TO SIN OR NOT TO SIN: STUDYING SOCIO-ECONOMIC IMPACTS OF RELIGIOUS AGENTS CHOICES

YULIA NELEPTCHENKO

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Abstract

This thesis investigates behavioural aspects of religious agents decision making when they believe to be punished for wrongdoing in the afterlife. In the thesis, a novel theoretical framework explaining the choices of sinning/non-sinning to be introduced, alongside with an empirical examination of a major religious event's impacts on observed behaviours of the faithful.

The theoretical framework aims to identify the circumstances under which agents optimally choose to succumb to temptation. Specifically, it aims to discover how the limitations of alternative resources can bound their choices and help rationalize sinning behaviours. A formal model of such preferences would explain the abundance of vice practices observed from a different point of view.

The empirical part of the thesis focuses on a major Catholic event that grants full remission of sins to Catholics. The research question in this part is: How does the forgiveness obtained during the event change the sinning patterns of Catholics? While the empirical part is not directly connected to the one-period model suggested, since the data examined are time series and longitudinal, possible inter-temporal extensions of the model could include specifications to capture the observed deviations in behavioural patterns. This is especially relevant in the time-proximity to the event when the afterlife punishment for committed sins is nullified.

The theory proposed belongs to the Behaviour Economics dual-self models of principal-agent class. Previous studies on an inner conflict resolution the only immediate tool that

could be used by the principal, or the planner, to control the agent, or the doer, is a cognitive resource of willpower. The theoretical model proposed in this thesis offers a new approach to solving principal-agent types of problems arising in a complex personality. In my model, the tool kit of the religious planner is expanded to include an alternative consumption of goods and leisure as instant self-control resources. The planner, as a controller of resources, can threaten, and execute the threat, to modify consumption of goods and leisure for the doer if she chooses to consume a third type of good called "sin". The resources to alter with are limited by the initial endowments available. The model is stated as an expected utility constrained maximization problem of the planner and bears three optimal solutions. The solutions are first-best, fully parametrized and corner. Based on the solutions obtained, all choices, of sinning and non-sinning, can be rationalized as a function of the parameters of the model.

The last chapter of the thesis will focus on investigating behavioural implications of the Catholic foremost religious event, called a Jubilee Year, on crimes levels. During the celebration, a massive remission of sins is offered to Catholics, raising an interesting question whether more, less or equal amount of crimes will be committed in the time-proximity to the event occurrence. The study to be conducted via two channels. The first path is to examine historical Italian time series data on crimes for a period during which a few Jubilee events were held. The second route is to perform a conditional analysis on a longitudinal data set on European countries criminal activities count, recorded around the Great Jubilee of 2000 celebration, where predominantly Catholic countries to be considered under the treatment of the event and the rest of the countries in the sample to serve as a control group.

The results of the empirical study on the event's impacts on crimes levels show that Catholics committed less crimes during the event celebration. In Italy, where a number of Jubilees were celebrated, a particularly interesting pattern of crimes behaviour around the event occurred.

Acknowledgements

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Writing the dual-self model presented in this dissertation required a PhD level knowledge of Behavioural Economics. I am grateful to Professor Yoram HaLevy from University of Toronto/Hebrew University of Jerusalem who enabled me a productive learning at his class and exposed me to the unique beauty of behavioural dual-self models.

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Finally, a word to my father, who recently passed. If you can see/hear me, now both of your children have a Doctorate, in addition to yours.

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Chapter 1

Literature Review

An ambiguous notion of self-control combines two, seemingly mutually exclusive, concepts. "Self" is a single entity, while "control" implies an existence of the controller and a controlled.[1] Nevertheless, the very idea of self-control is accepted by all and widely used, hinting that the "self" might not be perceived as monolithic as formally defined. However, to establish a subsistence of the imposed by the definition of "control" duality, and to model it in Economics, a further investigation of the human mind structure was required.

Naturally, modern neuroscience turned to investigate the enigma of the brain sub-systems, to detect their locations and trace their interactions. Earl K. Miller and Jonathan D. Cohen (2001) and Antoine Bechara (2005), among others, provided a glimpse of what happens inside the brain.

A. Bechara (2005) adopted a perception, that, in accordance with other neuroscientists, places the controller, or a far-sighted planner, in the prefrontal cortex, as the reflective system in charge of future gains and losses, and the controlled, or a myopic doer, in the amygdala, as an impulsive system accountable for the consumption of immediate pleasure and pain.[2] Figure 1.1 maps the precise locations of the two sub-systems in the brain.

The two sub-systems have both-ways interactions, i.e. sometimes the reflective system dictates her will, sometimes the impulsive does. The controller has a stock of a cognitive resource of willpower to override the hyperactivity of the impulsive system, but this resource is very limited and not always sufficient for the controller to prevail. Bechara (2005) discusses in detail the cognitive resources (willpower) of the planner and their restricted power, emphasizing the "survival of the fittest" as a pattern to determine the winner in the fight between impulsive consumption/non-consumption.[3] And the winner takes it all. To evaluate

[1] A famous quote by McIntosh (1969) states the same thought slightly different: "The idea of self-control is paradoxical unless it is assumed that the psyche contains more than one energy system, and that these energy systems have some degree of independence from each other."

[2] The main goal of his study was to suggest a neural framework that could explain myopic deeds, especially addictions.

[3] He mentions (on p. 1460) that "There might be more than one mechanism by which the reflective system exerts control over the impulsive system".

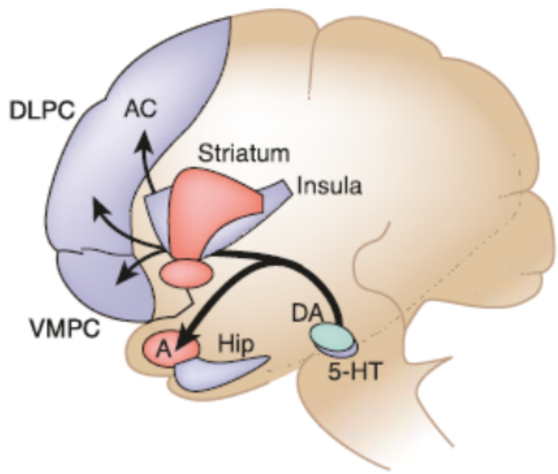

Figure 1.1: A schematic diagram illustrating key structures belonging to the impulsive system (red) and the reflective system (blue).
Source: Bechara (2005).

and compare different options, the choices of Bechara's agent are priced in neural "currency", a neuroscience analogy to Microeconomics pricing in terms of a numeraire good. Interestingly, he claims that the behaviour of a large group of individuals that succumbed to addictions matches the behaviour of patients suffering from VMPC (ventromedial prefrontal cortex) damage, as both groups were found to be over-sensitive to immediate rewards.[4]

On the contrary, E. K. Miller and J. D. Cohen (2001) argued that the prefrontal cortex complexity cannot be overestimated and that the mechanisms used by the prefrontal cortex to exercise control remain elusive. Its complexity is demonstrated by Figure 1.2.

After reviewing the results from neurophysiological, neurobiological, neuroimaging and computational studies, Miller and Cohen (2001) suggested a cognitive model of competing paths in the brain, where the winners are the ones with the strongest sources of support

[4]If true, this would make hundreds of millions of smokers/alcoholics/gamers, etc. all over the world seemingly "brain-damaged" individuals. Such claim is far-fetched and I hope to provide a non-neurological explanation to impulsive behaviours in the model to follow in the next chapter, where succumbing to temptation is a function of alternatives and the future consequences, rather than a brain malfunction.

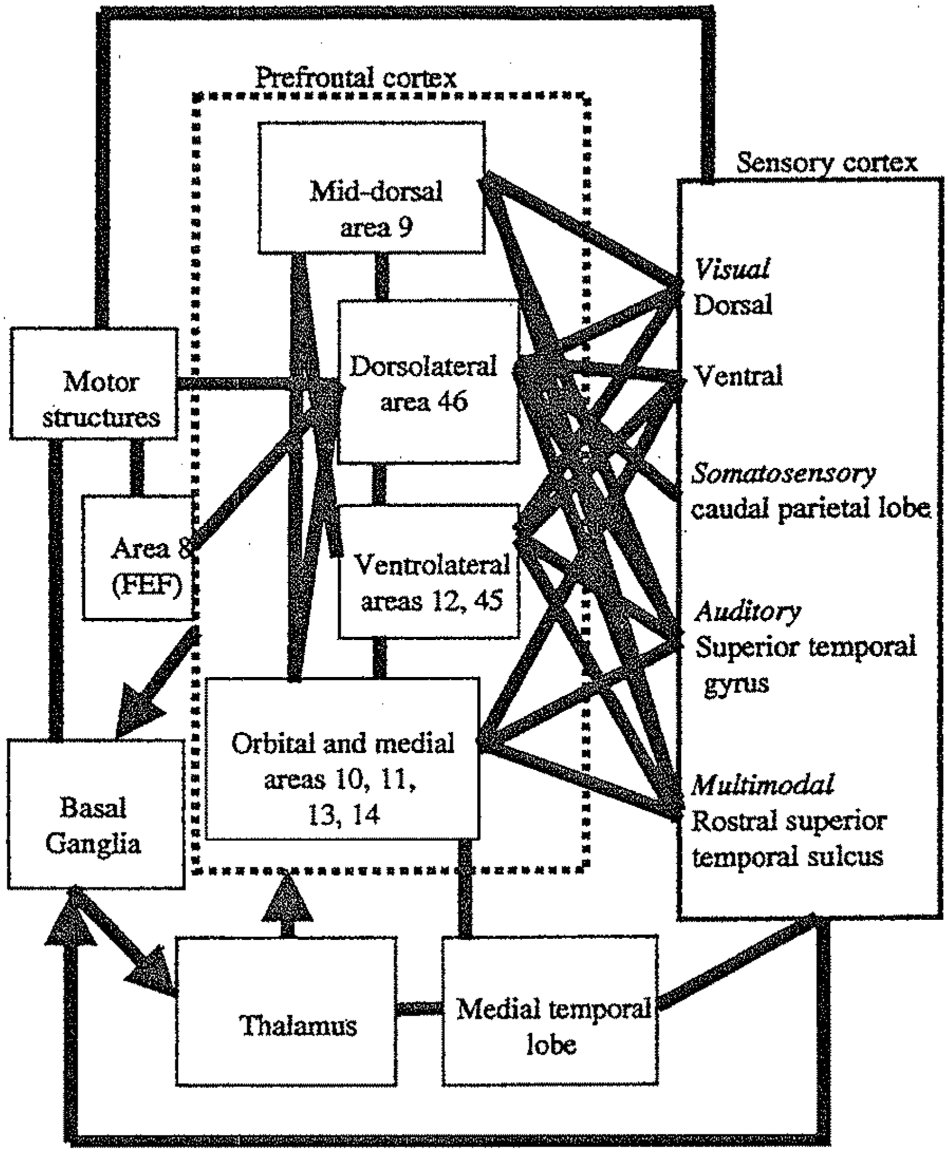

Figure 1.2: Prefrontal cortex and its connections.
Source: Miller and Cohen (2001).

and the dominated options are suppressed. In their model, when an opportunity for an impulsive deed (a cue) occurs, response units are activated, a fight happens and one unit wins.[5] The prefrontal cortex has a high capacity for multi-modality and integration, and

[5]They give an example of England, where we usually first look left and then right while crossing the

a high degree of flexibility. As such, the functionality of the prefrontal cortex, where the planner "resides", is described by Miller and Cohen (2001) as follows: "The function of the prefrontal cortex can be likened to that of switch operator in a system of railroad tracks. We can think of the brain as a set of tracks (pathways) connecting various origins (e.g. stimuli) to destinations (responses). The goal is to set the trains (activity carrying information) at each origin to their proper destination as efficiently as possible, avoiding any collisions. When the track is clear (i.e. train can get from its origin to destination without risk of running into others), then no intervention is needed (i.e., the behaviour can be carried out automatically and will not rely on the prefrontal cortex). However, if two trains must cross the same bit of track, then some coordination is needed to guide them safely to their destinations. Patterns of the prefrontal cortex activity can be thought of as a map that specifies which pattern of "tracks" is needed to solve the task." They further continue with how prefrontal cortex biases the flow of activities. Conflicts occur only when two trains are destined to cross the tracks at the same time, as in a co-activation of competing sets of units, and signal the need for additional control.[6]

Neurological studies confirmed what psychologists and economists already envisioned, the idea of "two minds".[7] The first modern dual-self models published were more conceptual/influential than providing precise solutions for the two selves conflict resolution. For instance, Thomas C. Schelling (1984) generally described the selves as the straight self and the wayward self, claiming that a consumer could have two, or even more, sets of values that alternate and are mutually exclusive.[8] Taking the next step toward a rationalization of

street, making a mistake. Prefrontal cortex's duty is to adjust the reaction to the situation, reminding the person of the best course of action given the surrounding conditions.

[6]On p.192 they add further: "Perplexing property of cognitive control is its severely limited capacity. The origins of this limitation are unknown."

[7]Early references on human mind duality go as far as Plato's Republic, Adam Smith's "passions" and "impartial spectator" and relatively recent Freud's id (pleasure principle) and ego (reality principle).

[8]Earlier short paper of Thomas C. Schelling (1978) already started to develop an idea of a person who behaves like two people.

the divided psyche behaviours, the dual-self models of Behavioural economics separated the mind into two entities in disagreement and started to formalize their interactions. In order to do so, Behavioural theorists built a variety of frameworks based on distinctive underlying characteristics of the selves and the discords to be ended, i.e. what types of conflict the two selves resolve and what means they have to fight for their course. The three types of conflict modelled in the literature are temporal, incentive salience and asymmetric information, while the resources in hand are cognitive.

First of all, one of the selves in the models lives many periods and maximizes her utility over a long (or infinite) horizon. Consequently, she is defined as a long-run self or a far-sighted planner, as she needs to plan the optimal consumption allocations for all periods of her existence. On the contrary, the other self exists over a shorter horizon or even only one period of time. As such, he is called a short-run self or a myopic doer. He maximizes utility over his transitory lifetime. It is worth noting that the very difference in life expectancy between the selves automatically implies distinctive optimal solutions for the utility maximization problem they face, *ceteris paribus.*

An example of a purely temporal conflict is the model by George Ainslie and Nick Haslam (1992), who viewed the selves as "interests", which dominate each other as long as their discounted utility curve rises above the competitor's one(s). Figure 1.3 below provides an example of such a person who goes to bed too late, as her short-run interest's discounted utility exceeds in value the discounted utility of the "on-time sleeper" exactly when the time to rest comes. This model is special in a sense that it allows for the maintenance of the hierarchy of higher long-run interest over lower short-run one together with an ascendancy of the short-run interest for extended periods of time. In terms of the example they provided, this would mean that a person could find herself going late to bed for many consecutive nights. Nonetheless, this model is based solely on time preferences of the utility functions, and their parameters, of the two selves, and does not consider a case where the short-run

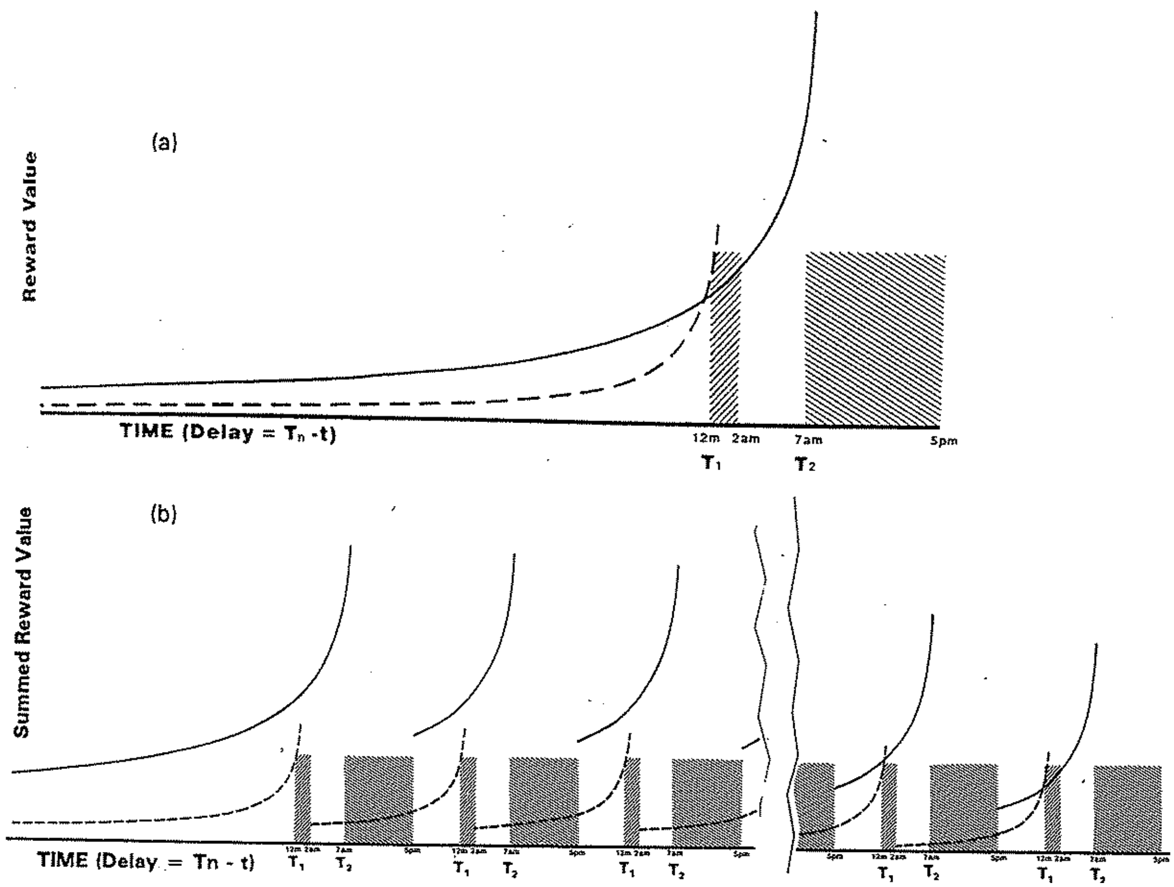

Figure 1.3: Hyperbolic curves of the discounted value of staying up for two hours at midnight versus going to bed and feeling rested until the end of the next workday, one pair of rewards and ten pairs.
Source: Ainslie and Haslam (1992).

self lives only one period of time and is not allowed to have any time preference by construction.

Another type of controversy proposed in the literature is an incentive salience conflict, which arises when the two selves find a good diversely tempting, i.e. they attach unique subjective weights to the utility component of the same good. A dual-self model of "Animal spirits", related to this matter, was formulated by George Loewenstein and Ted O'Donoghue (2004). In their framework, a deliberative system has a goal-based long-term perspective, while the affective system is the emotional/motivational one. The drives of the affective system include, but not limited to, anger, fear, hunger and sex. The intensities of the drives, or stimuli, determine the level of the affective system activation, relative to the deliberate one. Figure 1.4 below illustrates their approach.

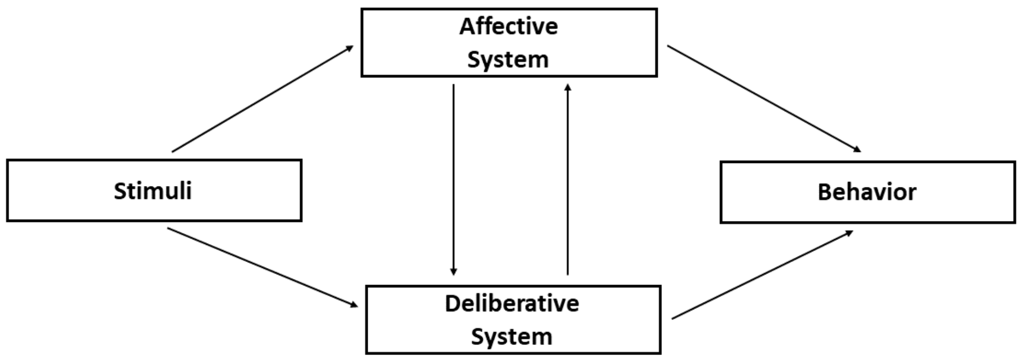

Figure 1.4: Two-system approach.
Source: Loewenstein and O'Donoghue (2004).

None of their systems has a complete control. The affective system holds a primary control of behaviour, but the deliberative system can distort the potentially impulsive choices by exercising willpower, or at least to attempt to distort. By doing so, the deliberative system overrides, fully or partially, the affective responses. They have applied the model to a static setting, different time preferences frameworks, risk preferences and social preferences. The latter addressed a case where the deliberative system is driven by moral and ethical principles and deviates from a pure self-interest.[9]

[9]In particular, they have discussed the importance of willpower limitations as a resource and suggested that poor people are more prone to engage in risky behaviours because they have to exercise the willpower constantly, as the low initial endowment of wealth is forcing them to forgo enticing purchases. For the unfortunate, living within their means exhausts the willpower cognitive resource to a point that they simply cannot resist inexpensive temptations. In the model to be presented in Chapter II, an alternative explanation

Alternatively, Gordon C. Winston (1980) offered a model of a compulsive consumption, where two minds, wanting to consume and wanting to avoid consumption, coexist simultaneously. His myopic mind has "flip-flop preferences", which allow him to change his attitude toward a certain good over his short reference period of time, while the long-run self has one set of preferences stable over her longer existence period. The sudden change of tastes, when happens, causes the incentive salience conflict. To resolve it, Winston (1980) suggested a few strategies to manipulate the shadow price of the addictive/tempting good. Out of Winston's (1980) results, the most remarkable is the conclusion about the possible welfare superiority of hedonistic choice over the long horizon expected utility maximization, claiming that exercising self-control is not always optimal, even when possible. Consequently, under some circumstances, the invoking of self-control might actually reduce consumer's welfare. In other words, hedonism pays.[10]

A third type of intra-personal conflict discussed in the behavioural literature is an asymmetric information conflict. This type of conflict occurs when one of the selves holds a private information the other self does not possess. Ronit Bodner and Drazen Prelec (2003) introduced a one-period model of self-signalling where the "gut" has a private information about person's preferences to consume addictive good the "mind" is not aware of, and can transfer this information to the "mind" by signalling. An overall utility of a person from consuming a good is a linear-separable combination of two parts with different weights attached: an outcome utility of natural impulses and a diagnostic utility of the "perfect choice". The weights, in turn, determine what choice is more likely to be made. If the person believes in a positive upshot resulting from her diagnostic choice, and chooses accordingly, an abstaining equilibrium occurs. Otherwise, a person with a pessimistic image of herself is likely to find

for the impact of the low initial endowment of wealth on impulsive choices is suggested.

[10]His idea of complicating the short-run self with two sets of preferences did not find many supporters within the next generation of the dual-self theorists, as a conflict resolution between the two selves, each one with a single set of preferences, but different time horizons, attitudes toward goods and resources in hand, found to be complex enough already.

herself in an equilibrium of high consumption, related to the outcome utility component. The "gut" can impact the choices by boosting the self-esteem of the person with an injection of a "moral placebo", a self-signalling process. The increased optimism will tip the scales toward the diagnostic choice. Bodner and Prelec's (2003) model is special in a sense that the "gut" has the ability to endogenously manipulate the choice, at least to some extent.

In reality, all the three types of the conflicts mentioned earlier could occur simultaneously, or at least two out of three. Isabelle Brocas and Juan D. Carrillo (2008) published an extensive multi-period multi-action model where they considered what empirical phenomena could be explained by combinations of different conflicts between the two selves and their resolutions. According to their results, an asymmetric information conflict, combined with the temporal horizon, forces the planner, as an uninformed self, to ordain a positive bond between consumption and labour each period, i.e. there is a covariance between effort and consumption. They further derived that the present-biased consumption observed is a by-product of this two conflicts combination. Alternatively, when the asymmetric information is coupled with the incentive salience, the optimal strategy of the planner is to set a consumption limit as a rule. Interestingly, the solutions they have proposed heavily rely on a presence of the asymmetric information, which is seen as a physiological constraint on the flow of the information between distinctive segments of the brain.[11] Consequently, they did not consider a mix of the temporal horizon with the incentive salience.

Another fruitful stream of the multiple-self models investigated the means the planner and the doer could use to obtain their desired outcome.[12] Of particular interest are the measures a planner would adopt in advance in order to distort future potential choices and ways to resist immediate temptation, succumbing to which would harm her optimal planning allocation. The former include, but not limited to, commitment devices, mental accounting,

[11]They have provided some neurological evidence for a limited connectivity between different parts of the brain.

[12]In all the models, except one I review later, the planner has resources while the doer has none.

mental rules, and more. The latter is related to the only cognitive resource studied by the literature, a willpower.[13]

Richard H. Thaler and Hersh M. Shefrin, in their seminal paper "An Economic theory of self-control" from 1981, suggested that the conflict resolution between a myopic doer and a farsighted planner should be drawn upon a principal-agent theory, viewing the doer as a manager in a firm and the planner as an owner.[14] In this intra-personal agency, the planner can exercise control over the doer by imposing rules/constraints or directly altering the doer's utility function in a fashion very similar to a business operation. Table 1.1 summarizes the techniques that could be used for control, by a firm and by a divided self.[15]

A few years later, in 1988, Hersh M. Shefrin and Richard H. Thaler published another influential paper, "The behavioural life-cycle hypotheses", connecting their previous paper to a life-cycle theory and permanent income hypotheses.[16] In a dual-self framework, they have endowed the planner with three major tools to control the doer and/or alternate his choices: mental accounting, framing and cognitive self-control (willpower). Mental accounting is a practical method of labelling all the wealth in advance as belonging to one of the three categories: a current income, current assets and a future income. After the labelling, the funds allocated to each category become non-fungible. The current income is assumed to be the most tempting to be consumed by the doer, while the future income is the least tempting. The doer has a usual concave utility function with a marginal diminishing utility and is interested to consume as much as he can. However, after consuming all current income, he is subjected to a fixed dis-utility penalty applied to the consumption of the first unit of current assets, imposed by the planner. The same procedure applies to the first unit

[13]In the model proposed in Chapter II additional resources of alternative consumption and leisure will be introduced.

