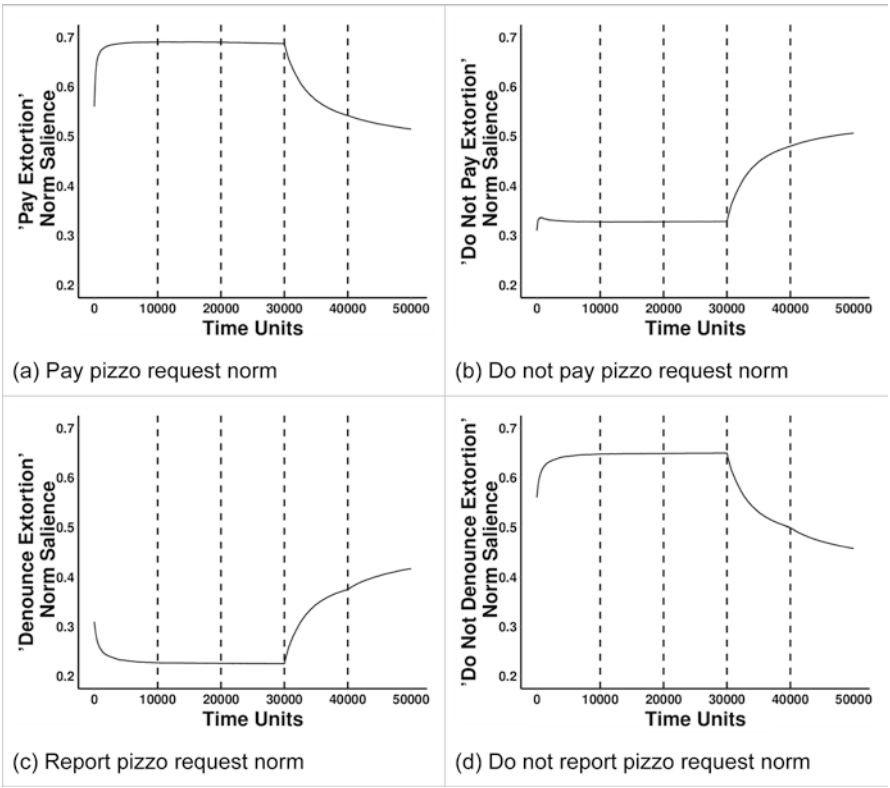

Fig. 12.4 Mean value of the entrepreneur norm salience. The *y*-axis shows the mean strength of the norms and the *x*-axis represents the elapsed simulation time measured in time units. The *dashed lines* indicate the moment in which the periods' configuration is changed beginning with period P1's to 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 12.6 Entrepreneurs' norm salience mean and standard deviation value at the end of each period

	Periods				
Norm	P1	P2	P3	P4	P5
N1	0.689±0.02	0.689±0.01	0.687±0.02	0.542±0.02	0.514±0.02
N2	0.327±0.02	0.327±0.01	0.328±0.01	0.479±0.02	0.506±0.01
N3	0.227±0.01	0.226±0.01	0.225±0.01	0.374±0.02	0.416±0.04
N4	0.647±0.01	0.648±0.01	0.649±0.01	0.499±0.02	0.485±0.04

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' mindset towards the NEW set of

Table 12.7 Proportion of entrepreneurs associated with each set of norms at the end of the simulation

Period	Traditional (%)	Do not pay only (%)	Report 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

norms.[12] This impact is presented in Table 12.7, 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 pizzo ($p = 1.082 \times 10^{-05}$) (Fig. 12.3b) and an increase in both the proportion of reported pizzo (Fig. 12.3c) and imprisonments (Fig. 12.3d).

Additionally, a group of entrepreneurs (about 0.3 %) shifted their dominant norm regarding the payment of pizzo from a situation in which the salience of *pay pizzo request* norm is 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 mindset, which is also reflected in both the increase in reported pizzo (Fig. 12.3c) and mafiosi imprisonment (Fig. 12.3d).

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 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. 12.3 and 12.4, we note a significant change in the proportion of paid pizzo requests with respect to period P4 ($p = 1.082 \times 10^{-05}$) (Fig. 12.3b). Analysing the transitions shown in Table 12.7, 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' mindset 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 pay pizzo request* as their dominant norm, and an additional 3.4 % shifted to the *report pizzo 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 have been made possible by the use of agents endowed with complex architectures. These type of architectures allowed us to inspect agents' minds and understand how norms affected their decisions instead of relying only on the analysis of their behaviours.

[12] We are aware that several other factors may have influenced this change; however, here we model only the normative aspect.

12.3 Participatory Modelling for Validation

Sections 12.1 and 12.2 discuss availability and use of data in the GLODERS models. In addition to hard statistical data and use of narrative data or stylised facts, GLODERS employed a third data-gathering method: participatory modelling.

Participatory modelling is a form of modelling used in descriptive modelling processes such as system dynamics and increasingly in agent-based modelling (Badham, 2015). Participatory modelling uses relevant practitioners, or stakeholders, to extract their expertise of the field they work in.