[14]Richard Thaler won a Nobel Prize in Economics in 2017, for his remarkable contribution to Behavioural Economics field, in particular to research of limited rationality, social preferences and lack of self-control.

[15]This table is extracted from an earlier and more extensive version of Thaler and Shefrin (1981), a NBER working paper from 1978.

[16]Modigliani and Brumberg (1954) and Friedman (1957), respectively.

Table 1.1: Summary of Control Techniques for Organizations and Individuals.
Source: Shefrin and Thaler (1978).

Category	**Illustrations from Bank Analogy**	**Illustrations from Individual Behaviour**
Pure Discretion	• Employee make decisions using interview and credit scoring program as he sees fit	• Unconstrained doer maximization
Methods to Alter Incentives	• Check employee decisions through random sampling and reinterviews • Make the loan department a profit center • Moral Suasion - profit sharing	• Self-monitoring - Weight Watchers • External incentive alteration - Antibuse - Agreeing to give paper at a conference • Internal devices - private side bets - saving for its own sake
Pure Rules	• Use credit scoring program exclusively	• Externally Enforced Rules - Precommitment - pension plans as exclusive form of saving - fat farms
Partial Rules	• Employee discretion over a limited range of credit scores • Employee discretion over a limited domain of decisions	• Rules-of-Thumb - no borrowing - no dissaving - savings plan • Opportunity Manipulation - not using credit cards - keeping an empty refrigerator

consumed from the future income. Figure 1.5 illustrates this mechanism. The mental accounting mechanism presented below is executed using external and internal rules. The former is related to delegating the reallocation of wealth into different accounts by an

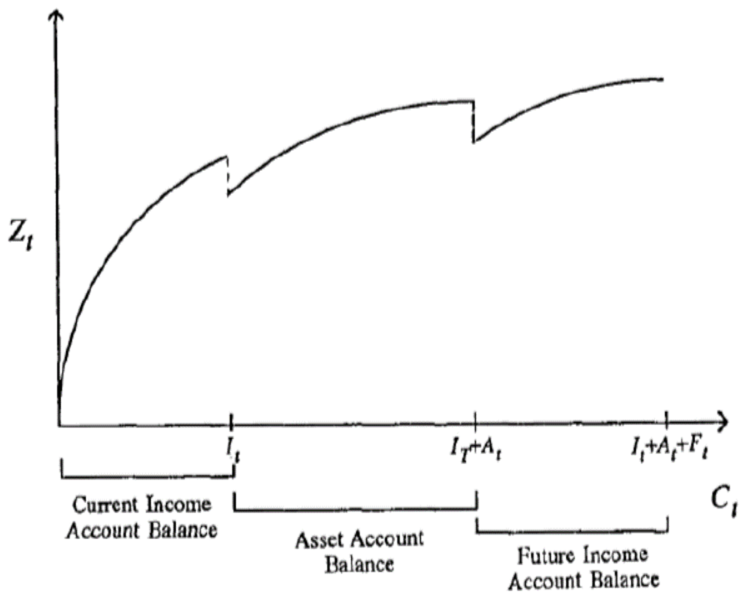

Figure 1.5: Doer's utility, Z_t, under mental accounting.
Source: Shefrin and Thaler (1988).

external agency, such as pension plan, while the latter is self-enforced and requires more willpower, when the time comes to execute the mental rule. An example of the internally enforced rule is a predetermined rule-of-thumb. As internal rules are more costly in terms of willpower efforts, they are considered, by Shefrin and Thaler (1988), a second-best, in comparison to the external rules. Framing describes a situation where the same amounts of wealth, "framed" differently, would have a distinctive marginal propensity to consume. For instance, a lump-sum bonus could be treated differently than a regular labour income, even if this bonus was fully anticipated and both sums belong to the same mental account of current income.

A theme of predetermined internal rules and their importance in decision making was emphasized once again by Jess Benhabib and Alberto Bisin (2005), from a different point of view. Their approach is close in essence to a neurological study of Miller and Cohen (2001), where the prefrontal cortex has the ability to alternate the paths of decision making.[17] In particular, they distinguish between two processes that can be invoked by the agent: an automatic and an alternative. An automatic process is the one that is susceptible to impulses and temptations, while the control process is a fully immune one. Figure 1.6 provides a schematic representation for their agent's decision making process at time 0 versus time t.

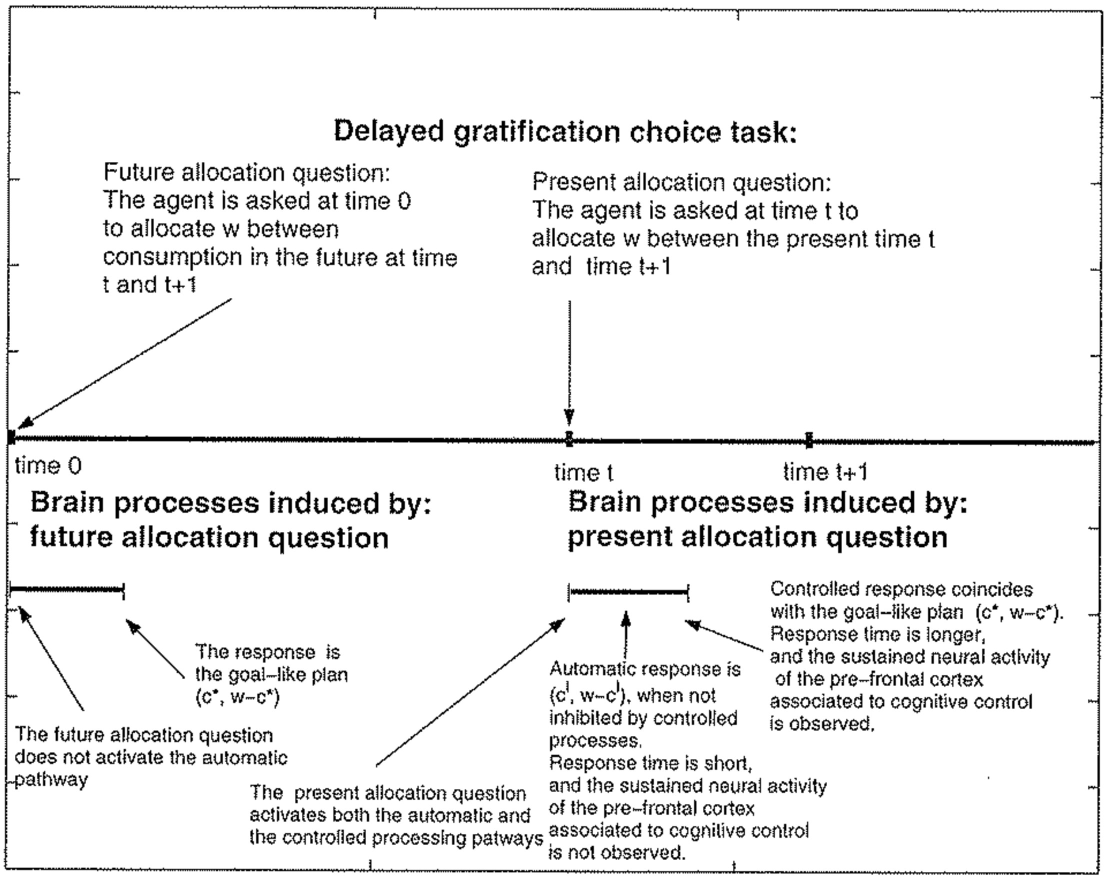

Figure 1.6: Delayed gratification: timeline.
Source: Benhabib and Bisin (2005).

As stated by the model, at time t, an automatic process allows the consumption to proceed freely as long as a predetermined level of "over-spending", or a "cut-off" threshold, is not reached. On the contrary, when an overspending occurs, an internal alarm sounds and

[17]Reviewed previously.

the alternative, or control, process takes the dominating role. After coming to power, the alternative process stops the overconsumption.[18] As the automation design proposed is relatively simple and of low/zero cognitive cost, they further conclude that only when her prefrontal cortex is damaged will an individual exercise no self-control.[19]

In reality, an "automatic pilot" consumption, that always follows the well-defined predetermined rules, is not observed empirically. The self-control bears a "feeling of effort" and many times the cognitive costs required to resist temptation are excessive to endure for the agent. Recognizing this difficulty, another stream of multiple-self models turned to study the cognitive costs of self-control.

Drew Fudenberg and David K. Levine published a few dual-self models. In Fudenberg and Levine (2006), they have defined the conflict between the planner, or the long-run self, and the doer, or the short-run self, as a simple one stage game, where the long-run self makes the first move, and the short-run self plays the best response. If this game to be extended to many periods, the long-run self would play against a sequence of the short-run selves. Remarkably, this relatively simple structure allowed to establish an equivalence of the subgame perfect (SR-perfect) Nash equilibrium and a reduced form optimization problem of the planner. After formally stating the optimization problem, Fudenberg and Levine (2006) applied it to a range of behavioural phenomena studied by other researchers, using specific functional forms common to such problems and adding the cognitive costs to the equations. In particular, they have investigated savings, procrastination and banking/"pocket cash" rationing.

At first, the cognitive costs were modelled as linear, reflecting the perception that the cognitive center of an agent has a fixed amount of resources, that could be used to resist

[18] It is worth noting that this model does not formally belong to the dual-self literature, but the two processes invoked by the prefrontal cortex resemble very much a pure discretion consumption by the doer and the internal rules imposed by the planner, mentioned in Thaler and Shefrin (1981) and Shefrin and Thaler (1988).

[19] See Note 4 here on this matter related to Behchara's (2005) study.

temptation in a constant proportion to the short-run self forgone utility increase. This, in turn, would make the self-control infeasible when the doer's utility is too high to control. To circumvent this difficulty, convex cognitive costs where proposed by Fudenberg and Levine (2006) instead of linear, i.e. there is no fixed limit of willpower an agent can exercise, but the costs of cognitive control increase marginally with each unit of forgone utility of the short-run self to be resisted. The very idea of possible non-linearity of self-control costs is highly related to experimental observations which showed that the individuals' ability to resist temptation declines in the presence of other, attention demanding, tasks, even when this additional cognitive load is completely unrelated to the temptation in question, or any temptation at all. This idea was illustrated by experimental studies results of Baba Shiv and Alexander Fedorikhin (1999) and Andrew Ward and Traci Mann (2000), where an additional cognitive load found to be an ally of the short-run self, as depleting the long-run self's cognitive tools available to combat impulsivity.

In Shiv and Fedorikhin (1999), two carefully designed experiments were conducted in order to study the impacts of the additional cognitive load on the ability to fight temptation. In each experimental set-up, the researches intentionally created a burden of distinctive intensity on the cognitions of two groups of subjects and right after let the respondents make a choice between tempting and non-tempting good. Specifically, the subjects were asked to memorize numbers of different lengths, a two-digit number in one group or a seven-digit number in another group. The hypothesis in focus was to check if the two-digit number respondents will have more cognitive resources left available after memorization to resist consumption of a tempting good; that is, if the two-digit number respondents are in a high-processing resources condition, in comparison to the seven-digit number subjects who would have less cognitive resources remaining and so to be found in a low-processing resources condition. The very purpose of the numbers to remember was to manipulate the remaining processing resources stock. Prior to the start of the experiments, the subjects were told that the goal of the experiments is to investigate the impacts of environment changes on memory performance, i.e. memorizing and remembering the number given correctly is important. They were also informed that some snacks will be offered during the procedure.

In experiment 1, the number to memorize was briefly shown, then the subjects were offered a binary choice between a chocolate cake and a fruit salad. The chocolate cake represented a good superior in affective dimension (tempting) and inferior in the cognitive one, and the fruit salad vice versa (non-tempting). Each person could have only one dessert. After choosing, the subjects had to go to another room to report their memorized number and the choice of dessert. In addition, in one version of the experiment, the cake and the salad were real, while in another they were replaced with their pictures, in order to see if the temptation is greater when the representation of the tempting good is real versus symbolic. In the experiment with the desserts pictures, the subjects collected the chosen dessert in the second room. At the end of the experiment, the respondents were asked to explain their choice of dessert. The explanations provided were coded into a single variable of Decision Basis, measuring impulsivity (heart versus mind motivations and the like) on a scale from one to seven.[20] The results of experiment 1 are summarized in Figure 1.7 on the next page. As shown in the figure under the symbolic representation of the goods, almost the same percentage of the subjects chose the cake, in both groups; that is, the amount of cognitive load did not impact much the choices made when the goods were not physically present. Consistent with the choices observed, the average "impulsiveness" of the decision making remained relatively stable, in both groups, when only the pictures were shown. On the contrary, the presence of the cake and the salad made it difficult for the high cognitive load/low availability of processing resources group to resist the cake.

[20]Where seven is the most impulsive.

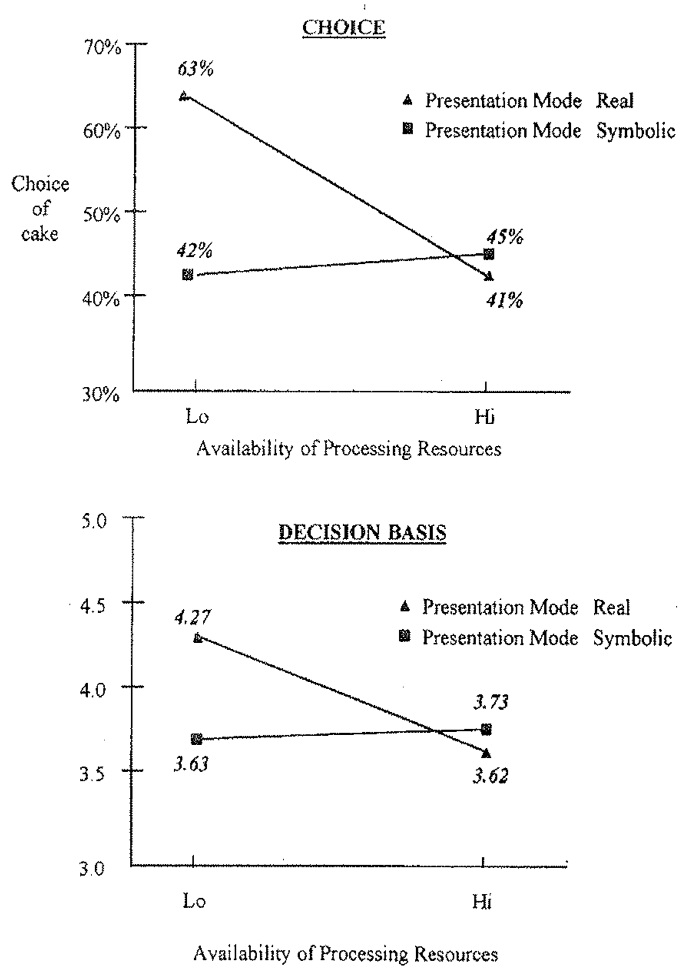

Figure 1.7: Experiment 1 - Choice and decision basis as a function of processing resources and presentation mode.
Source: Shiv and Fedorikhin (1999).

In experiment 2 the procedure was similar to the experiment 1 with the real representation of the goods. However, the subjects had to also testify about their own overall level of perceived impulsiveness, by answering a specific question about it after the experiment was over. Based on the answers, the subjects were dichotomized to "impulsives" and "prudents" and the experiment outcomes grouped accordingly. Figure 1.8 on the next page illustrates the results of experiment 2.

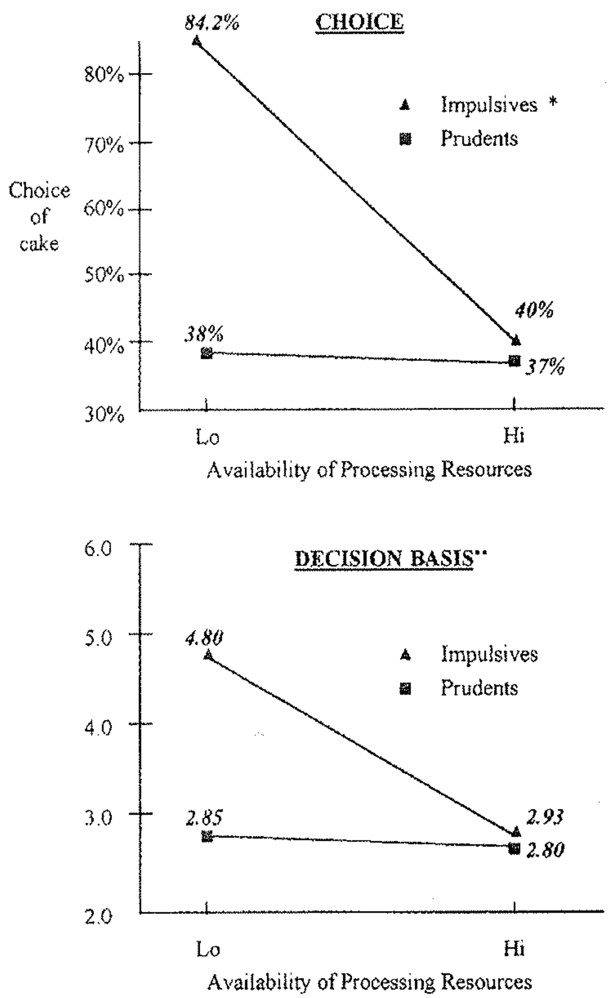

Figure 1.8: Experiment 2 - Choice and decision basis as a function of processing resources and consumer impulsivity.
Source: Shiv and Fedorikhin (1999).

The up-shots of experiment 2 were similar to the results of experiment 1. Moreover, the "prudents" performed almost equally well under both cognitive loads, while the "impulsives" decision making process was highly impacted by the length of the number given to memorize.

Another look at the same problem in an experimental setting was offered by Traci Mann and Andrew Ward (2000). They have studied the impacts of cognitive load on restrained/unrestrained eaters. Unlike in Shiv and Fedorikhin's (1999) paper, the participants "carried" the predetermined condition of being dieting/non-dieting prior to the study, and were asked about their eating habits a few weeks in advance. For the experiment itself, the subjects were assigned into two groups: low cognitive load and high cognitive load tasks, and told that during the session they will be offered some pleasant-tasting food. Both groups included restricted and unrestricted eaters. The high cognitive load task group had to memorize art slides for later recognition test, while the low cognitive load task group were given simple performance assignments. The subjects were also requested to keep in mind their reaction time. During the experiment, each participant had on the table carefully pre-weighted Doritos, candies and chocolate chips cookies, all high-calorie foods. Summarized results of the experiment are shown in Figure 1.9.[21]

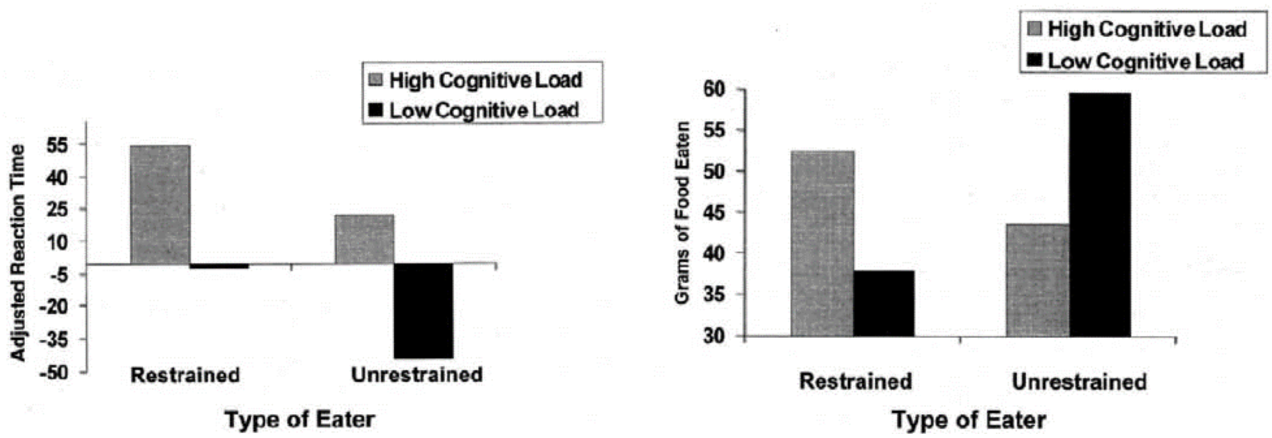

Figure 1.9: Left panel - Mean adjusted reaction time (milliseconds) as a function of restraint status of eater and cognitive load condition. Right panel - Mean amount of food eaten (grams) as a function of restraint status of eater and cognitive-load condition.
Source: Ward and Mann (2000).

The left panel of the figure suggests that the average reaction time of the restrained eaters was elevated under both loads, in comparison to the unrestrained eaters. The right panel shows that the mean amount of food consumed by the participants was higher for the restrained

[21]Mann and Ward (2000) have also conducted another similar experiment, where the high cognitive load group had an additional word-fragment completion task right after the art slides, to emphasize the rebound from food related thoughts under an easier task. In addition, near the end of the study the subjects were asked to estimate how much food they had eaten. The purpose of the last question was to awaken the self-awareness.

eaters under the high cognitive load, but lower for the unrestrained ones. For the restrained eaters, the high cognitive load had a dis-inhibition effect on eating, effectively weakening the participants' ability to resist the consumption of the tasty high-calorie foods.

The results from both experimental studies, by Shiv and Fedorikhin (1999) and by Mann and Ward (2000), indicated that the limited resources used for self-control are shared with other domains that require cognitive resources. A reallocation of such mental resources from self-control to other attention/effort demanding tasks significantly diminishes the subjects' capability to fight temptations.

The evidence collected by the experimental studies strengthened the perception that the cognitive self-control costs are convex, as opposed to linear. Drew Fudenberg and David K. Levine (2011) continued to enrich their original model from 2006, where the planner had convex costs of (the other self) self-control. They have applied the model to real and experimental data from selected behavioural studies, in order to investigate if the model fits empirical findings.[22] The results obtained were two-fold. On the one hand, the calibration of the model allowed an observer to estimate parameters and separate features related to the planner's preferences from those of the doer. The doer's lifetime horizon was found to equal one day and his preferences embedded a risk aversion coefficient of around two. As for the planner, her subjective interest rate was allowed to vary between one percent to seven percent annually. On the other hand, the dual-self framework with quadratic costs of self-control offered an alternative explanation to a few well-known behavioural paradoxes, e.g. Allais paradox and an unstable interaction between risk and delay.

The next step Fudenberg and Levine (2012) have taken was to intentionally modify a few underlying characteristics of the two selves preferences. The lifetime horizon of the doer

[22]In this paper, they have used a quadratic functional form for the costs of self-control. The preferences of the planner were modelled in four specifications, solutions for which can be found in the appendices. The cases included: a general case of nested utility and durable consumption, nested CES/log, a base case of non-nested utility without durable consumption and the base case with logarithmic utility.

was extended by including periods of "no-action" in a multi-period model. As a result, the short-run self became a shorter-run self, who is less myopic than the one-period-lasting short-run self. His myopy was mitigated by a lengthy lifetime, that compelled him to smooth consumption over longer period of time. As for the far-sighted planner's self-control, a limited willpower variable was created to represent the cognitive self-control resources. The stock of this variable available each period was defined as a function of recent past executions of self-control and its' replenishment assumed to be linear over time, i.e. each period the same fraction of willpower is renewed/re-endowed.

Last but not least, in the sub-stream of dual-self models initiated by Fudenberg and Levine (2006), is a paper by Drew Fudenberg, David K. Levine and Zacharias Maniadis (2014). They have employed a basic version of the convex costs dual-self model for an application on choice under risk. In a simple lottery setting with three outcomes, they have generated the famous "fanning-out" indifference curves inside the Marschak-Machina triangle using a "divided-self" framework. Overall, the convex cognitive costs models of Fudenberg et. (.al) (2006, 2011, 2012, 2014) were found to have an explanatory power on many behavioural phenomena previously interpreted by the "united-self" frameworks only.

Another recent work, closely related to the convex costs dual-self models, continued Fudenberg and Levine's (2012) way of thinking about the cognitive self-control resources as confined, depletable and renewable. Emre Ozdenhoren, Stephen W. Salant and Dan Silverman (2012) have introduced a model where a consumer with a limited willpower endowment had to eat a cake over time. As the optimal consumption planning implementation requires a self-restraint, the agent has to exercise willpower, in order to avoid over-consumption during one period which would lead to under-consumption over future period(s). At the same time, their agent faces other visceral urges she needs to resist.[23] The self-regulation resource,

[23]This paper does not formally include a short-run self definition, but these urges are conceptually similar to the impulsiveness of the short-run self found in the dual-self models.

willpower, is of limited supply and common to a few domains. To control the other urges, the agent then reallocates willpower from eating the cake optimally to resisting other urges. By doing so, she intentionally reduces the willpower amount left for controlling the cake-eating and diverges from the perfect consumption smoothing. Such behaviour is rationalized by Ozdenhoren, Salant and Silverman (2012), and their consumer is found (almost always) better off deviating from the initial cake-eating consumption plan. Although the same willpower resource could be used by the agent to optimally control eating the cake and/or to resist visceral urges in their model example, it could also be defined as mega-domain-specific, i.g. a person could be observed as a very hard working (never procrastinating) *and* overeating.

In terms of the agent's ability to regenerate the willpower stock over time, Ozdenhoren, Salant and Silverman (2012) suggested that exercising self-control frequently would lead the agent to build more willpower capacity for the future, i.e. willpower resembles a muscle that depletes after exhaustion, but also recovers and becomes stronger time after time.

The last model to be reviewed in this short literature summary is a two-period dual-self model by Benabou and Pycia (2002). This model is unique in a sense that it adopts the general planner-doer structure proposed by Thaler and Shefrin (1981), but not their hierarchical principal-agent interpretation of the relationship between the two selves. Instead, they endow both selves with resources, such as energy, Freudian libido, nervous impulses, etc., to fight for their course. Consequently, the conflict between the two selves turns to be similar to a full scale social/political conflict or a costly influence/lobbying game. The outcome of this game is determined by the amount of resources each self sacrificed in the fight, allowing to fully rationalize succumbing to temptation in a case that the short-run self invested more resources.

In this concise literature review, an evolution of dual-self models was presented, along with a few selected neurological and experimental studies related to the topic. As shown, the literature have developed a variety of fruitful research directions, such as types of the conflicts to be resolved between the two selves, hierarchical structures, self-control tools and techniques, applications of the dual-self models to various behavioural phenomena, and more. Of particular interest was a cognitive resource of willpower, as the only tool available for the planner to resist an immediate temptation.

In the next chapter an additional dual-self model will be proposed. Similar to Shefrin and Thaler's (1981) framework that was based on the principal-agent theory, the far-sighted planner will be the one to control resources. However, in the proposed model, the conflict resolution between the selves is reached by using resources of alternative consumption and leisure, and not a cognitive resource of willpower, as in other multiple-self models.

Chapter 2

A dual-self model of religious preferences

2.1 Introduction

The model developed in this chapter suggests a simple one-period, "time-freezing" dual-self framework, in which a religious long-run self (or a far-sighted planner) and a short-run self (or a myopic doer), interact. In the model, the planner has control over resources of wealth and leisure endowed for the period and entitled, as a controller, to make a decision about these resources allocation, for both selves.[1] During the period, an opportunity to consume a third type of good called "sin" occurs. The religious long-run self dislikes the consumption of sin, as she believes in the afterlife punishment for the wrong-doing, while the short-run self enjoys consumption of everything, including sin. The planner then uses her authoritarian mandate over consumption and leisure resources available as a tool to deter sinning, by threatening the short-run self to alter the consumption of goods and leisure for the period in the case of sinning.

The planner's conundrum is to choose an optimal allocation of wealth and leisure, that will be effective as a threat, in order to obtain the desired outcome of sin avoidance. On the other hand, the amount of the resources endowed is limited. In the model proposed, the planner's optimal choice dilemma is stated as a constrained expected utility maximization problem and bears three first-best fully-parametrized corner optimal solutions, where the parameters include the initial endowment of wealth, the price of afterlife punishment for sin to be paid and the joy derived from sinning by the doer.

The three optimal solutions arising allow rationalization of all the choices observed in real-life settings, of sinning and non-sinning. By the solutions of the model, a relatively rich planner, who owns enough resources to offer the doer an adequate alternative consumption of goods in the case of non-sinning, will effectively deter sinning. A less wealthy, but fearing the future punishment for sin, long-run self, will use a reduction of leisure as a threatening

[1] Structurally, this model would fit into a class of dual-self principal-agent frameworks, formally initiated by Thaler and Shefrin (1981) and Shefrin and Thaler (1988).

tool and avoid sinning as well. A relatively poor planner, who believes in mild afterlife punishment for sin, will optimally succumb to temptation and consume all the sin offered.

There are few potential channels the model could contribute to the Behavioural Economics literature. Firstly, the existent dual-self models consider only a cognitive resource of willpower as a tool available for the long-run self to combat an immediate temptation to sin. In all the models studied willpower as a mechanism for self-control, its severe limitations as a cognitive resource are emphasized. So far, the very option of non-cognitive self-control was not formally introduced in the dual-self literature, with the exclusion of the costly commitment devices that had to be adopted by the planner in a period preceding the occurrence of temptation to sin. The model proposed in this chapter expands the tool kit of the planner to include resources of wealth and leisure for instant self-control. By doing so, it directly connects the lower initial endowment of wealth with more sins committed, as sinning found to be optimal by the model only when the initial endowment of wealth is insufficient.

Secondly, one of the optimal solutions obtained rationalizes the choice of sinning, under a well-defined combination of parameters. Furthermore, as all the optimal allocations predicted by the model are corner, or "all-or-nothing", allocations, in terms of consumption of all the goods, including sin, the optimal solutions obtained fit precisely a behavioural phenomenon called a "bi-modal equilibrium". Such bi-modality is hard to rationalize, especially as first-best solution(s).

Last but not least, the model suggested could be equally applied to any damaging in the future consumption of goods or behaviour, with no adjustments required, as long as the long-run self expects to pay the price for wrong-doing and the short-run self does not. An incentive salience conflict between the two selves toward a good called "sin", modelled in a one-period framework, allows to isolate the impacts of such a conflict on optimal choices from inter-temporal preferences of the long-run self and/or the necessity to make an asymmetric information assumption.[2]

The chapter is organized as follows. The next section describes the model. Section 2.3 formally presents the optimal choices of the planner under different parameters combinations. Concluding remarks are provided in Section 2.4. Technical aspects of the model's solutions are detailed in the Appendix A.

2.2 The Model

I consider a simple one period dual-self model in which the human mind hosts two separate entities: a long-run self (she) and a short-run self (he). The long-run self physically lives a finite continuum of n periods of the one-period model presented here and believes in after life. The short-run self existence is limited to one period of time. Following Thaler and Shefrin (1981) and Shefrin and Thaler (1988), inter alios, principal-agent dual-self approach, the long-run self is a far-sighted planner and the short-run self is a myopic doer. As a planner, the long-run self is the decision maker. At the beginning of the period, she makes a decision about an allocation of two available resources: consumption and leisure, for both selves. The short-run self depends on the decision made by the planner and has no direct impact on how the decision is made. Furthermore, the short-run self does not own any resources at his disposal. In terms of preferences, both selves enjoy consumption of goods and leisure. In addition, the short-run self can increase his private utility by consuming a good called "sin". For simplicity and without loss of generality, the opportunity to sin occurs only once during the time period modelled here. Contrary to the short-run self, the long-run self does not derive joy from sinning, as she believes to be penalized for the wrong-doing at the entrance to the afterlife stage. Such penalty, when imposed, would reduce the well-being in the afterlife, at least for some period of time. To formalize the polarized approaches in preferences of the

[2] To the best of my knowledge, this model is the first presenting the dual-self incentive salience conflict solely.

two selves toward sinning, a following assumption is made.

ASSUMPTION 1: *Sin is a good for the short-run self, and a bad, negative asset for the long-run self.*

Assumption 1 implies that while the short-run self would derive utility from sin consumption, the long-run self would suffer dis-utility, making a consumption of sin an extreme case of an incentive salience conflict between the two selves. Such conflict arises over consumption of sin only, as over consumption of goods and leisure the preferences of both selves align. When an opportunity to sin occurs, the long-run self contracts the short-run self in order to prevent sinning. As the controller of the resources, she can threaten, and execute the threat, to restrict the short-run self consumption of goods and/or leisure in the case of sinning. As a result of such threat execution, if happened, the utility from consumption of goods and/or leisure for both selves would change.

I now consider a formal model of the planner's preferences, in a linear-uniform functional form. In the absence of sinning, the utility function of the long-run self is given by a linear-separable function $U^{Sin=0}_{Long-run\ self} = x + 1$, where x is a consumption of goods satisfying $0 \leqslant x \leqslant c$, and c is the initial endowment of wealth the agent obtains every period by working (or from any other source of income). After the working hours are subtracted, the rest of the period is spent in leisure. The utility from all units of leisure available is normalized to equal to one. Stating the long-run self utility function in the case of non-sinning as $U^{Sin=0}_{Long-run\ self} = x + 1$, relies implicitly on Assumption 2.

ASSUMPTION 2: *It is always optimal for the long-run self to consume all the leisure hours available in the case of non-sinning.*

In the case of no sinning, the utility of the long-run self equals the utility of the short-run self: $U^{Sin=0}_{Long-run\ self} = U^{Sin=0}_{Short-run\ self} = x+1$. The controversy between the two selves develops only when an opportunity to sin arises. At this stage, the long-run self offers the short-run self a contingent contract: if there is no sinning occurs, the utility of the two selves remains $U^{Sin=0}_{Long-run\ self} = U^{Sin=0}_{Short-run\ self} = x+1$. Alternatively, in the case of sinning an allocation of goods and leisure will be changed to y ($0 \leqslant y \leqslant c$) and z ($0 \leqslant z \leqslant 1$), respectively. The levels of y and z are simultaneously chosen, creating a bundle of consumption of goods and leisure offered in the case of sinning. Choosing a value of z smaller than one would reduce the amount of leisure hours available. Furthermore, it would leave the short-run self with less time to enjoy the sinning. This way the long-run self can alleviate the future punishment for sin, at least partly, as fewer hours spent in sinning would reduce the amount of sin consumed. On the contrary, when the long-run self chooses to offer $z = 1$, the leisure allocation is not reduced. If $z < 1$ is chosen, $(1-z)$ fraction of sin is avoided, and a fraction of z is consumed. As z can take any value between zero and one, the long-run self is not a priori limited to adopt a corner solution of "all or nothing" for sinning, i.e. a consumption of a fraction of sin can be offered, if found optimal by the planner. On the other hand, choosing positive z comes with a price to be paid in the afterlife. Allowing the short-run self to consume part of the sin makes the long-run self liable for zG, for which she will be judged and charged at the entrance to the afterlife stage. The price of sinning, G, is defined by Assumption 3.

ASSUMPTION 3: *The price for sinning is positive,* $G > 0$.

Assumption 3 rules out the possibility that the planner will avoid a future punishment for wrong-doing or will be rewarded. The price for sinning, $G > 0$, can be seen as a lump-sum or as a stream of future prices to be paid, evaluated at one point in time, e.g. at the entrance to the afterlife stage. This price is stable during the one period of time modelled here, and so treated as a predetermined parameter. The payment for sinning, $zG > 0$, reflects the afterlife punishment in the Purgatory or similar environments, as described by various religious doctrines. Importantly, this payment is proportional to the fraction of sin consumed de facto, emphasizing the idea that the efforts of the long-run self to mitigate the sin, if made, also count when the time to be judged comes.

Two bundles can be proffered by the planner to the doer: $(x+1)$ in the case of non-sinning and $(y+z)$ in the case of sinning. It is worth noting that the offer can be made in bundles only, as x cannot be combined with z, or y with 1. In other words, the planner's offer is expressed in terms of menus and not from menus, where each menu contains a combination of two goods. Consequently, the choice of to sin or not to sin made by the doer will tie the bundle of $(y+z)$ or $(x+1)$ to both selves consumption allocation of goods and leisure, respectively.

The preferences of the short-run self are given by $U^{Sin=0}_{Short-run\ self} = x+1$ in the case of no sinning and $U^{Sin=1}_{Short-run\ self} = y+z+\Theta$ in the case of sinning, where Θ is the joy derived by the short-run self from the consumption of sin. Θ is realized as a random draw from a random variable, following Assumption 4.

ASSUMPTION 4: *The payoff from sin, Θ, is a random variable distributed uniformly over an interval $(0, g]$, where g is an upper bound indicating the maximum utility the short-run self can derive from sinning.*

If $\Theta = \theta$, then the decision rule of the short-run self is: Do not sin if $x+1 \geqslant y+z+\theta$, and sin otherwise.

The long-run self, who in interested in minimizing the dis-utility from sin and maximizing the utility from consumption of goods and leisure, faces an expected utility (EU) problem:[3]

$$\underset{x,y,z}{max} EU = p(x,y,z:c,g)(x+1) + (1-p(x,y,z:c,g))(y+z) - (1-p(x,y,z:c,g))zG \quad (2.1)$$

[3]A mathematically identical problem of the planner is solved by Smith (2022).

$$s.t. \;\; 0 \leqslant (x, y) \leqslant c$$

$$0 \leqslant z \leqslant 1$$

where the first component of the maximization problem represents the utility from no sinning with probability of p, while the second component is the utility in the case of sinning with probability of $(1-p)$. The last expression in equation (2.1) is the afterlife punishment in the case of sinning, with probability of $(1-p)$. Parameters c, g and G can take upon any positive value. The constraints state the boundaries of possible consumption of goods, x and y, at zero and c. The leisure in the case of sinning is restricted to an interval between zero leisure and the maximal amount of leisure available, that is normalized to one. The preferences of the planner obey completeness and transitivity, stated by Assumption 5.

ASSUMPTION 5: *The planner can rank any two combinations of* (x, y, z) *in terms of utility, and if* $(x_a, y_a, z_a) \succ (x_b, y_b, z_b)$*, and* $(x_b, y_b, z_b) \succ (x_c, y_c, z_c)$*, then* $(x_a, y_a, z_a) \succ (x_c, y_c, z_c)$.

By algebraic rearrangement of equation (2.1) we obtain:

$$\underset{x,y,z}{max} EU = p(x, y, z : c, g)(x + 1) + (1 - p(x, y, z : c, g))(y + z(1 - G)) \tag{2.2}$$

$$s.t. \;\; 0 \leqslant (x, y) \leqslant c$$

$$0 \leqslant z \leqslant 1$$

The domain of the EU function in equation (2.2) is a three-dimensional box, or a rectangular cuboid, defined by: $x \geqslant 0, y \geqslant 0, z \geqslant 0, x \leqslant c, y \leqslant c, z \leqslant 1$. An example of the box is shown in Figure 2.1.[4]

As illustrated by the figure, the box has twelve edges, six sides (or faces): $(x = 0, x = c, y = 0, y = c, z = 0, z = 1)$, and eight vertices: $V_1 = (0, 0, 0)$, $V_2 = (c, 0, 0)$, $V_3 = (c, c, 0)$,

[4]In the figure the constraint box has a shape of an equilateral cuboid, or a cube, which is a private case of a rectangular cuboid.

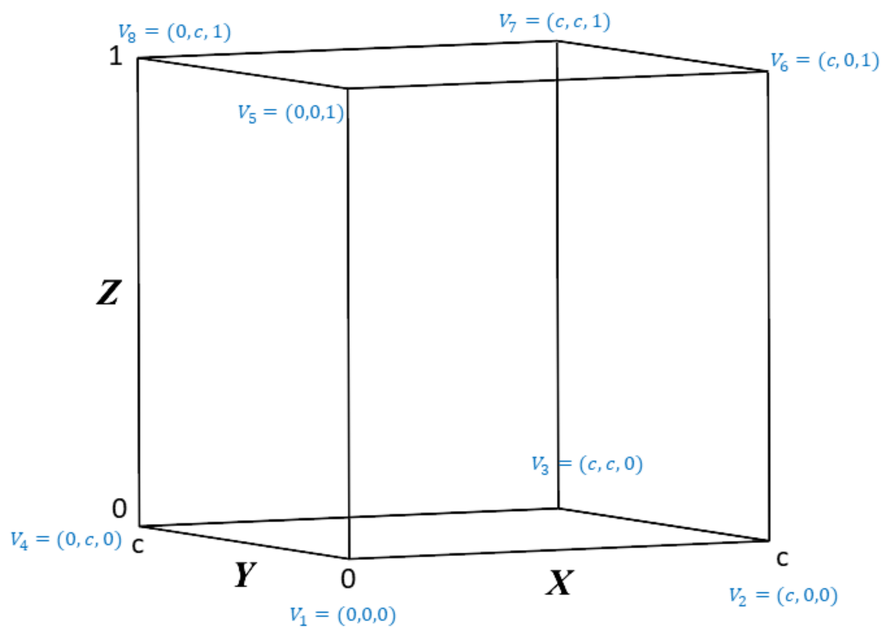

Figure 2.1: Constraint box.

$V_4 = (0, c, 0)$, $V_5 = (0, 0, 1)$, $V_6 = (c, 0, 1)$, $V_7 = (c, c, 1)$ and $V_8 = (0, c, 1)$, where $V_n = (x, y, z)$ for $n = 1... 8$. The edges of the box can be characterized by the line segments connecting every two neighbouring vertices, e.g. $V_1 - V_2$, and each side of the cuboid contains all the points included in the space between the four edges connecting four vertices with one identical allocation of resource (out of x, y and z). For instance, the $x = c$ side accumulates all the points of the plane bounded by the line segments: $V_2 - V_3$, $V_3 - V_7$, $V_7 - V_6$ and $V_6 - V_2$.

As stated by the EU problem in equation (2.2), the probability of sin not to occur, p, depends on allocations of (x, y, z) chosen by the planner. Furthermore, it is a function of the difference in utilities between the two bundles offered: $(x+1)$ and $(y+z)$. The best bundle to achieve a maximal probability not to sin is $V_2 = (c, 0, 0)$, with $\triangle_{V_2} = c+1-0-0 = c+1$, while the worst bundle is $V_8 = (0, c, 1)$, with $\triangle_{V_8} = 0+1-c-1 = -c$. Following Smith's (2022) approach, the differences in utilities can be standardised by adding c into both extreme cases equalities, making the minimal difference between the two bundles equal to zero and the maximal difference equal to $2c+1$. Finally, the difference between any two bundles to be normalized by dividing by g, the upper bound of the joy from sin for the short-run self, where g obeys Assumption 6.[5]

ASSUMPTION 6: $g > 2c+1$.

Assumption 6 guarantees the non-triviality of the *EU* problem[6] the planner facing, as the maximal joy from sin for the doer, g, is set sufficiently high to raise the question of optimal (x, y, z) allocation. Otherwise, when $g \leqslant 2c+1$, a combination of $V_2 = (c, 0, 0)$ can always be selected by the long-run self and sinning avoided with certainty.[7]

For the non-trivial cases, the probability function, generally stated in equation (2.2), can be formally defined as follows.

$$p(x, y, z : c, g) = \frac{x+1-y-z+c}{g}$$

The next step is to look at all the iso-probability planes limited by the domain of the *EU* function. Truncated by the sides of the constraint box, this planes take shape of polytopes and parallel to each other. Each polytope can be labelled as in equation (2.3).

$$p(x, y, z : c, g) = P_i = \frac{x+1-y-z+c}{g} \tag{2.3}$$

[5]Such standardizations would not change the optimal choices made by the planner, as the planes of $(x+1-y-z)$ are maintained.

[6]As stated in equation (2.2).

[7]The trivial case behavioural implications are to be discussed with the rest of the optimal choices.

where $p \in \left[0, \dfrac{2c+1}{g}\right]$. The union of all the iso-probability polytopes is the constraint box from equation (2.2). The expected utility (EU) on each probability polytope varies with the changes of (x, y, z) allocations, and the iso-utility curves generally do not coincide with the iso-probability planes. Finding the direction(s) of the EU improvement and the points of maximal utility on each probability polytope, P_i, could be of help in order to identify a local optimum over each probability level. This, in turn, would simplify the indefinite quadratic programming problem from equation (2.2) to a linear programming problem for each probability polytope, P_i. After finding all local optima, a direct comparison of the local maxima expected utilities could potentially lead to an identification of the global maximum/maxima. However, there is an infinite amount of probability polytopes to consider.

Smith (2022) suggested that the optimal solution(s) of the planner will always lie on the $x = c$ and/or $y = c$ walls of the constraint box.[8] That is, for any given level of z, $0 \leqslant z \leqslant 1$, it is optimal for the planner to offer the maximum consumption of goods available in the case of sinning, or non-sinning, or both. In terms of the probability planes, this would imply that for any z held constant on each probability polytope, P_i, the planner can increase her utility by moving toward $x = c$ wall or $y = c$ wall of the constraint box. In other words, for all the probability planes that intersect with $y = c$, the best allocation of y is $y = c$. The same is true for all the probability polytopes touching the wall $x = c$. Accounting only for the points where $x = c$ and/or $y = c$ for each probability plane would reduce further the complexity of the maximization problem faced by the long-run self, as all the points where $x \neq c$ *and* $y \neq c$, could be excluded from the analysis, as well as the edge of the constraint box where $x = 0$ and $y = 0$ ($V_1 - V_5$ line segment).

Recall that the choices of the planner are bounded by the six sides of the constraint box, which has eight vertices: $V_1 = (0, 0, 0)$, $V_2 = (c, 0, 0)$, $V_3 = (c, c, 0)$, $V_4 = (0, c, 0)$,

[8] An alternative way to move "toward the walls" in order to increase EU can be found at the closure of the technical Appendix A.

$V_5 = (0, 0, 1)$, $V_6 = (c, 0, 1)$, $V_7 = (c, c, 1)$ and $V_8 = (0, c, 1)$, where $V_n = (x, y, z)$ for $n = 1... 8$. As this eight allocations are fully defined in terms of (x, y, z), a direct calculation of p_{V_n} and EU_{V_n}, by substituting the coordinates of each vertex into equations (2.2) and (2.3), could be of benefit in order to investigate the direction(s) of the expected utility improvement(s) on the line segments connecting the vertices. Table 2.1 lists the probabilities and the expected utilities for each vertex of the constraint box.

Table 2.1: Comparative statics of the probabilities and expected utilities (EU) at the eight vertices of the constraint box.

Vertex	Vertex Probability	Vertex Expected Utility
$V_1 = (0, 0, 0)$	$p_{V_1} = \dfrac{c+1}{g}$	$EU_{V_1} = \dfrac{c+1}{g}$
$V_2 = (c, 0, 0)$	$p_{V_2} = \dfrac{2c+1}{g}$	$EU_{V_2} = \dfrac{(2c+1)(c+1)}{g}$
$V_3 = (c, c, 0)$	$p_{V_3} = \dfrac{c+1}{g}$	$EU_{V_3} = \dfrac{c+1}{g} + c$
$V_4 = (0, c, 0)$	$p_{V_4} = \dfrac{1}{g}$	$EU_{V_4} = \dfrac{1-c}{g} + c$
$V_5 = (0, 0, 1)$	$p_{V_5} = \dfrac{c}{g}$	$EU_{V_5} = \dfrac{cG}{g} + 1 - G$
$V_6 = (c, 0, 1)$	$p_{V_6} = \dfrac{2c}{g}$	$EU_{V_6} = \dfrac{2c(c+G)}{g} + 1 - G$
$V_7 = (c, c, 1)$	$p_{V_7} = \dfrac{c}{g}$	$EU_{V_7} = c + 1 + \dfrac{cG}{g} - G$
$V_8 = (0, c, 1)$	$p_{V_8} = 0$	$EU_{V_8} = c + 1 - G$

As shown in Table 2.1, the first four vertices expected utilities do not depend on G, as for all this cases $z = 0$. This observation holds for all the line segments connecting any two points with $z = 0$ allocation, including diagonals, such as a line segment $V_2 - V_4$.[9] On the contrary, for the last four vertices listed in Table 2.1, the expected utilities are a function of G, as $z = 1$ makes the planner liable for $zG = G$.[10]

The two vertices of $V_1 = (0, 0, 0)$ and $V_5 = (0, 0, 1)$, and the line segment related of $V_1 - V_5$, could be eliminated from further considerations, as not belonging to the side(s) of $x = c$ and/or $y = c$, of the constraint box.[11]

A quick direct comparison of the vertices expected utilities tabled could be of help, hinting to the possible direction(s) of utility improvement(s) for different values of parameters, while moving "on the edges" of the constraint box, especially for the walls $x = c$ and/or $y = c$. However, the use of such comparative statics requires to rank first the utilities of all points lying between the vertices on each line segment. Conveniently, for each pair of neighbouring vertices only one resource allocation out of three (x, y, z) changes, while the other two remain constant. Proposition 1 suggests that all the potential optimal allocations will lie on the $x = c$ side of the constraint box.

PROPOSITION 1: *Regardless of values of parameters g, G and c, it is always optimal for the planner to choose the maximal consumption of goods available in the case of non-sinning, $x = c$.*

Proposition 1 implies that the planner's problem stated in equation (2.2) can be further reduced to an optimal choice of (c, y, z), given the parameters, as all the potential global maxima (V_2, V_3, V_6, V_7, and the line segments connecting between them) belong to the

[9] The "floor" of the cube in Figure 2.1.

[10] These vertices define the "ceiling" of the box in Figure 2.1.

[11] For completeness of the analysis, this two vertices are still discussed here.

$x = c$ side of the constraint box.[12] As a result, the bundle offered in the case of non-sinning will always consist of the maximum consumption of goods and leisure available, i.e. $(x + 1) = (c + 1)$.

Before proceeding to the formal consideration of the planner's optimal choice over the $x = c$ wall of the constraint box, it is worth reminding that the probability function in equation (2.3) does not depend on a parameter G, while in equation (2.2) G appears. This caveat can be resolved by firstly dividing the values of parameter G into two cases: of $G > 1$ and of $0 < G \leqslant 1$, then solving the cases separately. As parameter G symbols the price of the afterlife punishment for sin in the model, $G > 1$ would indicate the high price, or a harsh punishment, while $0 < G \leqslant 1$ reflects a relatively low price, or a mild punishment. As will be shown further, the severity of the punishment for sin can alter the optimal choice of (x, y, z) for the planner, *ceteris paribus*. I now turn to discuss all the cases and their optimal solutions, given the parameters.

2.3 The optimal choices made by the planner

The goal of the long-run self is to maximize the utility from consumption of goods and leisure, and to minimize the dis-utility from consumption of sin, according to equation (2.2). By offering the short-run self distinctive bundles of resources in the case of sinning/non-sinning, she can endogenously manipulate the very probability of sinning to occur. This probability is formalized in equation (2.3). To complicate the problem, the planner's choices are restricted by the initial amounts of wealth and leisure resources available. These limitations accompany the expected utility (EU) problem, stated in equation (2.2), as constraints. Aware of the exact amount of the resources endowed, the planner acts accordingly and makes the offer. The short-run self reacts by the decision of to sin or not to. The interaction between the

[12] From this point on, the planner's problem could be potentially stated in two dimensions only, of y and z, while x to be replaced by parameter c.

two selves is schematically depicted in Figure 2.2.

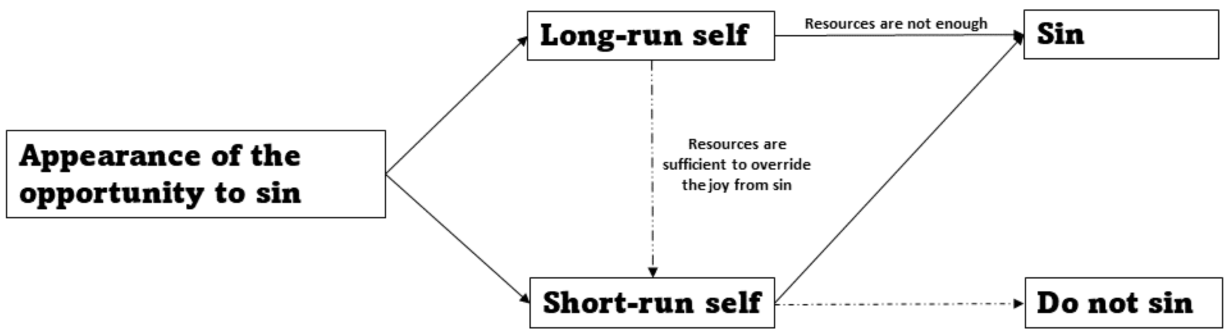

Figure 2.2: The interaction between the two selves.