Participatory modelling can use different methods to elicit this knowledge, such as interviews with individuals, focus groups with a range of stakeholders or conferences and workshops consisting of talks and discussions. The data collection can be structured, by collaboratively constructing concept or cognitive maps (Papageorgiou & Salmeron, 2013; Prell et al., 2007). However, often the data is collected in a more narrative form and the mapping later done by modelling experts.

One of the main reasons for using participatory modelling is the complexity of the target system models are built to represent (Byrne, 2013). Most often models are there to help the understanding of interdependent subsystems. Practitioners often bring high levels of expertise of the subsystem they work in. The discussion with other stakeholders can elicit how the subsystems hang together and how they interact. A second aspect that is important for model building is an idea of the temporal dynamics of the target system. Practitioners often have deep knowledge of the system over time and can provide important information about processes and causal mechanisms.

Extortion racket systems are just such a complex system, consisting of different agents and agencies: legal, normative and spatial aspects; communication sources and channels; behaviour influences; and expectations and collaborations. Extortion racketeering has previously been analysed isolating certain aspects such as the legal framework (Militello, 2011) or the perpetrator-victim relationship (Smith & Varese, 2001). And while deterrence and legal aspects are essential for an analysis of extortion racketeering, extortion racketeering is a crime that is deeply embedded in social, economic and spatial aspects (cf. Chap. 3).

GLODERS employed participatory approaches throughout the project through a stakeholder board, consisting of 27 domain experts from 10 countries, including judges, police commissioners and policy researchers in the field of extortion racketeering. Participation of the stakeholder board was written into the project at several stages and for a variety of purposes.

1. Provision of data: Extortion racketeering, as much of criminology, is beset with the difficulty of obtaining data. Stakeholders working in the field can function as gatekeepers to data otherwise unavailable. In GLODERS data access through stakeholders was integral to the model building. Obtaining detailed documentation of legal proceedings, interviews, witness statements and police investigations of extortion racketeering allowed for data-driven modelling of processes inside the criminal world (cf. Chaps. 10 and 11) and model calibration in the

society focussed model (Chaps. 7 & 8) model. Data exchange relied on mutual trust as well as the focus on models being useful for practitioners once built (see point 3).

2. Harnessing expertise: Although access to data and documentation was essential for the success of GLODERS, what was probably even more important was harnessing the knowledge of international extortion racketeering experts throughout the project. In an initial international workshop the project was introduced to the stakeholders. This was very important as computational modelling is a relatively new methodology, which most practitioners never heard of before. Introducing them to the methodology and its application in GLODERS allowed a discussion about mutual expectations and needs. For the stakeholders it was important to understand what might be needed to make GLODERS a success and what they could expect as a project outcome. For the consortium it was important to understand what stakeholders wanted and needed as results and what they were able and willing to contribute.

   Two following stakeholder meetings, after 12 and 24 months, respectively, presented intermittent modelling results to the stakeholder board to obtain feedback. Feedback received was on the identification of different relevant actors, the basic behaviours of these actors, the interplay of normative, legal and social aspects and the initial dynamics results of the models. These interim validations helped to keep the model development realistic and relevant.
3. Ensuring relevance: Relevance was indirectly ensured through the interim validation as mentioned above. Keeping a close eye on a realistic implementation made sure that the simulation focussed on understanding the target system, resisting shortcuts and simplistic operationalisations. The stakeholder meetings also had direct influence on the relevance as stakeholders questioned the applicability of the models directly. Two aspects are important in modelling, that the model is accurate and that the model is built with a purpose in mind. A model built for training police officers is very different from a model used for crime prediction.
4. Increase impact: Involving stakeholders in the modelling throughout the process does not only improve the model itself but also the dissemination of the model. The involvement ensures that stakeholders get the model they need and want, meaning they will be more likely to promote the model with colleagues and collaborating organisations. Transfer of academic research into the policy realm is not without hurdles. Involving practitioners will break down at least some of the hurdles although it will not be able to solve all (e.g. different time frames). Particularly the model of processes inside the criminal world was built in close collaboration and permanent contact with stakeholders and will be used in a practice setting to analyse extortion racketeering networks by providing a kind of virtual experience for the police. GLODERS also had a more formal way to engage stakeholders in the impact and dissemination through running a stakeholder training workshop in which practitioners were introduced to the final models with a focus on the practical aspects of model use and application.

Participatory modelling has many useful features for modelling research and GLODERS is a good case study for explicating the four listed above. Engagement with practitioners was written into the project in the form of the stakeholder board. Four formal stakeholder meetings took place, one kick-off meeting in which expertise and expectations were shared, two interim validation meetings and one training workshop. In addition to the formal interactions the consortium had regular contact with the relevant stakeholders throughout the project. In addition to the formal stakeholder board other practitioners were engaged, such as interviews with *Addio Pizzo* and *other civic organisations.* The interviews with civic organisations helped to understand how bottom-up resistance might be modelled and how it might affect both state actions (supporting law enforcement) and change in society (change of social norms).

The GLODERS models show how modelling can integrate a range of data sources, such as surveys, stylised facts, legal documents, narrative data and, last but not least, participant modelling.

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