The planner's strategies observed in Figure 2.2 are summarized in the following proposition.

PROPOSITION 2: *When the planner has sufficient resources, sin is avoided. Alternatively, sin occurs.*

Proposition 2 suggests that all the choices observed, of sinning and non-sinning, can be rationalized, given the parameters of the model: G, g and c. Specifically, succumbing to temptation could be explained by lack of alternative consumption resources. All the cases, which are to be discussed in the next subsections, and the propositions related, will jointly provide a complete proof for Proposition 2, as the probability space will be covered by fully parametrized optimal solutions. I now turn to examine the cases.

2.3.1 A trivial case of the rich planner

In this subsection, a rich long-run self, who owns an adequate amount of resources, in particular wealth, and her optimal choices, are to be presented. Assumption 6 stated that $g > 2c + 1$. In the case of the rich planner, this assumption is relaxed and replaced by the complementary $g \leqslant 2c+1$, leading to Proposition 3.

PROPOSITION 3: *A very rich planner, endowed with a sufficient amount of wealth to obey $g \leqslant 2c+1$ inequality, will always have enough alternative consumption to offer the doer in order to deter sin, for any $G > 0$.*

According to Proposition 3, the rich planner is capable to avoid sin and ensure higher level of afterlife well-being by substituting the consumption of sin with the consumption of other goods in this life. Instead of "taking money to the grave", she arrives to the afterlife stage with less sins heaped, effectively minimizing the amount of negative asset (sin) accumulated, by paying to override the potential joy from sin for the doer with other "sinless" earthy pleasures.

The convergence to the optimal solution of the rich long-run self is shown in Figure 2.3.[13] As shown in the figure, it is optimal for the rich planner to choose an allocation of $V_2 = (c, 0, 0) = (2, 0, 0)$, reaching $maxEU = EU_{V_2} = \frac{(2c+1)(c+1)}{g} = \frac{(2+1)(1+1)}{5} = 3$.[14] By offering $(x+1) = (c+1)$ and $(y+z) = (0+0)$ bundles to the doer in the case of non-sinning and sinning, respectively, she is capable to avoid the afterlife punishment with certainty. Figure 2.3 illustrates a case of a relatively harsh future punishment for sin, $G = 1.1 > 1$. For $0 \leqslant G < 1$ specification, the results are quantitatively identical, as $EU_{V_2} = \frac{(2c+1)(c+1)}{g}$ does not depend on G, and will be presented with the rest of the mild afterlife punishment, $0 < G \leqslant 1$, examples, in subsection 2.3.3.

[13]Software codes for all figures are available upon request. The figures illustrate numerical solutions for the planner's problem, identical to the solutions obtained analytically for three-dimensional space.

[14]A border case of $g = 2c+1$ is convenient to make the comparison to the next case, where c is lower, *ceteris paribus*.

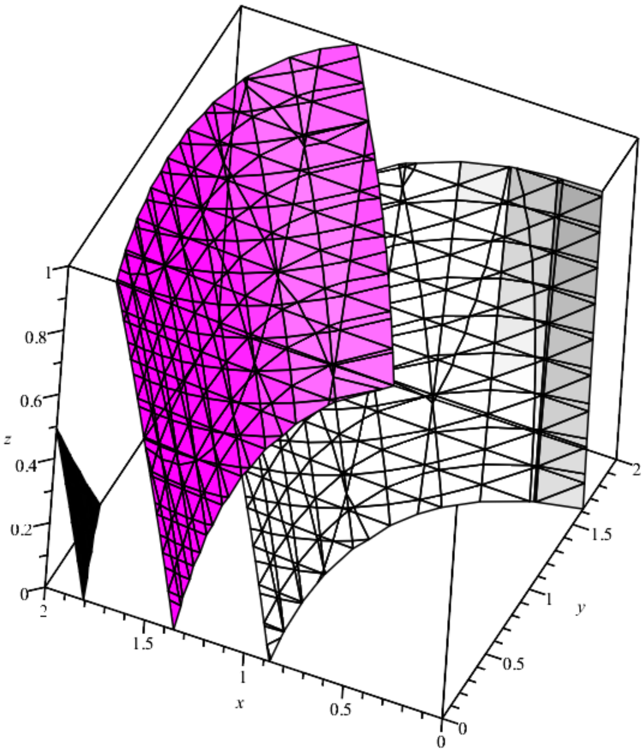

Figure 2.3: Convergence of iso-utility curves to the maximum expected utility at $V_2 = (c, 0, 0)$.
Notes. $G = 1.1$, $g = 5$, $c = 2$. Expected utility contours: $EU_{white} = 1.45$, $EU_{pink} = 2.05$, $EU_{black} = 2.7$.

2.3.2 A wrath of God, or G > 1 case

When $g > 2c + 1$, by Assumption 5, the optimization problem faced by the planner is more complex, as her resources are restricted in comparison to the previous case. On the other hand, the future afterlife punishment is severe. Proposition 4 suggests that a God-fearing planner will deter sinning.

PROPOSITION 4: *When the punishment for sin is harsh, $G > 1$, it is optimal for the planner to never sin, i.e. to choose $z = 0$.*

By Proposition 4, the optimal choice of the planner will lie on the line segment connecting

$V_2 = (c, 0, 0)$ and $V_3 = (c, c, 0)$. When $x = c$ and $z = 0$, the dominating option over a segment $V_2 - V_3$ is determined by: $maxEU_{(c,y,o)} = max[EU_{V_2}, EU_{V_3}]$. When $p_{V_3} = \frac{c+1}{g} \geqslant 0.5$, $V_2 = (c, 0, 0)$ is preferred.[15] Otherwise, $V_3 = (c, c, 0)$ dominates. In terms of probabilistic intervals, $V_3 = (c, c, 0)$ is optimal over $p \in \left[0, \frac{c+1}{g}\right]$. $V_2 = (c, 0, 0)$ rules over the higher range of probabilities, $p \in \left[\frac{c+1}{g}, \frac{2c+1}{g}\right]$, when $p_{V_3} = \frac{c+1}{g} \geqslant 0.5$. $z = 0$ in both optimal allocations.

The optimal solution of $V_3 = (c, c, 0)$ is depicted in Figure 2.4, with $p_{V_3} = \frac{c+1}{g} = \frac{2}{5} < 0.5$.

Comparing the results obtained by the optimal choice of $V_2 = (c, 0, 0)$, illustrated in Figure 2.3, to the results shown in Figure 2.4, an interesting observation occurs. The maximal utility at the optimum is: $EU_{V_3} = \frac{c+1}{g} + c = \frac{1+1}{5} + 1 = 1.4$. Holding other parameters constant, the initial endowment of wealth was reduced from $c_{Figure\ 2.3} = 2$ to $c_{Figure\ 2.4} = 1$, effectively changing the optimal allocation from $V_2 = (c, 0, 0)$ to $V_3 = (c, c, 0)$. However, the maximal utility the planner is capable to obtain at the optimum declined by more than one util, as $\triangle_{EU_{V_2} - EU_{V_3}} = 3 - 1.4 = 1.6$. This discrepancy is related to the fact that at the proximity to the global optimum of $V_2 = (c, 0, 0)$, the expected utility $EU_{V_2} = \frac{(2c+1)(c+1)}{g}$ is convex in wealth.[16] In the context of the model, such phenomenon can be interpreted as a two-fold purpose of the initial endowment of c. On the one hand, wealth serves to fund the alternative to sin consumption in order to minimize the liability resulting from sinning. On the other hand, a direct utility from the consumption of substitution goods counts as well. The change in the initial endowment of wealth also alters the width of the probability intervals over which the two optimal solutions, $V_2 = (c, 0, 0)$ and $V_3 = (c, c, 0)$, dominate each other.

[15] For details, see proof of Proposition 1(II) in the technical appendix.

[16] This observation belongs to Prof. Barry Smith.

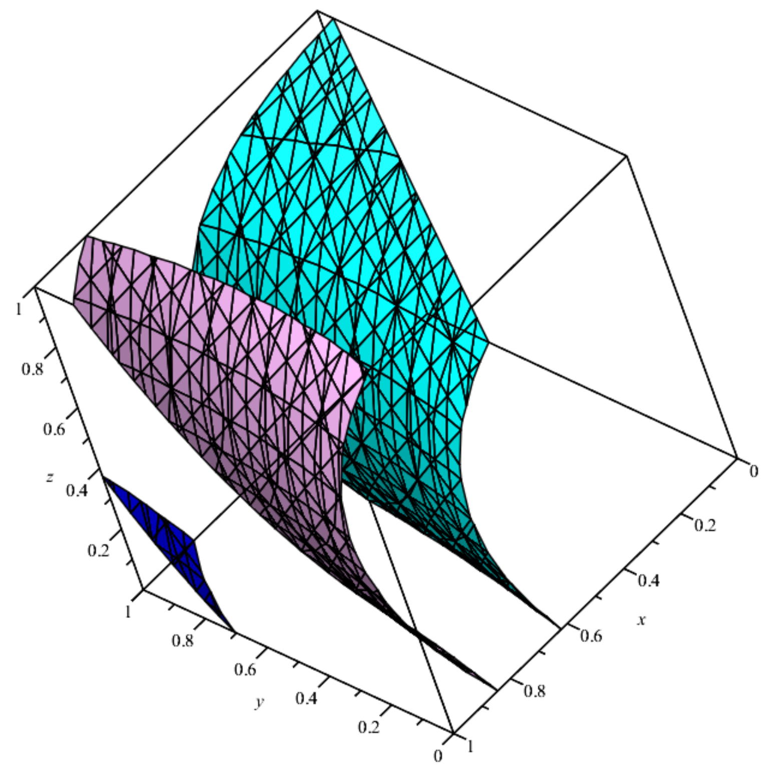

Figure 2.4: Convergence of iso-utility curves to the maximum expected utility at $V_3 = (c, c, 0)$.
Notes. $G = 1.1$, $g = 5$, $c = 1$. Expected utility contours: $EU_{cyan} = 0.85$, $EU_{plum} = 1.05$, $EU_{blue} = 1.3$.

When observed by an outside spectator, who can only distinguish between the behavioural outcomes of sinning and non-sinning, both optimal choices made by the agents, when $G > 1$, of $V_2 = (c, 0, 0,)$ and of $V_3 = (c, c, 0)$, might look identical, as they obtain the same result of non-sinning, $z = 0$. However, this observation is only partial and so misleading, as the rich planner, who chooses $V_2 = (c, 0, 0,)$ uses wealth as a tool to obtain the desired result of sin minimization, while the less wealthy, who optimizes by selecting $V_3 = (c, c, 0)$ resources allocation, relies on a threat of leisure reduction to zero in the case of sinning. For the poor long-run self, threatening to lessen already modest allocation of goods available for consumption in the case of sinning would be an idle threat, that could not help to obtain the so-wanted outcome of sin deterrence. Aware of this limitation, she turns to leisure nullification as a threatening tool.

The optimal allocations of (x, y, z), chosen by the rich and the poor God-fearing planners reflect the different paths they take in order to obtain the selfsame noted from outside upshot of non-sinning, subject to the constraint of the initial wealth endowed. While the behavioural outcomes observed for the both types of planners seem identical, the maximal expected utilities obtained differ substantially. However, there is an optimal choice left for the poor long-run self to deter sin, as long as she believes in harsh afterlife punishment for sinning.

2.3.3 A mild afterlife punishment, or $0 < \mathbf{G} \leqslant 1$ case

The case of the light afterlife punishment for sin is the most challenging. Of particular interest is to find out under what circumstances, or combinations of parameters, it is optimal for the planner to succumb to temptation, if there are any. So far, the model did not predict any positive amount of sin, or $z > 0$, to be consumed optimally. However, the amounts of sins and sinners observed in real life settings suggest that, at least for some agents, sinning might be a rational choice. A rationalization of such behaviour(s) is proffered by Proposition 5.

PROPOSITION 5: *When the afterlife punishment for sin is mild,* $0 < G \leqslant 1$*, there is a non-empty probability range over which sinning is optimal for the planner.*

For the $0 < G \leqslant 1$ case, the optimal solutions for the planner's problem partially coincide with the solutions for the $G > 1$ case, as the relationship between $V_2 = (c, 0, 0)$ and $V_3 = (c, c, 0)$ over a probability range of $p \in \left[\frac{c+1}{g}, \frac{2c+1}{g}\right]$ does not depend on G. The optimal solution of $V_2 = (c, 0, 0)$ is illustrated in Figure 2.5.

One can immediately notice that the only difference between the parameters values in Figure 2.5 and Figure 2.3 is that $G_{Figure\ 2.5} = 0.8 < 1$ versus $G_{Figure\ 2.3} = 1.1 > 1$.

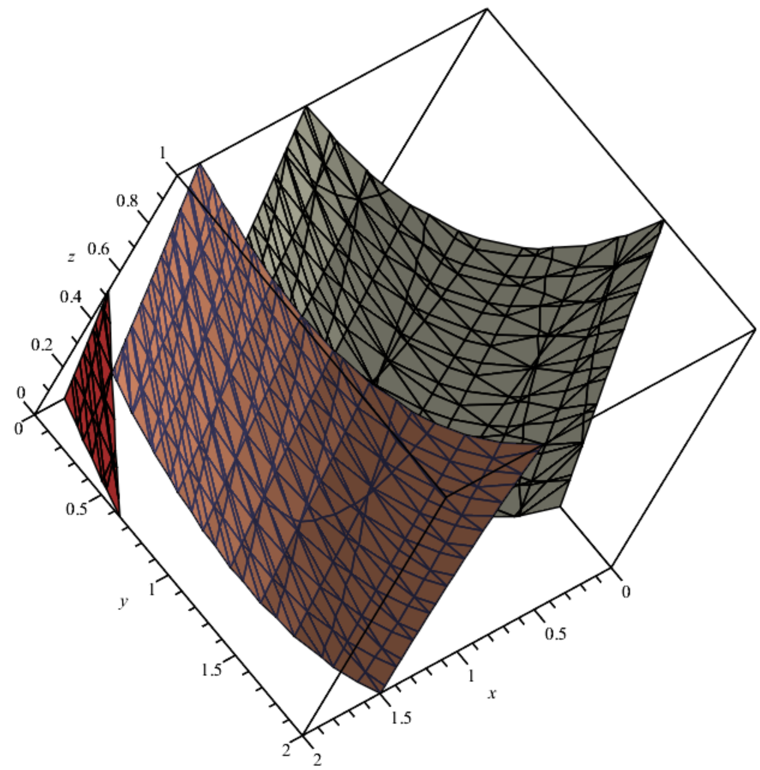

Figure 2.5: Convergence of iso-utility curves to the maximum expected utility at $V_2 = (c, 0, 0)$. *Notes.* $G = 0.8$, $g = 5$, $c = 2$. Expected utility contours: $EU_{wheat} = 1.45$, $EU_{coral} = 2.25$, $EU_{brown} = 2.7$.

As predicted by the model, $maxEU = EU_{V_2} = \dfrac{(2c+1)(c+1)}{g} = 3$, in both cases. The behavioural interpretation of this result is that, for any non-negative value of G, the rich planner will obtain the same maximal utility, effectively bribing the doer out of sin by offering an adequate alternative consumption of goods.

The optimal choice of $V_3 = (c, 0, 0)$ is graphically presented in Figure 2.6. Figure 2.6 looks very similar to Figure 2.4, except for the different value of $G = 0.8 < 1$. In terms of probabilistic intervals, $V_3 = (c, c, 0)$ will dominate $V_7 = (c, c, 1)$, as long as $G > \dfrac{g-c-1}{g-c}$, over $p \in \left[0, \dfrac{c+1}{g}\right]$, as for the parameters chosen for the figure, $G = 0.8 > \dfrac{g-c-1}{g-c} =$

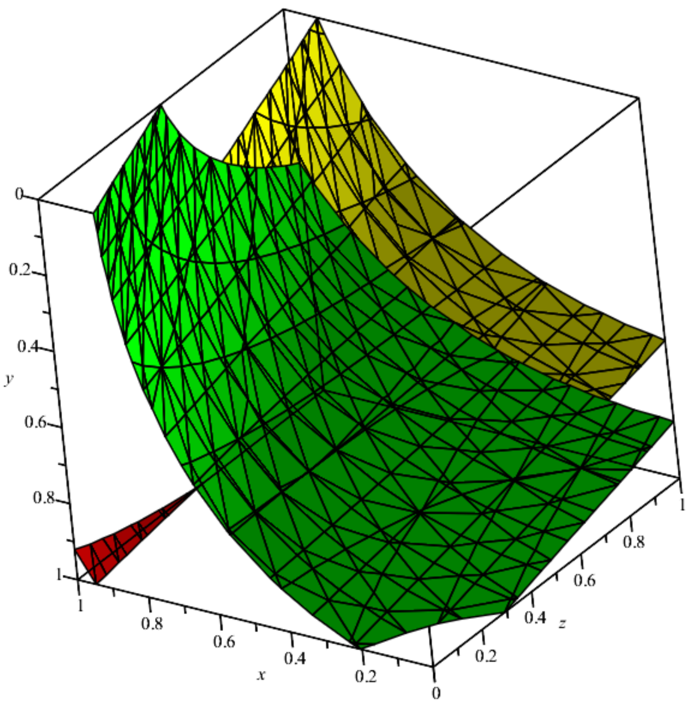

Figure 2.6: Convergence of iso-utility curves to the maximum expected utility at $V_3 = (c, c, 0)$. *Notes.* $G = 0.8$, $g = 5$, $c = 1$. Expected utility contours: $EU_{yellow} = 0.85$, $EU_{green} = 1.05$, $EU_{red} = 1.37$.

$= 0.75$.[17] The dominance over $V_2 = (c, 0, 0)$, under $p_{V_3} = \dfrac{c+1}{g} = \dfrac{2}{5} < 0.5$, is the same as in Figure 2.4. $EU_{V_3} = \dfrac{c+1}{g} + c = 1.4$.

Last but not least, Figure 2.7 tracks the convergence of the expected utility to the $V_7 = (c, c, 1)$ optimal allocation, the only case where the consumption of sin is rationalized. Figure 2.7 illustrates the case where G was reduced by 0.1 utils, from $G_{Figure\ 2.6} = 0.8$ to $G_{Figure\ 2.7} = 0.7$, *ceteris paribus*. This small reduction in the afterlife punishment for sin effectively changed the optimal solution from $V_3 = (c, c, 0)$ to $V_7 = (c, c, 1)$, as $G = 0.7 \leqslant \dfrac{g-c-1}{g-c} = 0.75$. When G crossed the threshold, sinning became optimal with $EU_{V_7} = 1.44 > EU_{V_3} = 1.4$ (in the previous case). If G declines further, the maximal expected utility at $V_7 = (c, c, 1)$

[17]Cf. proof of Proposition 5 in the technical appendix.

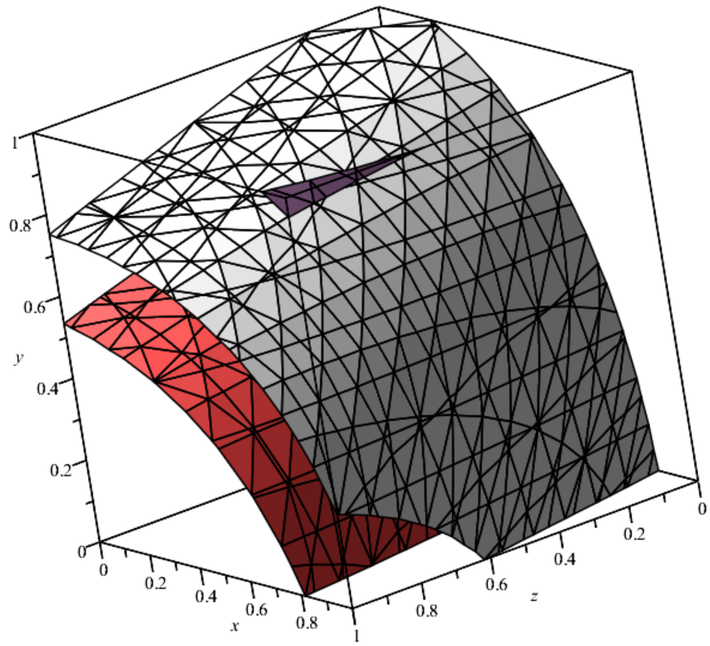

Figure 2.7: Convergence of iso-utility curves to the maximum expected utility at $V_7 = (c, c, 1)$. *Notes.* $G = 0.7$, $g = 5$, $c = 1$. Expected utility contours: $EU_{orange} = 0.85$, $EU_{gray} = 1.05$, $EU_{violet} = 1.41$.

would increase even more, as $EU_{V_7} = c + 1 - G(1 - \frac{c}{g})$. $V_7 = (c, c, 1)$ dominates $V_3 = (c, c, 0)$ over a probabilistic range of $p \in [0, \frac{c+1}{g}]$, if $G \leqslant \frac{g-c-1}{g-c}$. Otherwise, $V_3 = (c, c, 0)$ is preferred, as shown in Figure 2.6. Interestingly, a small increase in c would widen the probability interval over which the sinning could occur, $p \in \left[0, \frac{c+1}{g}\right]$, without altering the optimal allocation of $V_7 = (c, c, 1)$, if chosen, as long as $G \leqslant \frac{g-c-1}{g-c}$.

2.4 Concluding Remarks

In this chapter a dual-self model of principal-agent type was proposed. In the model, a planner, or a long-run self, who is interested in maximizing consumption of goods and leisure and minimizing the consumption of a third type good called "sin", optimally chooses two bundles of the resources she controls, goods and leisure, in the case of sinning/non-sinning, in order to manipulate the very probability of sinning to occur. Such endogenous manipulation is possible by offering the two distinctive bundles of goods and leisure to the doer, or the short-run self, who enjoys consumption of all types of goods, including sinning. However, the resources the planner is endowed are restricted, making the optimization problem faced by the long-run self non-trivial, as not every sin can be deterred by resources reallocation, given their limitation.

The model bears three first-best, fully parametrized solutions, where the parameters of the model include: initial endowment of wealth, the price of afterlife punishment and the maximal joy that can be derived from sinning by the short-run self. The optimal solutions, together with related parameters relationships and probabilities intervals are listed in Table 2.2. As shown in the table, all the optimal solutions are corner, i.e. "all-or-nothing" approach is adopted by the planner for consumption of goods, leisure and sin. This type of sinning behaviour is documented in the behavioural literature as a "bi-modal equilibrium", or "binges and cold turkeys", and hard to rationalize. Furthermore, the optimal solutions of the model are only sensitive to small changes in parameters in the proximity of the thresholds, as stated by the inequalities in Table 2.2, and can be seen as stable equilibria. That is, the planner has no incentive to diverge from one of the optimal solutions as long as all the conditions listed by Table 2.2 inequalities are maintained.

The solutions of the model predict that a very rich planner will always have enough wealth to pay to override the potential joy from sinning with consumption of other goods.

Table 2.2: Parametrized optimal solutions of the model.

Assumptions	Price of Afterlife Punishment	Probability Interval	Optimal Solutions	Parameters Relations
$g \leqslant 2c+1$	$\forall\, G > 0$	$p = 1$	$V_2 = (c, 0, 0)$	
$g > 2c+1$	$G > 1$	$p \in \left[0, \frac{c+1}{g}\right]$	$V_3 = (c, c, 0)$	
		$p \in \left[\frac{c+1}{g}, \frac{2c+1}{g}\right]$	$V_2 = (c, 0, 0)$	if $p_{V_3} = \frac{c+1}{g} \geqslant 0.5$
		$p \in \left[\frac{c+1}{g}, \frac{2c+1}{g}\right]$	$V_3 = (c, c, 0)$	if $p_{V_3} = \frac{c+1}{g} < 0.5$
	$0 < G \leqslant 1$	$p \in \left[0, \frac{c+1}{g}\right]$	$V_7 = (c, c, 1)$	$G \leqslant \frac{g-c-1}{g-c}$
		$p \in \left[0, \frac{c+1}{g}\right]$	$V_3 = (c, c, 0)$	$G > \frac{g-c-1}{g-c}$
		$p \in \left[\frac{c+1}{g}, \frac{2c+1}{g}\right]$	$V_2 = (c, 0, 0)$	if $p_{V_3} = \frac{c+1}{g} \geqslant 0.5$
		$p \in \left[\frac{c+1}{g}, \frac{2c+1}{g}\right]$	$V_3 = (c, c, 0)$	if $p_{V_3} = \frac{c+1}{g} < 0.5$

A less wealthy, but fearing the afterlife punishment for sin, planner, will use resources of wealth and leisure as tools to deter sinning, while wealth will serve as a primary threatening tool and leisure as a secondary. A poor agent who believes in mild afterlife punishment for sin will optimally choose to succumb to temptation, if the afterlife punishment is lower than a certain threshold.

To conclude this chapter, the model proposed introduces a novel self-control mechanism, based on non-cognitive resources of wealth and leisure. As a sufficient initial endowment of wealth found crucial by the model to exert the ability of the planner to bribe the doer out of bad deed, this result directly connects the lack of wealth, or poverty, with the higher amount of sins observed in poor populations.

By diverging from the religious context adopted in the model and replacing the ”sin” with any consumption/behaviour that is damaging in the future, the model equally applies, with no adjustments required, to any impulsive deed.

Chapter 3

Examining economies of salvation: A study case of the Catholic Jubilee Year event

3.1 Introduction

Religious doctrines are multifaceted complex concepts. Developed and polished over centuries, many of the present-day religions, including monotheistic, prescribe behavioural patterns to the faithful by defining the good and bad, for both the transient body and the eternal soul. A fulfilment of such spiritual recommendations by a substantial amount of believers can be detected by observing shifts in various socio-economic indicators, especially in the time-proximity of a major religious event occurrence.[1]

In this chapter, a foremost Roman Catholic Church event called a Jubilee Year will be investigated. The only paper that examined the Jubilee Year religious event influences, so far, is a recent article published by Bronzini et.al. (2020), from Bank of Italy. In their study, the economic impacts of the Great Jubilee of 2000 pilgrimage to the city of Rome, and the province of Rome as a whole, were evaluated over time. Specifically, their study aimed to check if there are any long-lasting effects of the event on value added per capita, employment rate, housing prices and tourism. The Great Jubilee event was treated as an occasion similar to an Olympic Games hosting, keeping in mind that it lasted longer (a year) than any sports event, and so its impacts were expected to endure for extended period of time and/or their magnitude to be higher.[2]

Prior to the implementation of the empirical strategy chosen, Bronzini et.al. (2020) gathered valuable descriptive information, extracted from official Italian sources, about the extent of the event and the scope of the preparations made to welcome it. The provincial plan of investments was approved as early as four years prior the event, in 1996. It included more than eight hundred projects, priced jointly for almost 1.9 billion euros. Most of the funds

[1] For instance, see Campante and Yanagizawa-Drott (2015) on impacts of Ramadan on productivity, economic growth and happiness, or Becker and Woessmann (2009) on effects of Protestant Reformation on human capital accumulation via literacy channel.

[2] As the Great Jubilee of 2000 is a unique mega-event, any comparison to other athletic/political event(s) is hard to make. Statistics on the event's scale to be provided in the next paragraphs.

were allocated to infrastructure enhancement, including the improvements of the rail-road and roads, adjustments at Rome-Fiumicino Airport, creation of parking lots, and more. A smaller fraction of the budget was assigned to the maintenance of public areas, preservation of cultural assets and security. Besides the public funds invested by the provincial authorities, non-negligible private investments were made, especially in the tourism-related businesses. In total, the private and public investments in the preparations to the Great Jubilee of 2000 amounted to approximately 6.5 billion euros, or 10 percent of the annual regional GDP.

In 2000, when the tourists-pilgrims finally arrived, the duration of stay in Rome increased from 17 million nights to 24 million, or by 42 percent. The foreign expenditure rose from 4.8 billion euros to 5.8 million, or by 20 percent. To investigate other economic indicators, with the exclusion of tourism, Bronzini et.al. (2020) implemented an empirical strategy that involved a construction of a counter-factual for the province of Rome, in order to isolate the event's estimated effects. A synthetic control was generated using an algorithm of optimal weighting of other provinces, that did not host the event, economic outcomes.[3] The counter-factual analysis led to various results. The effect of the Great Jubilee event on value added per capita found to be positive but diminishing over time, while the employment rate increased. These two results combined were explained by the fact that the employment rate improvement was accompanied by a shift from high-productivity sectors to the low-productivity, tourism-related occupations, causing an overall productivity loss. As of housing prices, the Jubilee event positively influenced peripheral neighbourhoods of Rome, that appreciated from 2,000 euro to almost 4,000 euro per square meter, ten years after the event was over, in comparison to increase from 2,000 to 3,000 euros in other provinces over the same period of time. Such increase in prices was linked to the improvements in the transportation infrastructure completed prior the Jubilee.

[3]They took the synthetic control path, and not adopted, for instance, the differences-in-differences empirical approach, mainly because they had only one treated unit, the city of Rome.

Concluding the study, Bronzini et.al. (2020) calculated that the costs of investments exceeded the benefits from the event in the employment dimension. Finally, they stated that the Jubilee Year of 2000 event failed to create a sustainable growth in GDP in the long-run and suggested the policy-makers to be aware of this fact. As the decision to celebrate the Great Jubilee of 2000 was made by the Holy See, and not by the civil authorities of the province of Rome, it is difficult to see how such recommendations could be taken into account by the Roman Curia, who's officially declared purpose of the event was to benefit the souls of the faithful in the afterlife and not to improve their well-being in this life. On the other hand, a provincial decision not to budget preparations for the upcoming mega-event, if made, could lead to even less preferable outcomes, such as transportation chaos and lack of accommodation for millions of pilgrims-tourists.

Other than economic impacts on value added per capita, tourism, employment rate and the housing prices in the province of Rome, studied by Bronzini et.al. (2020) for the Great Jubilee of 2000, no other influences of the Jubilee Year celebration(s) were ever investigated.[4] In this chapter, the impacts of the religiously prescribed behavioural aspects of the event-related customs on socio-economic outcomes will be evaluated. Such investigation is of interest because during the Jubilee celebration, Catholics are given an opportunity for a fresh spiritual start by obtaining forgiveness for sins committed previously, a Jubilee indulgence. The Jubilee remission of sins is offered to every Catholic. However, in order to obtain it, a few conditions apply. One of the requirements states that the forgiveness will be granted to the faithful who genuinely promise to detach from all sins *and* not to sin again. The current study purpose is to examine whether Catholics sinning patterns change around the Jubilee Year occasion. Criminal offences recorded will serve as a proxy for the amount of bad deeds committed.

The study will be conducted via two channels. The first path is to examine historical

[4]To the best of my knowledge.

Italian time series data on crimes for a period of time during which eight Jubilee events were held. The second route is to perform a conditional analysis on a longitudinal data for European countries criminal activities count, recorded around the Great Jubilee of 2000 event, where predominantly Catholic countries to be considered under the treatment of the event and the rest of the countries in the sample to serve as a control group.

The chapter is organized as follows. The next section outlines an historical and religious background on the Jubilee Year event's origins and the its relation to the remissions of sins, indulgences. Section 3.3 describes the dataset to be used in the analysis of the Italian crimes time series and examines the impacts of multiple Jubilee events occurred during the time period in focus. Section 3.4 presents the data used for examination of the Great Jubilee of 2000 influences on European countries criminal activities, elaborates on the empirical strategies adopted and details the results obtained. Concluding remarks are provided in Section 3.5. Appendix B contains additional graphs and tables of an alternative specification for the empirical estimation discussed in Section 3.4.

3.2 Historical and religious background

3.2.1 Indulgences

Indulgences are an ancient Catholic custom of offering a cancellation of the temporal punishment due to sin in the next life in exchange for good works in this life. This custom is practised, with some modifications over time, since the eleventh century.[5] The Catechism of the Catholic Church defines: "An indulgence is a remission before God of the temporal punishment due to sin whose guilt has already been forgiven, which a faithful Christian who is duly disposed gains under certain prescribed conditions through the action of the Church, as the minister of redemption, dispenses and applies with authority the treasury of

[5]A full historical background on the evolution of indulgences can be found in dal Cavolo (1999).

the satisfaction of Christ and the saints."[6] "An indulgence is partial or plenary according as it partially or wholly frees a person from the temporal punishment due to sin."[7]

A *modus operandi* of such remission can be described as the following: A person who is interested in obtaining an indulgence has to be baptised, not excommunicated, and in a state of grace. The state of grace, in turn, requires a sacramental confession and a full further detachment from all, even venial, sins.[8,9] After a wholehearted confession is made by the believer and the forgiveness is granted by the confessor, the connection between the faithful and Christ is renewed, allowing him/her to override the sins temporal punishment in the Purgatory using the Church's infinite treasure of merits.[10] Being truly repentant and detest the sin is a crucial condition to obtain an indulgence, as it "cannot be acquired without a sincere conversion of mentality".[11] Every person is assumed to be a sinner, and in need for forgiveness at all times.[12] The Holy See is the only authority to grant indulgences, during special occasions/times declared by the Supreme Pontiff.[13,14] In Economics terms, all mentioned above makes the Catholic Church a monopolistic supplier of a particular religious service, a remission of sins, available exclusively to the followers of the Church, the Roman Catholics.

Indulgences played an important, if not to say crucial, historical role in shaping what we

[6] Catechism 1471, Code of Canon Law canon 992, Indulgentiarum Doctrina norm 1.

[7] Ibid. 1471, canon 993, norm 2, respectively. A "temporal punishment" here is the time to be spent in Purgatory, as opposed to the "eternal punishment" of hell. See Catechism 1472 on this matter.

[8] Cf. John Paul II (1999) general audience, citing Enchiridion Indulgentiarum.

[9] A complete list of the conditions required for the plenary indulgence, including an Eucharistic Communion and Prayers for the Pope intentions, can be found in Indulgentiarum Doctrina, norm 7.

[10] Cf. Catechism 1476-1479 and/or Indulgentiarum Doctrina Chapter 1.3. This treasure is related to a concept of the economy of Salvation, also called the Divine economy or an economy of Revelation. See Catechism 1103 and Mirus (2009) interpretation, for instance.

[11] See Indulgentiarum Doctrina, Chapter 4.7, 4.8 and 4.11. Beer (1978), in his theological study, suggested that the intensity of the sorrow a sinner feels determines the "quality" of the indulgence obtained. This degree of devotion can be known only to God.

[12] Indulgentiarum Doctrina, Chapter 1.3, based on earlier sources.

[13] Code of Canon Law, canon 995.

[14] The Church "condemns with anathema those who maintain the uselessness of indulgences or deny the power of the Church to grant them", Indulgentiarum Doctrina, Chapter 4.8.

know today as modern Europe. Until the sixteenth century, indulgences were sold by the Catholic Church for profit and the concept was widely abused.[15] *Quaestores*,[16] who were officially entitled to collect the alms-givings for indulgences, went way beyond the bounds of reason collecting the funds. The abuse was so significant that it led Martin Luther to raise a question about the legitimacy of indulgences and the Pope's authority over the punishment in the afterlife. On October 31, 1517, Martin Luther nailed his "Ninety-Five Theses or Disputation on the Power and Efficacy of Indulgences" on the door of the University of Wittenberg, inviting the Catholic Church to a theological dispute. This event started a second, Lutheran, schism of the Roman Catholicism, known as Reformation.[17,18]

Martin Luther and the Holy See did not reach a consensus on indulgences. On the contrary, with time more and more theological differences widened the division between the Roman Catholics and the Lutherans. Luther was excommunicated in 1521, but the revolution he started continued, causing religious wars in practically all European countries. The Church had reacted with Counter-Reformation, also called a Catholic Reformation or a Catholic Revival. During the Council of Trent,[19] it restated all Catholic postulates and rejected any compromise with the Protestants. On the other hand, the practice of granting indulgences was modified, the related financial transactions were strictly forbidden[20] and all who trafficked indulgences excommunicated.[21] An additional impact of the Catholic Reformation was a beginning of a massive patronage of artists who gloried the Catholic God

[15]For instance, the Saint Peter's Basilica in Rome was rebuilt from funds raised by selling a special indulgence, which obsoleted many serious sins, including theft and adultery. Another example is a "Butter Tower" of Rouen Cathedral built from monies collected for a special indulgence, which allowed eating butter during Lent. On the other hand, many churches, hospitals, leprosariums, bridges, roads and schools were built/renovated from funds collected by selling indulgences. See dal Cavolo (1999) for reference.

[16]"Pardoners" in Latin.

[17]October 31, a Reformation Day, is nowadays celebrated as an official holiday in five states of Germany.

[18]The Catholic Church was divided for the first time during the East-West Schism in 1054 AC, when the Greek Orthodox Church abandoned the spiritual authority of the Holy See.

[19]Years of 1545-1563.

[20]In 1567.

[21]By Pope Pius V, in 1569. See Beer (1978), inter alios, for reference.

in architecture, painting, sculpture and music.[22] Bernini, Rubens, Titian, El Greco, van Dyck, Rembrandt, among others, belong to a group of Counter-Reformation painters and sculptors. The Gregorian calendar was adopted during the Catholic Revival as well.

Nonetheless, the division caused by Luther was irreversible. Inflamed by the abuse of the concept of indulgences, it created a religious shock to be studied by social scientists, including economists, centuries later. The influential book of Max Weber (1905), "The Protestant ethics and the spirit of capitalism", spurred an outburst of an empirical research focused on the socio-economic benefits of the Lutheran schism for the Protestants versus Catholics.[23] In Economics, *nemine contradicente*, i.e. an investigation on how the aspects of the Roman Catholic doctrine could benefit (or not) the Holy See followers after the Reformation, was never conducted.[24]

Upon closer examination of Luther's writings, it becomes clear that his theses can be divided into two categories. The first category addresses the issues related to the Roman Catholic Church as a provider of the indulgences religious product, while the second category offers guidance on the product's advantages/disadvantages to the targeted consumers of indulgences, the Christians.[25] From an economic perspective, this division identifies and separates the monopolistic supplier of a particular religious service (indulgences), or the Church, from the aggregated demand dimension, the Christians. The supply side of this market is criticized based on the Church's (possible) inability to deliver the forgiveness promised, the high prices charged for the product, and the underlying motivation of the Church as a religious authority to make monetary profits rather than care about its flock's

[22] A baroque art establishment.

[23] See, for instance, Becker and Woessmann (2009) on literacy, that led to an economic prosperity via the education channel, Blum and Dudley (2001) on lower cooperation costs and Ekelund, Hebert and Tollison (2002) on more religious competition.

[24] The authors are not aware of research where any aspect(s) of the Catholic faith, or its' consequences, found preferable versus the Protestant or any other religious doctrine/secularism. In inclusive studies for all religions, Catholics usually served as a control group, being the largest religious denomination in the sample.

[25] In particular, theses 42-51 that start with: "Christians are to be taught..."

souls. The consumers, or Christians, are instructed (and warned) about the potential flaws of the product and the possible negative spillovers from the consumption of indulgences, especially when the latter is frequently repeated. According to Luther, freeing the faithful from future penalty does not make man better.[26] On the contrary, the underlying hypothesis is that obtaining forgiveness for sins on Earth, whenever desired, would make a person more of a sinner. That is, the occasional forgiveness for sins, and the following nullification of the afterlife punishment, would inflate the very concept of God's judgement and alleviate the fear from it. In the model presented previously in Chapter II, this fear took the shape of the price to be paid for sinning in the afterlife.

To relate the theoretical chapter's framework to the hypothesis examined empirically in this chapter, a formal connection can be made. In the model, the agent optimally chooses to sin or not to sin, given the parameters of the model, including the perceived afterlife punishment for sinning. When sin is committed, a negative asset of afterlife punishment for sin is created. If the model is repeated/extended over a long/infinite horizon, some sins will be consumed. With time, more and more punishments will be stored in the spiritual account of the faithful, weighing heavily on the agent's soul. The very opportunity to erase the afterlife penalties for sinning via the indulgences channel would significantly reduce[27] the overall amount to be paid in the afterlife, *ceteris paribus*, as the positive probability attached to the spiritual debt future cancellation would replace the aggregation of parameters indicating the prices to be paid in the afterlife with a distribution of cumulative prices, over which a positive probability to obtain zero punishment for sinning in the afterlife is assigned over a non-empty interval.[28] According to the model's parametrized optimal solutions, such

[26]Ibid., thesis 44: "Because love grows by works of love, man thereby becomes better. Man does not, however, become better by means of indulgences but is merely freed from penalties."

[27]Or set at zero.

[28]Alternatively, a similar distribution, even very simple, could be embedded in the one-period model as well. For instance, $\forall\ G \geqslant 0$, $p > 0$ to be assigned to $G = 0$, while the complementary $(1 - p) > 0$ to be attached to $G > 0$. Notice that $G = 0$ is not allowed in the original model, and such modification offers a possible "Catholic" extension of the model.

a reduction would, in turn, lower the threshold for sinning to occur. In other words, the (modified) model presented in Chapter II would predict,[29] that giving the option to erase the afterlife punishment for sinning should lead to more sins being observed, if the faithful fear God's judgement.

This chapter will examine empirically the impacts of the indulgences, massively granted during the Jubilee Years to Catholics, on sinning patterns, proxied by the criminal behaviours of the faithful, in the time-proximity to the event, while the underlying hypothesis is that more crimes are expected to be observed during the event or right after the event is over.

3.2.2 A Jubilee Year custom

A Jubilee Year is a Catholic Church event celebrated in Italy every twenty-five years, or more frequently, since 1300 AC.[30] If the Jubilee falls on a round twenty-fifth year, it is considered planned, or ordinary. Additionally, the Pope can declare an extraordinary Jubilee(s), which can be held any time, commemorating a special occasion, and vary in length. For the faithful, the ordinary Jubilees are expected events, as opposed to extraordinary and unexpected, in terms of religious policy-making intervention. During this year, when declared by the Holy See, all the Catholics are invited to participate in the celebration, obtain forgiveness for sins committed previously and obsolete all the temporal punishment due to sin via a channel of the special plenary indulgences.

The Jubilee concept was first mentioned in the Book of Leviticus[31] as a year during which all the slaves and prisoners should be freed, debts to be forgiven, lands returned to original owners and mercies of God ubiquitously manifested.[32] The main purpose of the event is to

[29] This prediction assumes the replacement of the parameter(s) indicating the afterlife punishment for sinning with the distribution(s) mentioned above.

[30] The first Jubilee Year was declared by Pope Boniface VIII. Dante Alighieri, spotted between the pilgrims of the First Jubilee, mentioned it in his "Divine Comedy", Canto XXXI of Paradiso.

[31] Leviticus 25, 10-14.

[32] Cf. Vatican official site, Jubilee 2000 documents.

offer all Catholics a grant of cancellation of punishment due to sin.[33] The Catholic Church explicitly ties the Jubilee Year custom with indulgences to mark a "new beginning in the love story between God and men" and offers a smooth path "to burn away sin and leave the past behind".[34] Nevertheless, the Jubilee indulgences differ from other indulgences, as they have to obey the specifics of the Jubilee Year ritual. In addition to confession, detachment from all sins, communion and prayers for the Pope's intentions, the faithful must pass via a Holy Door in places designated by the Church. Such Holy Doors are open on Christmas evening and sealed on the next after the following Epiphany.[35,36] Historically, the Doors were located exclusively in Rome,[37] in order to create an influx of pilgrims who would purchase the indulgences, donate to the Church and contribute to the local tourism-related businesses during the event. However, the Great Jubilee of 2000 was planned, and executed, as a planetary event with a significant simplification of rites, including a recognition of the doors of the local basilicas and churches as the Holy Doors, for the purpose of the Jubilee indulgences bestowal.

[33]Pope John Paul II (1999) starts his general audience with: "...In close connection with the sacraments of Penance, our reflection today turns to a theme particularly related to the celebration of the Jubilee: I am referring to the gift of the indulgences, which are offered in particular abundance during the Jubilee Year..."

[34]See dal Cavolo (1999).

[35]A full description of the modern procedure of opening/closing the Holy Doors can be found in the Vatican official site liturgy documents. Visualization of a medieval Holy Door opening can be obtained by watching the historical series "Borgias", season 3, episode 8, where the Pope Alexander VI opens the Jubilee of 1500. His intention was to collect alms-givings from selling indulgences to fund a crusade against the Turks. Interestingly, a full price-list for different sins to indulge is presented there.

[36]It is worth noting that the length of the event aligns almost perfectly with any data recorded annually, making an empirical research on the Jubilee Year impacts more precise.

[37]In four patriarchal basilicas: Saint Peter, Saint John Lateran (or Most Holy Saviour at the Lateran), Saint Mary Major and Saint Paul on the Ostian Way (or Outside the Walls). Additional locations include: the Basilica of the Holy Cross in Jerusalem, the Basilica of Saint Lawrence in Campo Verano, the Shrine of Our Lady of Divine Love and the Christian Catacombs. See the Apostolic Penitentiary's "The gift of the indulgence" by Cardinal Baum (2000) for reference.

3.2.3 The Great Jubilee of the year 2000

For the Holy See, a beginning of the new millennium had created a perfect opportunity to extend the scale of the Jubilee celebrations worldwide.[38] Such a special occasion required an appropriate preparation of the faithful and the Church. On November 10th, 1994, the Pope John Paul II published a special apostolic letter *"Tertio Millennio Adveniente"*,[39] calling all the Catholics to spiritually prepare themselves, over three years, for the journey into a new millennium. Fitting the Trinitarian approach, the three years preceding the Great Jubilee of 2000 were devoted to the Son (1997), the Holy Ghost (1998) and the Father (1999).[40] When the year 2000 had finally arrived, the celebrations took place simultaneously in Rome, in the Holy Land and in dioceses and other ecclesiastic territories all over the world. In Rome only, more than eight million Catholics participated in the meetings with the Holy Father, at different audiences, ceremonies and Angelus. 1.6 million Catholic youth were hosted during only two days (19-20 of August) of the World Youth Day. The total number of the pilgrims-visitors to Rome in 2000 was estimated, by different sources, to lie between 24.5 million people to 32 million.[41] The Italian National Institute of Statistics and the Bank of Italy reported that the total amount of nights spent in Rome by the tourists rose from 17 million in 1999 to more than 24 million in 2000, and the international tourism expenditure increased by twenty percent, from 4.8 billion Euro in 1999 to 5.8 billion Euro in 2000.[42]

Remarkably, the pilgrims-visitors travelled to Rome despite the fact that this pilgrimage was not necessary any-more for obtaining the Great Jubilee plenary indulgence, because the requirement to pass via the Holy Doors of Rome basilicas was simplified and replaced with an option of pilgrimage to a locally designated church. Moreover, the pilgrimage itself became an

[38] In 2000, the Roman Catholic Church had approximately 1.2 billion followers all over the world.

[39] "As the third millennium approaches."

[40] The calendar of the three-year preparatory period can be found on the Vatican official website, Jubilee of 2000 calendar documents.

[41] See Brunelli and Trecart (2000) for details.

[42] Cf. Bronzini et. al. (2000).

option, among few others, to obtain the remission of sins. After fulfilling the basic conditions for a plenary indulgence,[43] the faithful could choose one of the three categories of good works to perform. The first category, works of piety or religion, included a pious pilgrimage or a visit to a Jubilee place. The second option required works of mercy or charity, in particular visiting brothers/sisters in need, or supporting by a significant contribution works of religious or social nature, or to devote a personal free time to benefit the community. The third alternative is to perform acts of penance for at least one whole day, such as an abstention from unnecessary consumption of smoking and drinking, or fasting, or an abstention from meat *and* a donation to the poor.[44] Given a wide range of choice between the charitable giving/volunteering, abstention/fasting and a visit to a Jubilee place, no Catholic was left behind without a suitable option to obtain a Great Jubilee indulgence. Economically speaking, the "price" of participation in the event was reduced from a mandatory pilgrimage to Rome in order to pass via the Holy Doors to an array of options to choose from, affordable to all the Catholics.

At the end of the year 2000, the Holy See celebrated the success of the Great Jubilee, emphasizing a massive involvement of the Catholics in the related ceremonies. To conclude the celebrations, the Pope John Paul II published another apostolic letter, *"Novo Millennio Ineunte"*,[45] in which he outlined the priorities of the Church for the third millennium. As of the Great Jubilee, he found it "... impossible to take the measure of this event of grace which in the course of the year has touched people's hearts." In the next sections, an attempt to quantify the impacts of the event, at least in the dimension of criminal activities, will be made.

[43]Being in a state of grace, confessed, received the Holy Communion and interiorly disposed to detach from all sins. See Apostolic Penitentiary's documents on Vatican official site on this matter, published by Cardinal Baum (2000).

[44]Ibid., 8-10.

[45]"At the beginning of the new millennium."

3.3 Italy Case

3.3.1 Italian historical time series dataset on crimes

To observe the 150^{th} anniversary of the unification of Italy, the Italian National Institute of Statistics[46] (ISTAT) has collected and made publicly available a significant amount of historical data sets, including crimes. The dataset on illegal activities contains all the violations of the criminal code, as was reported to the law enforcement authorities, per annum, and per hundred thousand inhabitants, by known and unknown perpetrators.[47] The categories of crimes include homicides, battery *and* culpable injuries, offences, slanders *or* libels, thefts, robberies, extortions, kidnappings for robbery or extortion purposes, swindles *or* other frauds, violence/resistance to public officer, financial embezzlement, misappropriation, bribery, dereliction of duty, and more. All crimes were assigned an equal weight in the total crimes recorded data sample, that spans over 126 years, from 1888 to 2013. Figure 3.1 illustrates the evolution of crime levels in Italy. The dashed vertical lines refer to the eight Jubilee Years events held during this period, while the gray-shaded areas indicate wartimes.

In Italy, the period of time between 1888 and 2013 was rich with historically meaningful episodes. Changes in the political regime from monarchy to fascism to a republic, the two World Wars and the financial crisis of 2007-2008, among other events, caused prolonged periods of political instability and/or social unrest and created violent environments. This, in turn, impacted many socio-economic indicators, including criminal activities records.

[46] Instituto Nazionale di Statistica.

[47] All the reports opened from January 1^{st} to December 31^{st} were counted in the same calendar year.

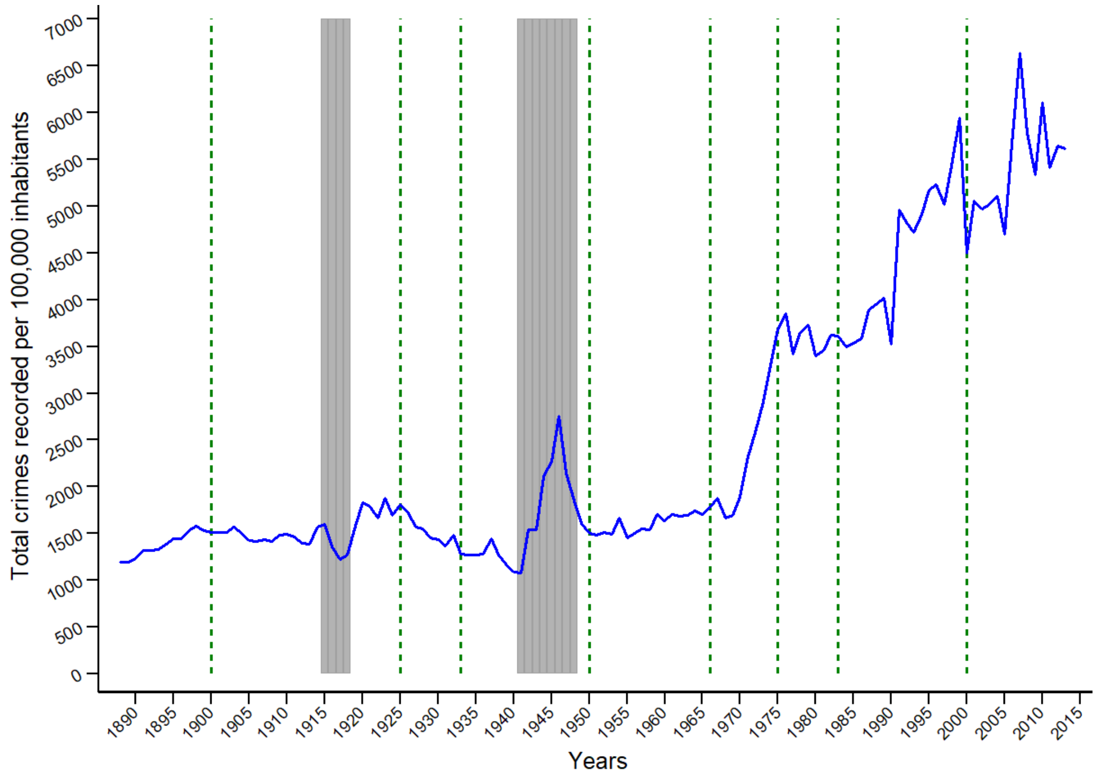

Figure 3.1: Criminal activities in Italy, years 1888-2013.

As one can immediately notice from the graph, the time series of Italian historical crimes could be roughly divided into two parts: before the year 1970, and after. The first sub-period of the time series exhibits a relatively low level of criminal activities and moderate volatility,[48] with no clearly pronounced trend, while the second sub-period has an upward trend and is more volatile.[49] Such a division could be justified by the beginning of a very violent period in Italian history that started in early 1970*s* and called "The Years of Lead". To determine precisely the year a structural break in the time series pattern occurred, two statistical tests were performed.[50] A Supremum Wald test with unknown in advance structural break date suggested the year of 1972 as a switching regime point, with a statistic of 179.91 and a *p-value*

[48] Excluding the wartimes: WWI of 1914-1918 and WWII of 1941-1948, including post-war stabilization period, where the drop and the spike are observed, respectively.

[49] This period to be discussed in sub-section 3.3.3.

[50] Post estimation tests, after a regression of crimes levels on years.

of zero.[51] Performing the test on the same year of 1972, as if it was the known/suspected structural break point led to a statistic of 148.47 and a *p-value* of zero as well. Based on the results of both tests, the time series to be divided into two sub-samples, covering years of 1888-1971 and of 1972-2013, respectively, and analysed in the following two sub-sections separately.

During the sampled time period, eight Jubilee Years were celebrated in Rome: five ordinary, or planned, and three extraordinary. As customary, the ordinary Jubilees were held every twenty-five round years: in 1900, 1925, 1950, 1975, and 2000.[52] The extraordinary Jubilees marked the specific events the Church found significant to give a reason for an additional celebration. In 1933 and 1983, two Jubilees commemorated the 1900^{th} and 1950^{th} anniversaries, respectively, of Jesus death and resurrection.[53] In 1966, the post-Vatican II Council Jubilee Year concluded the most important ecumenical event of the Roman Catholic Church in the 20^{th} century. Despite the multiple celebrations calling upon the faithful to reunite with the Church, the Roman Catholic share in the overall Italian population had declined, steadily and slowly, from 97.81 percent in 1888 to 78.34 percent in 2013.[54] This prolonged deterioration, together with the rise of other religious and secular denominations, is shown in Figure 3.2. A forecast on the future development of the largest religious/secular groups in Italy is projected until the year 2050. By looking at Figure 3.2 we do not observe sudden shifts or kinks that could be associated with the Jubilee Years, as no such change(s) occurred from 1950 to 2000.

While the count of Catholic shares provides an insight on the percentage of Italians formally associating themselves with the Roman Catholic Church, investigating how affiliations

[51] 15% default edges trimming, no constant.

[52] A detailed description of the ordinary Jubilees of the 20^{th} century can be found on Vatican official website, Jubilee of 2000 magazine documents. The Great Jubilee of the year 2000 could be seen as extraordinary in terms of the extent of the event, as a first planetary Jubilee.

[53] The Jubilee of 1983 is also called the Holy Year of Redemption.

[54] The source of the continuous religious shares data is the Association of Religion Data Archives (ARDA), Religious Characteristics of States Project dataset.

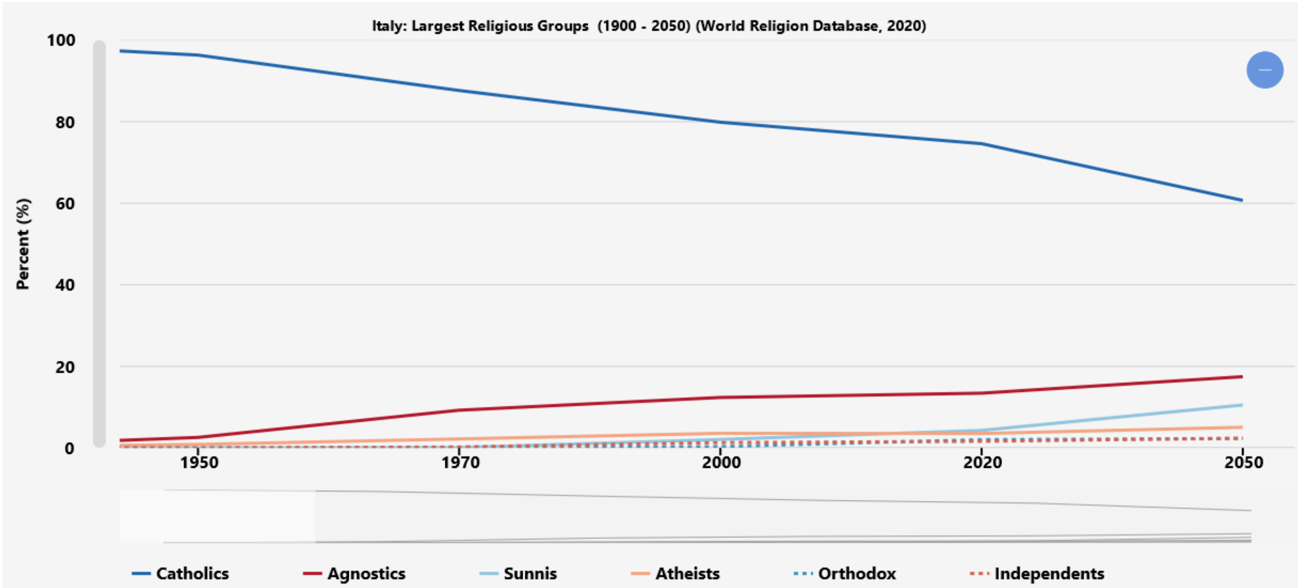

Figure 3.2: Growth of religious shares in Italy over time.
Source. Association of Religion Data Archives (ARDA) website.

impact beliefs and are translated to behaviours, could be of help. Table 3.1 summarizes Italian public opinion surveys on religiosity, conducted by the World Values Survey (WVS).[55,56] The World Values Survey distributes questionnaires and collects answers, related to values, to/from hundreds of thousands of people of different nationalities. Each wave of the survey covers a distinctive set of countries. As such, the data reported for the Italian public opinion, in Table 3.1, has gaps and/or missing observations. Nonetheless, it sheds light on many religiosity aspects and their recent developments. While belonging to the religious denominations declines, the religious beliefs seem to rise in all categories, together with the importance of religion, the confidence in religious organizations and the feeling of comfort found in faith. In the study on the impacts of the Jubilee event, the survey answers regarding believing in the existence of afterlife and the concept of sin are of particular interest. As shown in Table 3.1, a significant percentage of the modern Italian population shares the

[55]The survey is relatively recent.
[56]This table indicates opinions of all Italians, Catholics and non-Catholics. If Catholics only answers to be extracted from the survey, all the numbers reported are slightly higher.

Table 3.1: Italian public opinion on religious matters.

Italian Public Opinion	1981	1990	1999	2005
Religious Affiliation/Identification				
Percent belonging to a religious denomination	93.6	85.2	82.2	–
Percent identifying as a religious person	85.8	86.3	85.8	88
Religious Behaviours				
Percent attending religious services at least once a month	51.5	53.1	53.6	54.2
Percent meditating or praying	73.2	75.5	78.9	77.7
Religious Beliefs				
Percent believing in God	89.4	90.7	93.5	–
Percent believing in heaven	48.3	53.9	58.7	–
Percent believing in hell	37.4	41.9	49	–
Percent believing in life after death	58.6	68.1	72.8	–
Percent believing in a concept of sin	69.4	73.2	73.2	–
Percent believing church gives answers to people's spiritual needs	59.7	71.6	72.4	82.5
Percent believing church gives answers to moral problems	51.1	54.4	61.8	64.2
Religious Experiences				
Percent finding comfort and strength from religion	67.3	71.4	71.5	–
Attitudes				
Percent considering religion important	–	70.1	72.1	76.2
Percent confident in religious organizations	60.7	63	67	74.8

Source. The Association of Religious Data Archives (ARDA), calculated from World Values Survey.

Catholic Church official doctrine postulates on these matters.[57]

[57] The concepts of the afterlife and the punishment for sinning are integral parts of the Roman Catholic doctrine.

3.3.2 Italian crimes before 1972

The total crimes data for the first sub-sample, covering eighty-four years, is plotted in Figure 3.3. Similarly to Figure 3.1, the five Jubilee Years of the sub-period are marked by the green dash-dotted vertical lines and the wartimes are gray-shaded.[58] The solid red horizontal line indicates the sub-sample mean[59] and the two surrounding, from above and below, red dashed lines delineate the confidence interval of 95% from the mean.

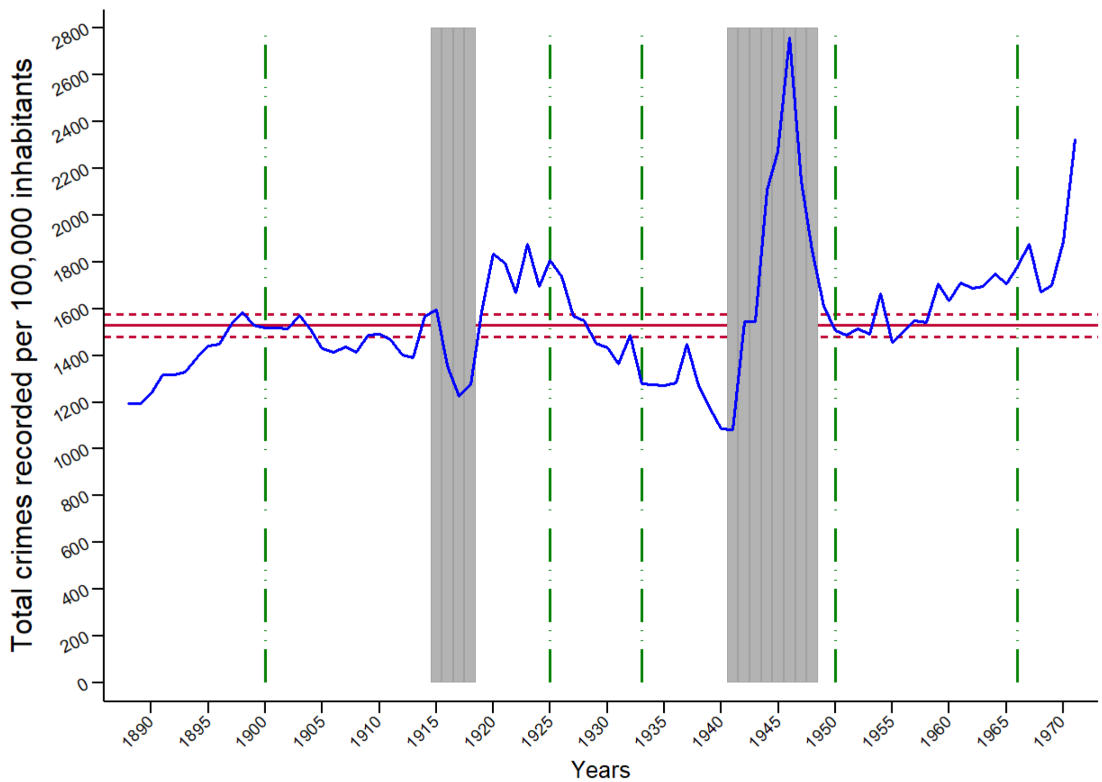

Figure 3.3: Total crimes in Italy, years 1888-1971.

In terms of the two World Wars, Italy participated in World War I, from 1915[60] to 1918, and World War II. Right after WWI, Benito Mussolini came to power in 1922 and remained a dictator of Italy until 1943. WWII-related period includes not only the years of war itself,

[58]Jubilee Years of 1900, 1925 and 1950 were ordinary, or classic, while 1933 and 1966 were extraordinary.
[59]Excluding wartimes.
[60]WWI started in 1914, but Italy officially joined the German/Austrian-Hungarian allies in 1915.

from 1941 to 1945, but also three post-war stabilization years, from 1946 to 1948.[61] The sharp increase at the very end of the sub-sample is related to the beginning of the next criminally unstable period of Italian history called "The Years of Lead".

By looking at the graph, one could discern, by visual inspection, that in three out of five Jubilees (1900, 1933, and 1950) the time series remain constant right after the events, decline in one case (1925), and increase in one case (1966). After the detected periods of stability, a visible increase occurred. To clarify this observation, Figure 3.4 plots the first difference for crimes levels depicted in Figure 3.3, including its' mean and the 95% confidence interval. Figure 3.4 shows that there were no statistically significant changes in crime levels following years 1900, 1933 and 1950.

As shown by the graph, after the years 1900, 1935 and 1950, the first difference remained inside the confidence interval for three years, suggesting that the changes in crimes levels were not statistically different from zero. This, in turn, provides an evidence of the series being constant. Moreover, these are the only periods of such prolonged stability over the sub-sample. Zooming-in at each Jubilee and analysing the events locally and separately, could provide valuable insight. Following the approach of technical analysis, used for financial data, a search for patterns will be conducted in the next paragraphs, where the Jubilees and their preceding/following years are to be discussed.[62] In all the graphs to follow, the red horizontal lines will indicate local means and their 95% confidence intervals.[63]

3.3.2.0.1 The Jubilee Year of 1900 was announced by His Holiness Leo XIII after the ordinary Jubilees of 1850 and 1875 were not celebrated.[64] The relevant Papal Bull was

[61] This fact is particularly emphasized by ISTAT in the context of the homicide statistics.

[62] For details on the technical analysis foundations and examples of the patterns, see `Investopedia.com` website.

[63] Each time the mean to be computed locally around the event. The confidence interval related to the mean is 1.96 times the standard deviation/square root of the number of observations. The number of observations taken into consideration will refer to the amount of years mentioned in the caption of each figure, which is about 10 years.

[64] For political instability reasons, see Scalzotto (2000), Vatican official documents, for reference.

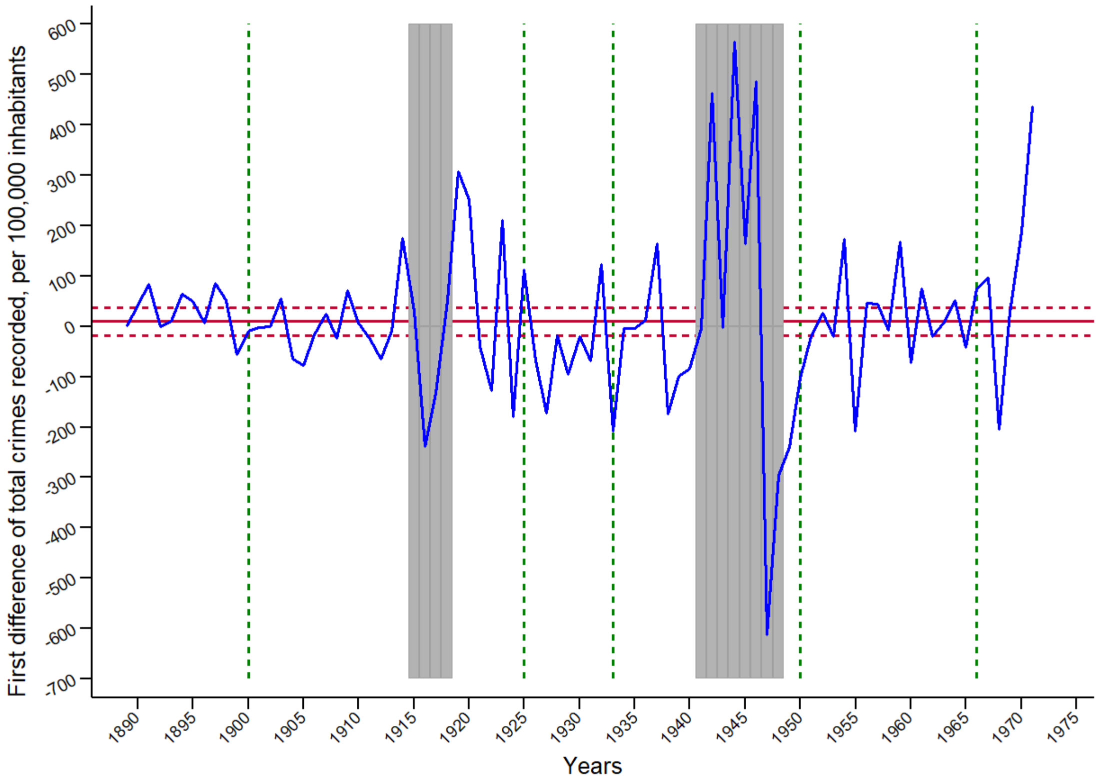

Figure 3.4: First difference of total crimes in Italy, years 1888-1971.

promulgated in May 1899 and supported by King Umberto's Disclose of the Crown before the Italian Parliament in September 1899. Figure 3.5 provides a close-up on ten years of criminal activities around the Jubilee Year of 1900.

As displayed by the figure, the crimes dropped in 1899, ending the previous positive trend.[65] The criminal offences count pattern observed around the Jubilee has a "two-towers" shape, with two spikes separated by three years of relative stability. Such a pattern is familiar from the technical analysis of the financial data, known as a "double-top". In the double-top trading pattern, two peaks are segregated by a "neckline", an interval with a relatively low and stable price level.

[65]A local upward trend, started from the beginning of the sample in 1888, is clearly seen in Figure 3.3.

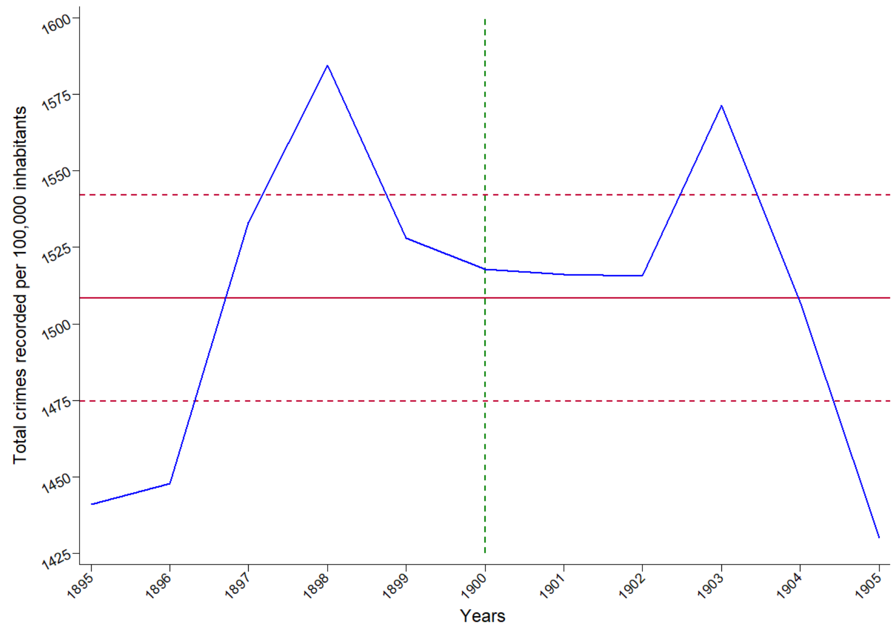

Figure 3.5: Total crimes in Italy, years 1895-1905.

The technical analysis is a time series method investigating dynamic patterns in time series behaviour.[66] It has been designed and routinely applied to financial data. In this thesis, a new application of the technical analysis to crimes time series is proposed and implemented, as a part of a religious event study, where the crimes levels are measured annually at the country level and considered a macro indicator. The novelty of this finding is that the pattern detected lasts for at least five years, as opposed to the transient existence of the financial data patterns, commonly observed during the daily trading, allowing for optimization of law enforcement and other related policies, if desired. Moreover, the pattern of criminal activities levels formed around the event in focus could be explained by the nature of the religious shock that caused the pattern to occur in the first place.

For the Jubilee of 1900 case, the first peak on the left side could constitute a last part of

[66] For reference, see Colby's (2003) "Encyclopedia of technical market indicators" or "International encyclopaedia of technical analysis: A - Z" by Siegel et.al. (2014).

the previous local upward trend, and to not belong to the Jubilee-related pattern.[67] From the year of 1900 and until the end of 1902, the vices levels remained relatively steady and rose again in 1903, compensating for the previous stability. Such behaviour over time of criminal activities is difficult to explain by other than Jubilee impacts, as no major event(s), that could cause crimes first to drop, then remain stable for a short period of time and rise again, occurred in Italian history at the very beginning of the 20^{th} century. If the Jubilee-related indulgences are the reason for the flatness in crimes levels detected around the Jubilee Year of 2000, detachment from all sins required for obtaining the plenary Jubilee indulgence and the promise not to sin again could cause the stability observed. After three years of partial abstention from bad deeds, some of the postponed crimes were executed, creating a one-time peak. Interestingly, the decline in crimes per 100,000 citizens in 1899 was (56.47), while compensation in 1903 accounted for 55.68 crimes, a number that is very close in absolute value to the reduction count.

3.3.2.0.2 The Jubilee Year of 1925 celebration aligned with a beginning of a local downward trend in criminal activities, that continued until 1931. This trend is visible in Figure 3.6. Three years prior to the Jubilee, in 1922, Benito Mussolini came to power, establishing his dictatorship to endure until the year 1943.[68] It is difficult to determine if the Jubilee of 1925 event is responsible for the start of the downward trend in crimes, or, perhaps, the fascistic regime of Mussolini had implemented more severe prosecution measures against the criminal offences, effectively causing the criminals to partly cease their activities. Except for these two possible explanations, no other meaningful occasion, that could create a downward local trend in criminal behaviours, is documented in Italian history. The double-top pattern observed around the Jubilee Year of 1900 is not detected here.

[67] See footnote 61 and Figure 3.3 on this matter.

[68] A longer-lasting downward trend, excluding the years surrounding the next Jubilee of 1933, is observed in Figure 3.3, persisting until the beginning of WWII.

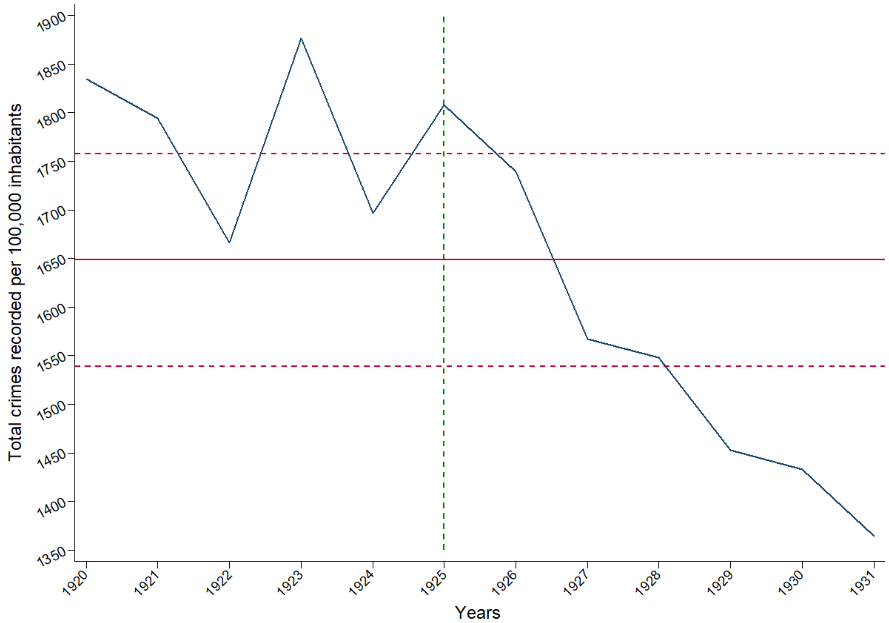

Figure 3.6: Total crimes in Italy, years 1920-1931.

3.3.2.0.3 The Jubilee Year of 1933 was extraordinary in the sense that it started on April 2^{nd}, 1933 and ended on April 2^{nd}, 1934.[69] The behaviour of crimes recorded, for ten years around the event, is depicted in Figure 3.7. Similarly to the Jubilee of 1900 graph in Figure 3.5, the crimes mimic the double-top shape, with two spikes separated by three years of relative stability. The second, compensation, peak, brings the crimes back close to the level prior to the event's start. Contrary to the Jubilee of 1900 case, the pre-Jubilee of 1933 peak's left side could not be accounted as a part of a previous trend, hinting that more crimes could be committed intentionally right before the event's initiation, in order to obtain the forgiveness later on.

3.3.2.0.4 The Jubilee Year of 1950 was celebrated right after the post-WWII stabilization period, which ended in 1948. The behaviour of criminal offences count around

[69] In this case, the data on crimes, recorded over a calendar year, does not fully coincide with the timing of the event.

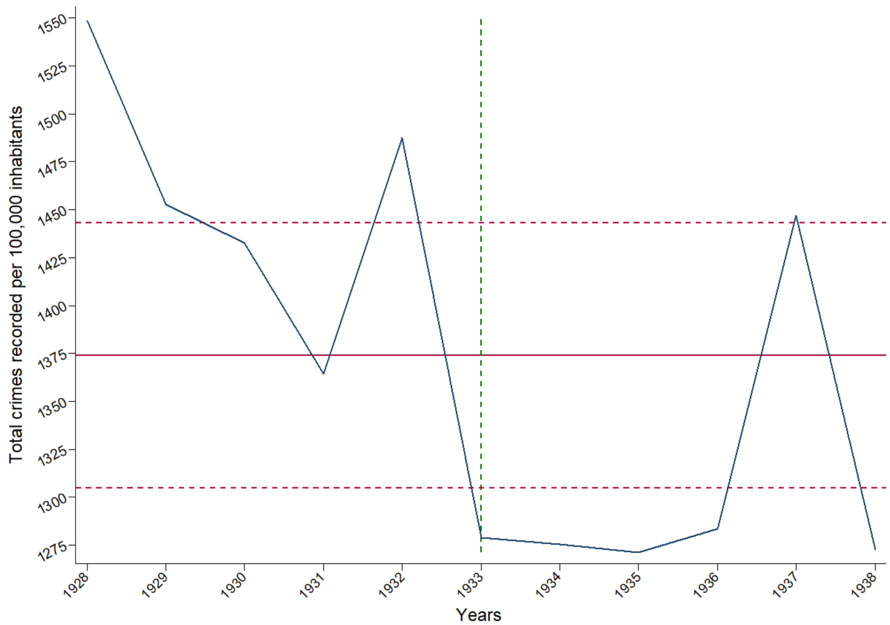

Figure 3.7: Total crimes in Italy, years 1928-1938.

the event is illustrated in Figure 3.8. The shape of the pattern observed resembles very much the double-top structure detected around the Jubilees of 1900 and 1933, with the left side of the first peak obscured by the strong downward post-war trend.[70,71,72] The criminal constant crime rate period lasted for three years, from 1951 to 1953, then a sharp one-time jump occurred. In this case, the second, compensation, spike exceeds in height the pre-Jubilee year count.

[70]Can be seen in Figure 3.3. The years prior to 1949 are not shown in Figure 3.8 because significantly higher amounts of crimes recorded in 1941-1948 would rescale the graph and vague the pattern around the Jubilee of 1950.

[71]Interpolation of the WWII-related years in crimes could probably reveal the first spike in full. However, the years from 1941 to 1948 are a long period of time to interpolate.

[72]With regards to the kink in Catholic shares documented by Figure 3.2 in 1950, the percentage of Catholics in the total Italian population changed from 95.98% in 1949 to 96% in 1950, and further to 95.56% in 1951. In terms of slopes of the curves involved, the shares were almost stable right before 1950 and declined by approximately 0.5% a year from 1950 onward. For the event's impacts studied, such a change is insignificant to alter the results of the analysis.

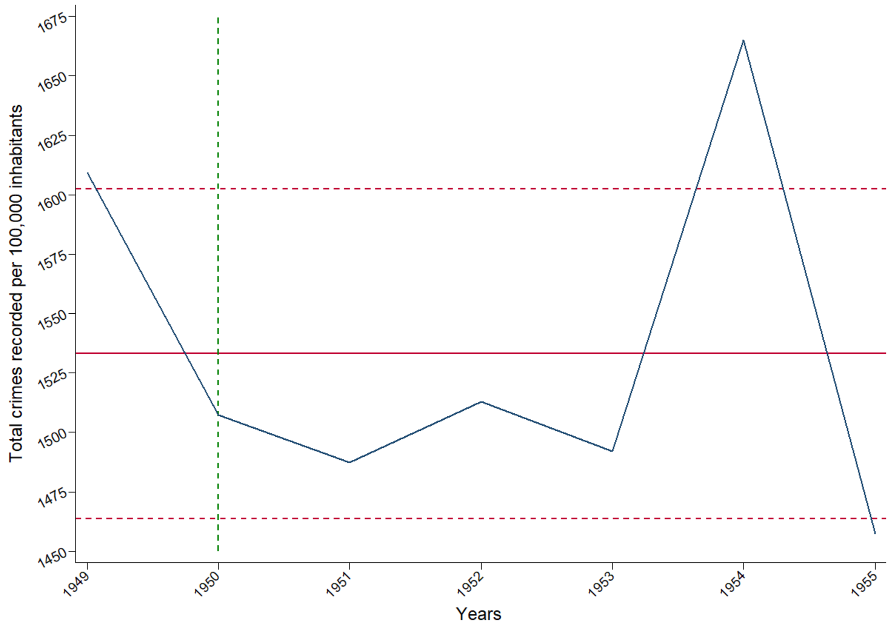

Figure 3.8: Total crimes in Italy, years 1949-1955.

3.3.2.0.5 The Jubilee Year of 1966 concluded the events of the Vatican II Council and was declared twice. At first, Saint Pope Paul VI declared the Extraordinary Jubilee of 1966 to last from January 1^{st} to May 29^{th}, while the announcement was made on December 7^{th}, 1965. On May 3^{rd}, 1966, a decision was made to extend the Jubilee until December 8^{th}. The crimes recorded pattern around the Jubilee of 1966 is depicted in Figure 3.9.[73]

The double-top structure, observed around a few previous Jubilees, is not detected here. It is worth reminding that in 1966 the faithful had to travel to Rome and pass via the Holy Doors of the patriarchal basilicas, in order to obtain the Jubilee plenary indulgence. The short first notice about the beginning and the initially planned compactness of the event could cause fewer pilgrims to attend the celebration. This, in turn, might be the reason why the pattern observed around the Jubilee of 1966 is not similar to the previously observed double-top shape.

[73]The right tail of the data plot indicates the beginning of the violent "Years of Lead", effectively impacting the wideness of the confidence interval.

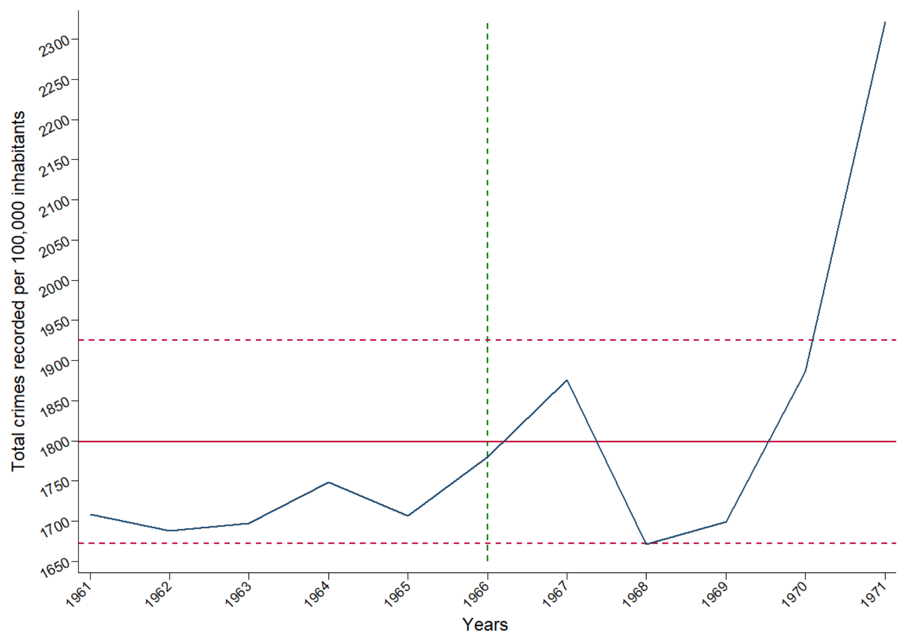

Figure 3.9: Total crimes in Italy, years 1961-1971.

To summarize the first sub-sample five Jubilees impacts, in three out of five cases the total crimes recorded around the celebrations exhibited a similar behavioural pattern. At first, the crimes declined, likely as a result of the detachment from all sins required for obtaining the Jubilee indulgence, then stabilized for three years, as if promises not to sin again, given after the sacramental confession, were kept. Finally, a one-time compensation peak occurred. In the case of Jubilee of 1933, a one-time pre-Jubilee increase in criminal activities can be clearly identified.

3.3.3 Italian crimes after 1971

The second sub-sample covers forty-two years, from 1972 to 2013. During this period, Italy did not participate in a global or a regional armed conflict, but rather fought internal wars. The crime levels trended upwards and displayed an increase in 1991. Figure 3.10 illustrates the dynamics of the criminal activities for the sub-sample and the three Holy Years

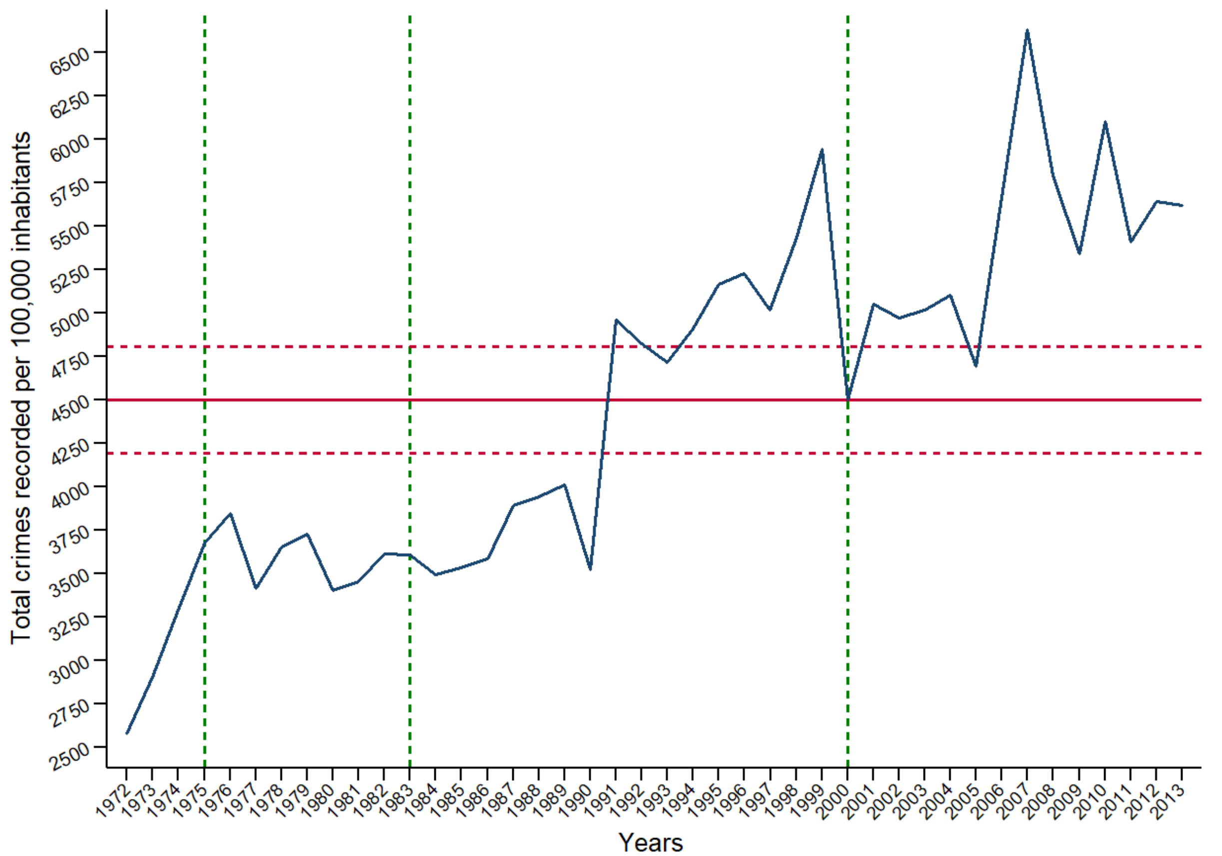

Figure 3.10: Total crimes in Italy, years 1972-2013.

celebrated: of 1975, 1983, and 2000.[74] As previously, the Jubilees of the period are indicated by the green vertical dashed lines, while the crimes mean and the 95% confidence interval around the mean are marked by the horizontal red solid and dashed lines, respectively.

At the beginning of the period, the "Years of Lead", which started in the late 1960s and continued until the early 1980s, causing a nationwide social unrest.[75] Opposite radical political powers, supported from outside Italy, executed terrorist attacks on civilians, including the assassination of the Democratic leader Aldo Moro, in 1976, and the Bologna rail station massacre, that killed eighty-five people, in 1980. The next wave of criminality in the

[74] Jubilee Years of 1975 and 2000 were held as ordinary, or classic, and the year of 1983 as extraordinary.

[75] The full scale of the upwards shift in crimes committed, caused by the "Years of Lead" ambience, can be seen in Figure 3.1.

modern Italian history is associated with the rise of the Sicilian Mafia in the early 1990s, and the measures the Italian government tried to implement against the organized criminal organizations. The Mafia reacted, among other acts of resistance, by killing two judges in 1992 and an attack on a tourist attraction, resulting in ninety-three injured people and ten dead, in 1993. Last but not least, the beginning of the Great Recession in 2007, caused by the global financial crisis of 2007-2008, fuelled another sharp increase in the Italian criminal activities count.[76] All the events mentioned have created a few increases in crime levels, depicted in Figure 3.10.

In terms of the sudden drops in criminal activities over the sub-sample period, the years of 2000 and 2008 could be noticed visually. As the data displayed an overall upward trend, de-trending would help to isolate the impacts of the various shocks on crime levels, including the influence of the Jubilees, if there are any, from the trend. Prior to de-trending, in order to check the stationarity of the data, a Dickey-Fuller (DF) test for unit root was performed. The DF test confirmed, at 5% significance level, that the time series is non-stationary and could be first-differenced to remove the stochastic trend. Alternatively, the presence of autocorrelation was examined. Figure 3.11 plots the serial correlation of crimes recorded, using the Bartlett's formula, at 95% confidence band. As shown, the serial correlation persistence declines linearly , providing evidence in favour of the unit root hypothesis. The autocorrelation fades away relatively fast, after four lags.

The results of first-differencing of crimes for this sub-period are shown in Figure 3.12. At the first glance, the only Holy Year that had a strong negative impact on vices count is the Great Jubilee of 2000. In addition, a decline and some stability appeared around the Jubilee of 1983. A search for extreme values of changes in the differenced data confirmed that the Holy Year of 2000 was the foremost negative outlier for the sub-sample. Overall, four

[76]Regarding the increase in the crimes recorded in 2006, ISTAT explicitly noted: "Since 2006 provisional data. In 2006 a process of migration between different information systems began in some prosecutors, which is increasingly affecting all of these offices, resulting in a reflection on the data."

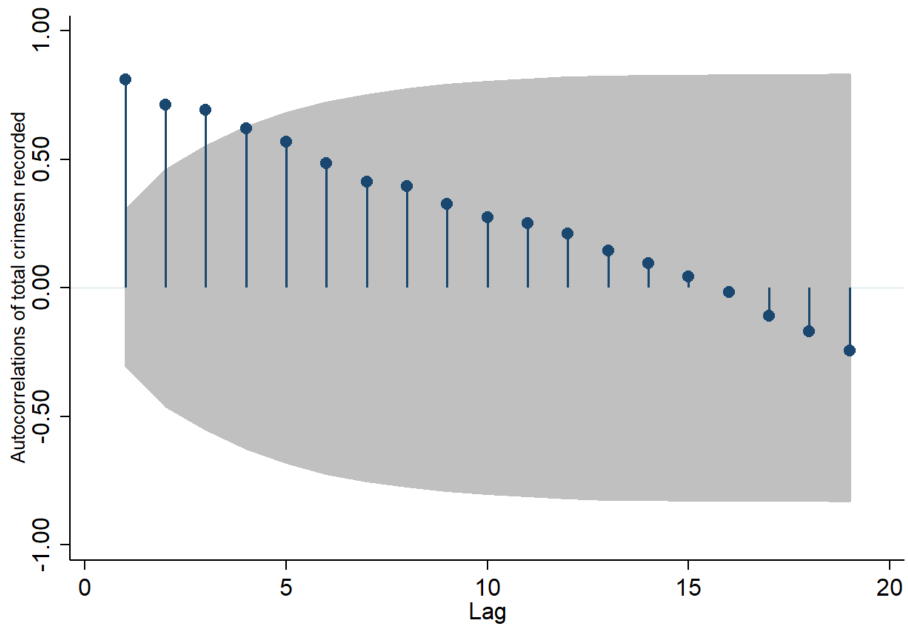

Figure 3.11: Autocorrelation of crimes in Italy, years 1972-2013.

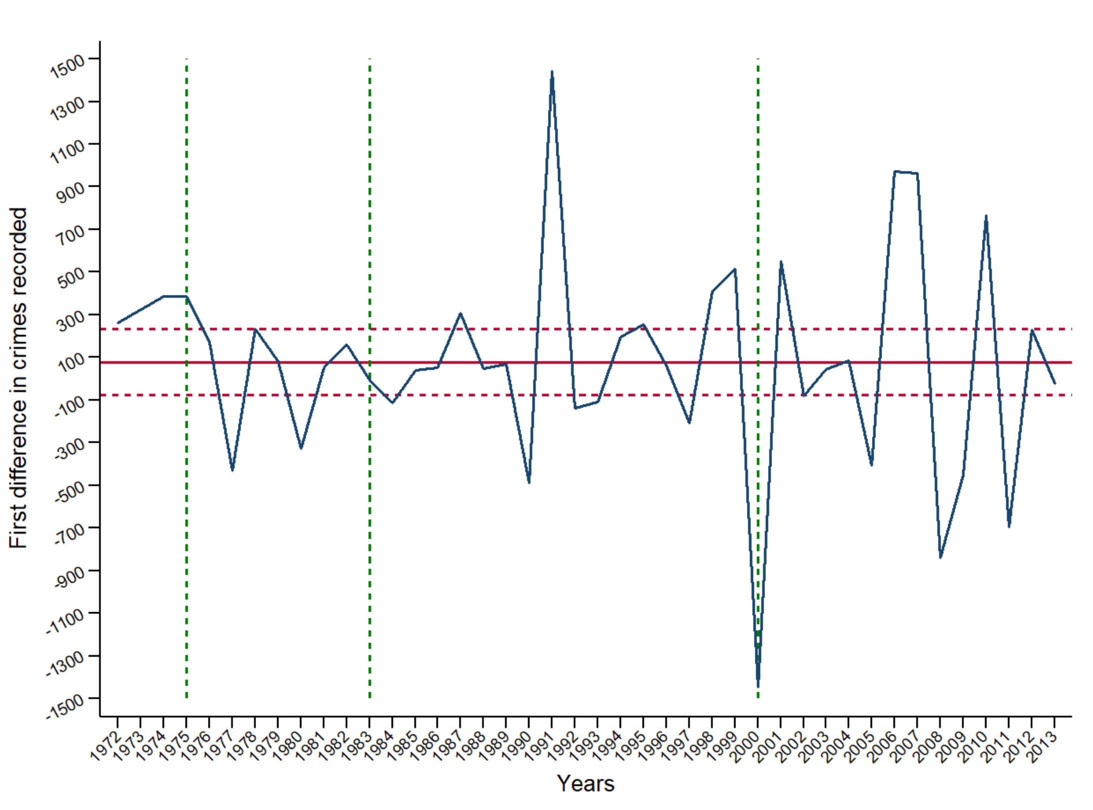

Figure 3.12: First difference of crimes in Italy, years 1972-2013.

values of first differences in crimes were recognized as extreme values: two positive and two negative. These points are identified by the box-plot in Figure 3.13. The lowest negative value of 1,444 crimes less than the previous year corresponds to the year of 2000, while the next negative outlier of 840 crimes refers to the year of 2008. As of the positive outliers, the smaller number, of 970 additional crimes, belongs to the year of 2006 of provisional data, while the increase of 1,440 crimes in 1991 verifies the violent impact of rise of Sicilian Mafia. To investigate the specific visible patterns around the Jubilees, if there are any, the next three paragraphs will focus on each Jubilee of the sub-period separately.

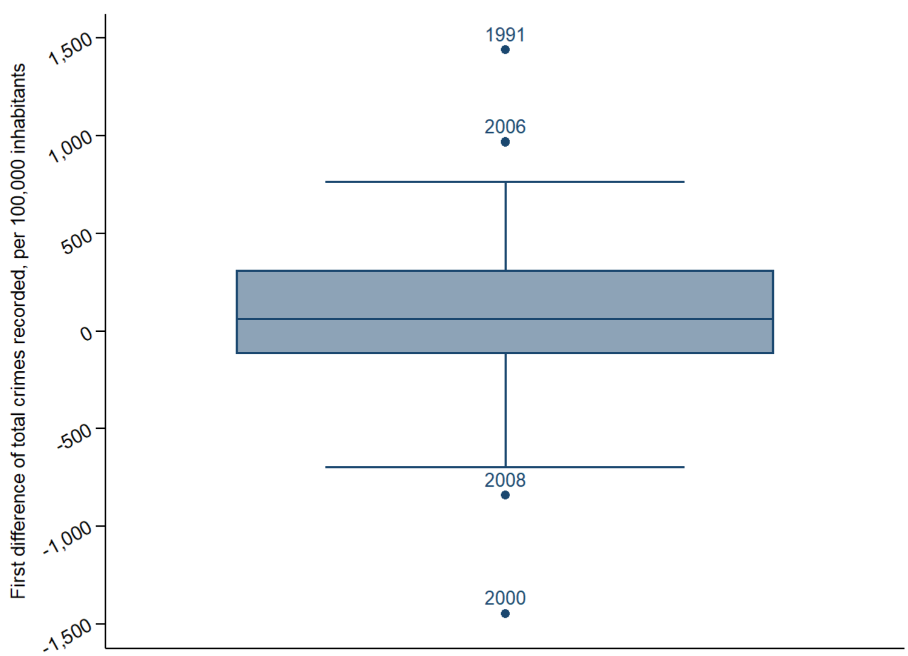

Figure 3.13: Boxplot of the first difference in Italian crimes, years 1972-2013.

3.3.3.0.1 The Jubilee Year of 1975 was celebrated toward the end of the turbulent "Years of Lead". Figure 3.14 plots the crimes and their first difference around the event.[77] No pattern, close to the double-top shape detected in the previous sub-sample, is observed. This fact could be explained by the absence of the event's impact or its' weakness, in comparison

[77] For Figures 3.14-3.16, the means and related confidence intervals are calculated over the amount of years stated in the captions of the figures. For this reason, the local means are not equal to zero.

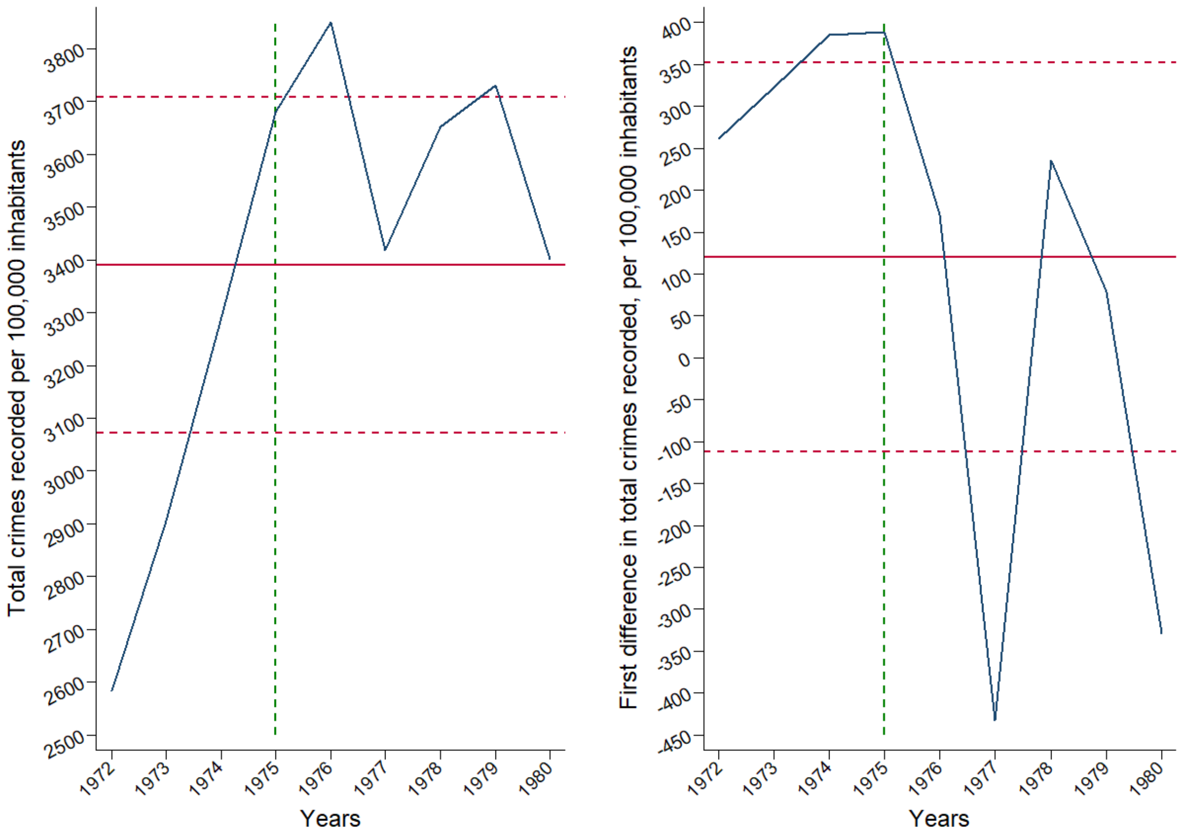

Figure 3.14: Total crimes and their first difference in Italy, years 1972-1980.

to the other powerful influences taking place around the same time.

3.3.3.0.2 The Jubilee Year of 1983 was extraordinary in the sense that it was celebrated from March 25^{th}, 1983 to April 22^{nd}, 1984.[78] The crimes pattern around the event is depicted in Figure 3.15. The decline in crimes during the event spreads over two years, 1983 and 1984, instead of one, turning the left spike of the double-top pattern, observed in the first sub-sample of the data, into a shape with two vertices. This, in turn, shrinks the stability interval to last for only two years, instead of three, as in the first sub-sample patterns. The right panel of the first differences indicates this as well.

[78]The annually recorded criminal offences data does not align in full with the Jubilee event time-line.

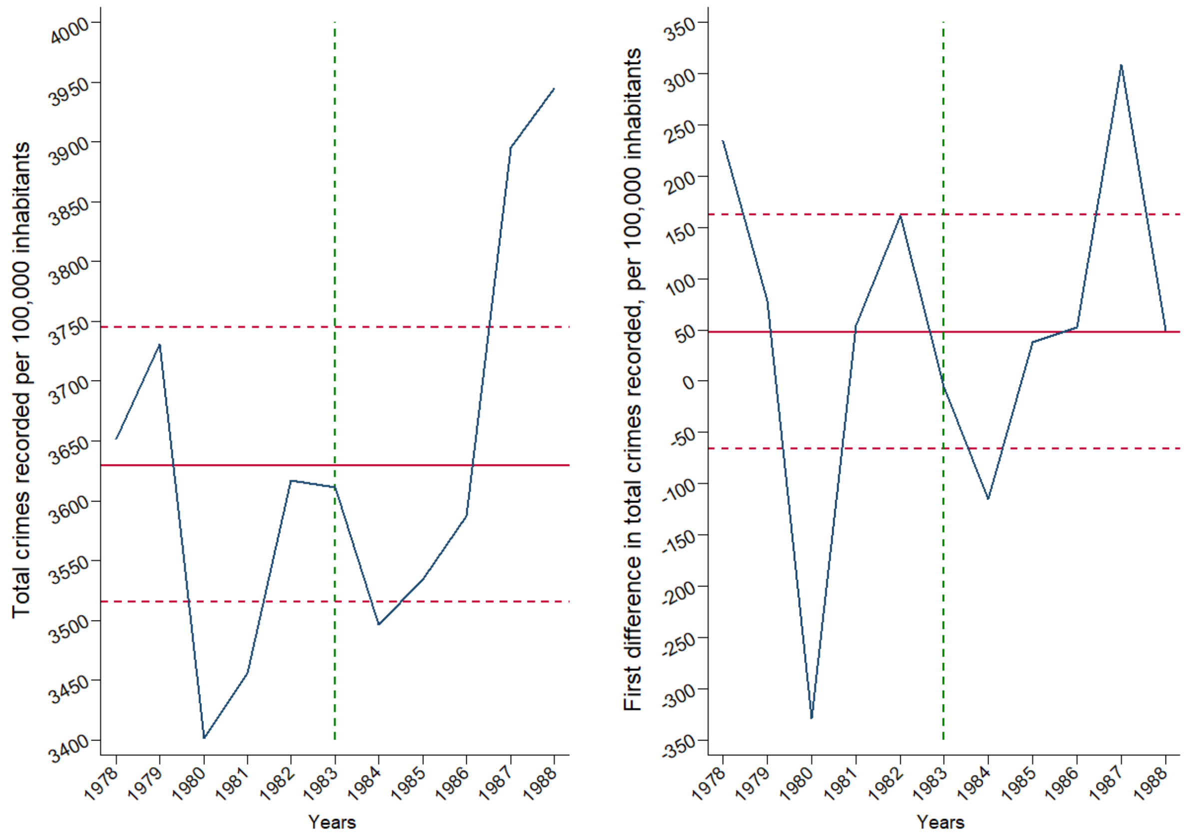

Figure 3.15: Total crimes and their first difference in Italy, years 1978-1988.

3.3.3.0.3 The Great Jubilee of 2000 was executed as a celebration of a much larger scale than any other Jubilee event held over the history of the Catholic Church. Moreover, a significant simplification of rites allowed Catholics to obtain the Jubilee plenary indulgence without the mandatory pilgrimage to Rome. Consequently, one could expect the pattern and the extent of the event's impacts to differ substantially from all the Holy Years previously investigated. In the pattern observed around the year 2000, depicted in Figure 3.16, the crimes spiked over the years 1998-1999, contrary to the Pope's call to the faithful to spiritually prepare themselves for the new millennium beginning. During the Great Jubilee itself, the one-time decline in criminal offences was substantial. However, the effect did not last and

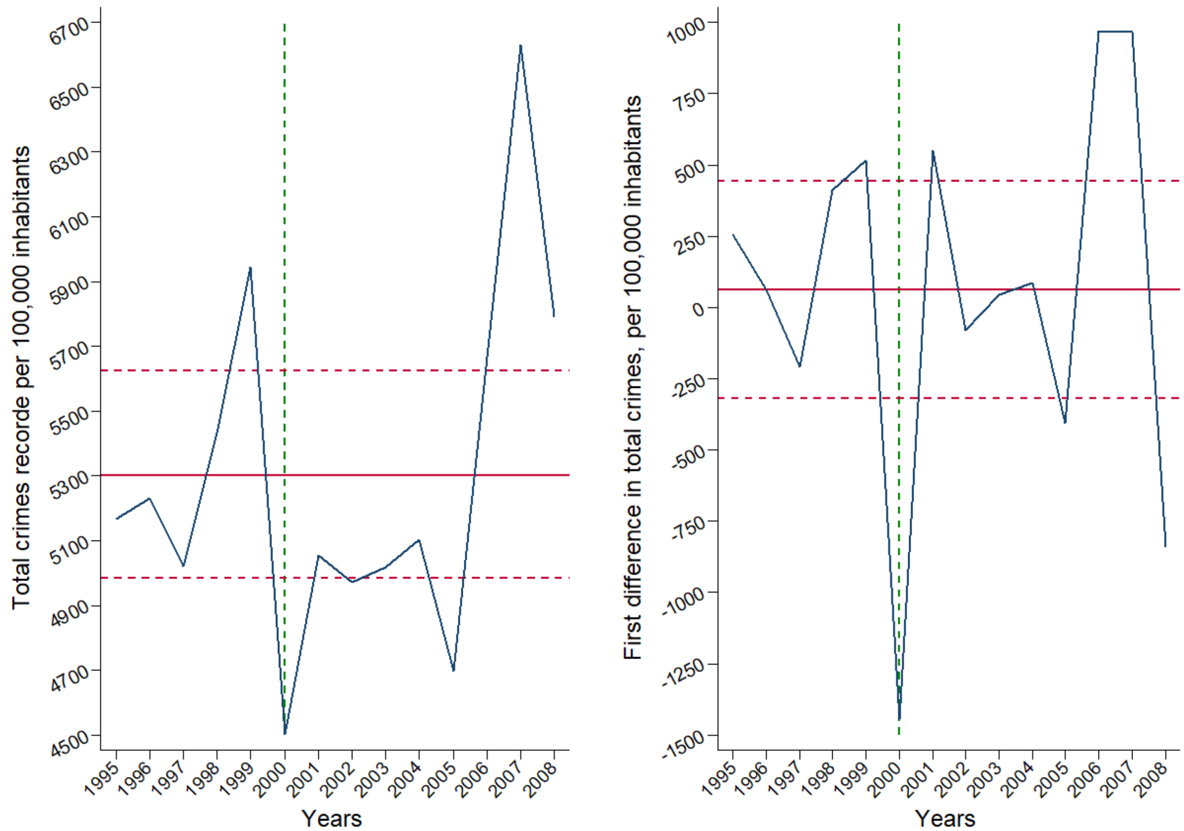

Figure 3.16: Total crimes and their first difference in Italy, years 1995-2008.

the number of crimes recorded corrected upwards partially right after the event's closure. Then some stabilization occurred. Quantitatively, the raw first difference in crimes recorded per 100,000 inhabitants from 1999 to 2000 was (1,444.61). In 2000, the Italian population was close to sixty million citizens. For sixty million inhabitants, a reduction in crimes of (1,441.61) per hundred thousand, from the preceding year of 1999, would accumulate to approximately 867,000 crimes less in total. As Rome experienced an additional influx of pilgrims-tourists[79], and thefts constituted around half of the total amount of crimes committed,[80] one could expect from the thieves not to miss the convenient opportunity to make a quick profit from

[79]Tourists duration of stay in Rome increased by 42%, from 17 million nights in 1999 to more than 24 million in 2000. See Bronzini et.al. (2020) for details.

[80]According to ISTAT, thefts accounted for 56.31% of the total crimes recorded in 2000.

tourists' pockets. However, this opportunity was missed. On the other hand, when taking into account the growth in crimes that occurred right before and after the Great Jubilee, then the negative effect of the event on crimes wanes.

To summarize the Italian crimes behaviour around eight Jubilees celebrated over the period of 1888-2013, at least in half of the cases the criminal offences dropped right before or during the event year, then remained constant for three years, then corrected upwards. In the case of the Great Jubilee of 2000, the level of recorded crimes first corrected, then stabilized.

3.4 European Studies

3.4.1 Data sets

3.4.1.1 EuroStat data on crimes

A second data set for the study on the impact of the Jubilee Year event on criminal activities is extracted from the European Commission Statistical Bureau (EuroStat) database. The sample of interest covers one full wave of the historical national administrative data on crimes collected annually from 1993 to 2007, fifteen years in total, with the Great Jubilee of 2000 event positioned right in the middle of the sampled period.[81] Out of the thirty-nine countries presented, thirteen had missing observations and were excluded from the dataset in order to create a balanced longitudinal sample. The remaining 26 countries had 15 annual observations each. That is, the times series dimension of the sample in focus is 15 years, while

[81] Only one Jubilee occurred for this period of time. A conceptually related worldwide event held during the year of 2000, known to the authors, was the "International Year for the Culture of Peace", declared by UNESCO and targeted all nations. This event launched media campaigns and collected around 75 million signatures in support of a culture of peace, under the Manifesto 2000 Project. In addition, a Culture of Peace News Network (CPNN) was established. For details, see UNESCO executive board session no.161 report (2001) on the event's results and Page's (2001) interpretation on its' efficacy. A separation of UNESCO event's influences on crimes recorded, if there are any, from the Jubilee impacts, will be addressed in the empirical analysis section.

the cross-sectional dimension is 26 units of observation (countries), making 390 observations in the panel data. All countries had stable geographical borders during the time period studied.

The annual offences data, as were recorded from January 1^{st} to December 31^{th} each year by law enforcement authorities, reflect all criminal law violations in each country. The main categories of crimes reported include intentional homicides, robberies, burglaries of private residential premises, thefts of a motorized land vehicle, unlawful acts involving controlled drugs or precursors and acts causing harm or intending to cause harm to the person, injurious acts of a sexual nature and acts against property involving violence or threat against a person.[82] All crimes assigned an equal weight in the sample. The data on crimes provided by EuroStat offers only the total amount of crimes recorded annually for each country, while the nations vary significantly by population size. Thus, creating a variable of crimes per hundred thousand inhabitants would help to adjust the overall amounts of crimes committed to the population size of each country, in order to make a valid comparison between the units of observation (countries) over time. For more consistency in sampling procedures, the population data for each country were extracted from the same source, the EuroStat database, and a variable of crimes per hundred thousand citizens was created, intended to serve as a dependent variable in the longitudinal data analysis.[83] A summary statistics for crimes recorded is presented in Table 3.2, across all countries and years.

A full list of countries in the sample will be provided in the next sub-section, together with the statistics on religious affiliations.

[82] Notice that the main categories of crimes included by EuroStat differ substantially from the types of crimes emphasized by ISTAT in the Italian case discussed previously. If the impacts of the religious event in focus to be found consistent for both data sets, provided on distinctive crimes types and reported by independent statistical bureaus, this would enhance the validity of the findings, if there are any.

[83] For one of the countries in the sample, United Kingdom, the crimes provided by EuroStat are divided to England *and* Wales, Scotland and Northern Ireland, while the population data is supplied for the whole country only. For compatibility, the crimes were summed to total British crimes, each year, then a variable of crimes per 100,000 British citizens was calculated.

Table 3.2: Summary statistics of crimes recorded across countries and years.

	Number of observations	Mean	S.d.	Minimum	Maximum
Crimes per 100,000 inhabitants	390	5,004.24	3,133.25	51.70	14,334.33

Notes. The unit of observation is a percentage of Catholics in country i at year t. Number of observations refers to 26 countries observed over 15 years.
Source. European Commission Statistical Bureau (EuroStat), years 1993-2007.

3.4.1.2 Data on European Catholicism

As the religious event studied, the Great Jubilee of 2000, is celebrated exclusively by the followers of the Roman Catholic Church, potential populations under the treatment of the event are the Catholics residing in each country sampled. Unfortunately, the exact number of indulgences granted to the faithful during the Jubilee Years, including the Great Jubilee of 2000, is unknown.[84] However, the Catholic share of the populations can serve as a proxy for such amount, especially in the case of countries where Catholics constitute the vast majority of the population and could potentially cause a substantial divergence in criminal activities count, if impacted by the Jubilee Year customs. To give a clear picture on the presence of the Catholic faith in Europe, Figure 3.17 maps all European countries by their Catholic share. The dark red color indicates countries where the majority of the population identifies as Catholics, while a yellow shade points out non-Catholic religious and/or secular dominances. As shown in the graph, the Catholic faith is a very prominent religious denomination in many European countries.

As of countries from the longitudinal balanced sample in focus, their populations and Roman Catholic shares in 2000 are presented in Table 3.3, in a descending order.[85]

[84] The Holy See, or any other source, never published a statistical research on the count of the indulgences obtained, to the best of my knowledge. One of the reasons for lack of such data could be the private and sacramental nature of the confession required for obtaining an indulgence.

[85] The percentage of Roman Catholics contains Catholics of Latin and Non-Latin Rites, both under the spiritual authority of the Holy See. The Non-Latin Rites denominations comprise combined Armenian, Coptic, Ethiopian, Mar Thoma and Syrian (including Alexandrian and Antiochian) Catholic Rites. However,

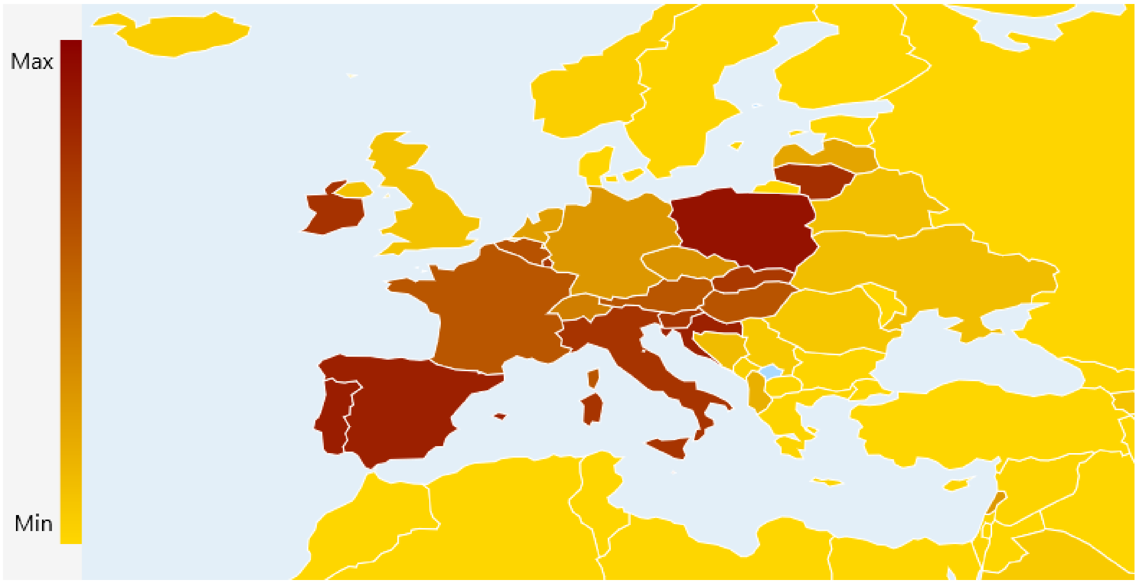

Figure 3.17: The percentage of Roman Catholics in the population of European countries as of 2020.
Note. A little blue dot in the middle is a "no data" region in Kosovo.
Source. Association of Religion Data Archives (ARDA), Geographic Information Systems (GIS) mapping.

As shown by the table, in twelve countries out of twenty-six, Catholics dominate other religious confessions by the simple majority, while in ten countries out of twenty-six the Catholic faith followers exceed seventy percent of the population. Given the fact that the Great Jubilee of 2000 was the first planetary Jubilee and every Roman Catholic could take part in the event without travelling to Rome, such elevated Catholic shares should be sufficient to detect the influence of the celebration on crime levels in predominantly Catholic countries, if there is any.

In the empirical analysis to follow, dichotomizing the countries in the sample by Catholic majority/non-majority (or super-majority of 70%) in 2000 can serve as an identification tool for countries under treatment of the event. Furthermore, the super-majority[86] sub-sample, as containing countries with higher share of Catholics in the populations, should potentially

the Non-Latin Rites Catholics constitute a historically minuscule fraction of Roman Catholics in Europe.

[86]Catholic share higher than 70% of the population.

Table 3.3: Total population and Roman Catholics by percentage in twenty-six selected European countries, in 2000.

Country	Total population, millions	Roman Catholic share of the population
Poland	38.35	90%
Croatia	4.48	86.84%
Portugal	10.31	84.53%
Slovenia	1.99	80.08%
Lithuania	3.5	79.12%
Italy	56.99	78.87%
Spain	40.28	74.93%
Austria	8.02	74.25%
Luxembourg	0.44	72.62%
Slovakia	5.39	72.1%
France	59.21	60.97%
Hungary	10.22	55.98%
Switzerland	7.17	42.3%
Germany	83.51	32.57%
Netherlands	15.86	32.2%
Czechia	10.25	28.09%
United Kingdom	58.95	9.6%
Romania	22.39	5.7%
Cyprus	0.94	1.56%
Sweden	8.87	1.38%
Norway	4.49	0.9%
Denmark	5.34	0.64%
Estonia	1.37	0.51%
Greece	10.99	0.5%
Finland	5.18	0.14%
Turkey	66.9	0.05%

Source. The Association of Religious Data Archives (ARDA).

be impacted more by the Jubilee celebration than the simple majority larger set of nations, on average, if there is such impact to be detected. The frequencies of the Catholic majority/super-majority over the sampled period are provided by Tables 3.4 and 3.5.

Table 3.4: Catholic majority frequency across countries and years.

Majority	Frequency	Percent
0	213	54.62
1	177	45.38
Number of observations	390	100

Notes. Majority definition stands for 50%+1 of Catholics in the population. Number of observations refers to 26 countries observed over 15 years.
Source. The Association of Religious Data Archives (ARDA), years 1993-2007.

Table 3.5: Catholic super-majority frequency across countries and years.

Super-majority	Frequency	Percent
0	250	64.10
1	140	35.90
Number of observations	390	100

Notes. Super-majority definition stands for higher than 70% of Catholics in the population. Number of observations refers to 26 countries observed over 15 years.
Source. The Association of Religious Data Archives (ARDA), years 1993-2007.

With regards to the Catholic majority/super-majority frequencies, it is worth noting that in some countries the Catholic shares developed slowly over time, crossing the thresholds (of 50% or 70%) from above or below only once over the time period in focus. For this reason, the same country could be counted as having a Catholic majority in one year, but not having it in another year, or vice versa. Furthermore, in one country, Slovakia, such threshold (of

70%) was crossed more than once, as the Catholic shares developed over time in a non-linear fashion. In Slovakia, the percentage of Catholics in the population was increasing from the beginning of the period and crossed the threshold of 70% from below in 1998, remained above the threshold until 2006, then declined beneath 70% level again.[87]

The development of the Catholic shares in each country over time is illustrated in Figures 3.18 and 3.19, where Figure 3.18 concentrates on countries with Catholic shares higher than fifty percent, and Figure 3.19 on the rest of the countries.

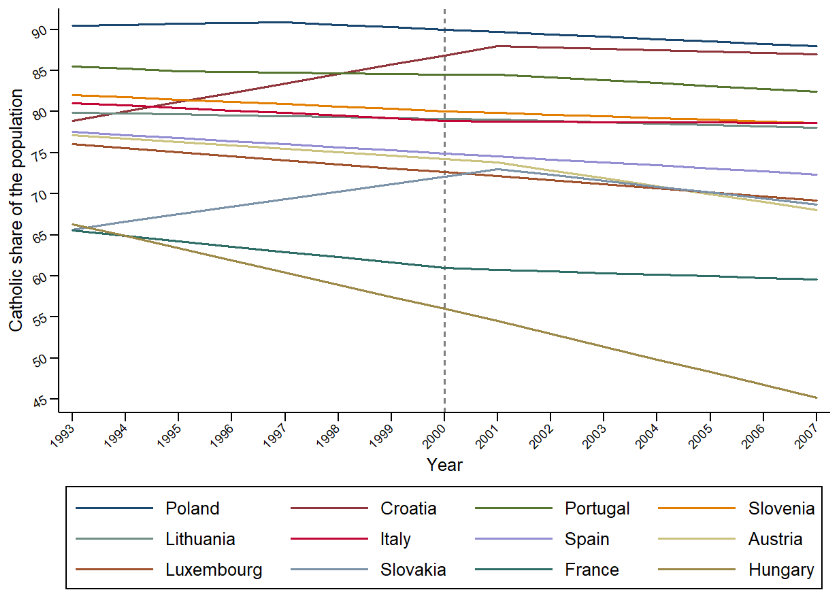

Figure 3.18: Catholics as a percentage of the population in Catholic majority countries. *Source.* The Association of Religious Data Archives (ARDA), years 1993-2007.

In Figure 3.18, a very weak decrease is observed for all except two countries, Slovakia and Luxembourg. These two countries have an increase with a kink in 2001. Hungary exhibits a steeper than other countries decline. In Figure 3.19, the percentage of Catholics in the population remains constant in all countries but Netherlands, Czechia and Switzerland, which show a linear decrease. In addition, kinks detected for Czechia in 2001 and Netherlands in 2005. As shown by the figures, no inflow/outflow of faithful is observed around the year

[87]These changes in Catholic shares to be illustrated by Figure 3.18.

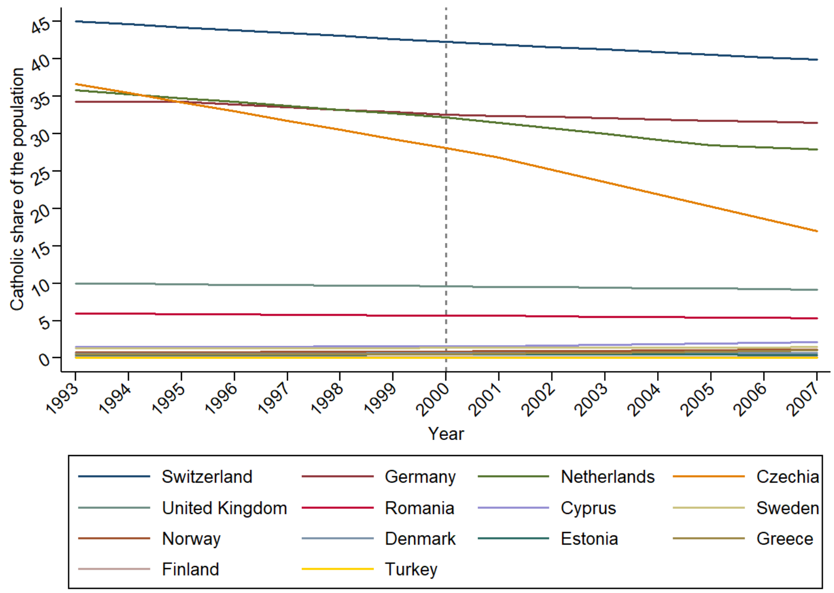

Figure 3.19: Catholics as a percentage of the population in Catholic minority countries.
Source. The Association of Religious Data Archives (ARDA), years 1993-2007.

of 2000, i.e. the occurrence of the Great Jubilee event did not cause a massive enrolment into Catholicism in order to obtain the remission of sins, nor retraction of believers from Catholicism after the event was over.

Polled Catholic shares summary statistics, for all countries in the sample, is provided by Table 3.6.

Table 3.6: Catholic shares summary statistics across countries and years.

	Number of observations	Mean	S.d.	Minimum	Maximum
Catholic share	390	40.84	34.57	0.05	90.88

Notes. The unit of observation is a percentage of Catholics in country i at year t. Number of observations refers to 26 countries observed over 15 years. The maximal percentage of Catholics, 90.88%, belongs to Poland, while a minuscule fraction of 0.05% indicates the percentage of Catholics residing in Turkey.
Source. The Association of Religious Data Archives (ARDA), years 1993-2007.

Despite the wide spread in the Catholic shares count between the countries, documented by Tables 3.3 and 3.6, Figures 3.18 and 3.19 showed that the percentage of Catholics in the populations changed gradually over time, in the vast majority of countries.

3.4.1.3 Data on additional macro-economic variables

While the event in focus, the Great Jubilee of 2000, is of religious nature, considering additional explanatory macroeconomic variables in the empirical analysis could enrich the model and help to verify that the results obtained on the impact of the event are robust to alternative specifications. I consider two variables that could potentially impact crime levels: urban population share and inflation rate. An urban population share is a macroeconomic measure related to the population density family of indicators. Specifically, an urban share of the population points out the degree of population concentration in the cities (or urban areas) and should, potentially, be positively correlated with the amount of crimes recorded. Summary statistics for urban population shares, collected by the United Nation Population Division and provided by the World Bank Development Indicators database, is shown in Table 3.7. Similarly to the Catholic shares, urban shares of the population developed slowly over time in each country.

Table 3.7: Urban population shares summary statistics across countries and years.

	Number of observations	Mean	S.d.	Minimum	Maximum
Urban population share	390	69.55	10.25	49.79	87.41

Notes. The unit of observation is a country i at year t. Number of observations refers to 26 countries observed over 15 years.
Source. World Bank Development Indicators, years 1993-2007.

Another socio-economic factor appropriate to incorporate as explanatory variable in the analysis is an inflation rate. This is because the decline in purchasing power of the local currency could reduce the level of the real disposable income for many households. For this study, the dataset on Consumer Price Index (CPI) were collected by the International Monetary Fund and provided by the World Bank Development Indicators.[88] Inflation rates for the sampled period are presented in Table 3.8.

Table 3.8: Inflation rates summary statistics across countries and years.

	Number of observations	Mean	S.d.	Minimum	Maximum
Inflation rate	390	13.90	81.22	-1.13	1500

Notes. The unit of observation is a country i at year t. Number of observations refers to 26 countries observed over 15 years.
Source. World Bank Development Indicators, years 1993-2007.

As shown in the table, inflation rates varied significantly over the sampled period. In particular, two-digits or even three-digits annual inflation was observed for the countries with a Socialist past at the beginning of the period.[89] One plausible explanation is that after Communism was replaced, a stabilization of Post-Socialism economies took a few years. This transition is reflected in the data by declining inflation rates from the year 1993 onward.

In terms of the social justice systems, the countries with a Socialist past inherited a fundamentally different law making and law enforcement infrastructures, which had to rapidly adjust to the standards of Western democracies after the regimes switched, as all ex-Communist countries in the sample applied to join the European Union.[90] To account for such distinctive in criminal coding/recording past in the empirical analysis, ex-Communist countries in the sample were marked by an ex-Communism binary variable. These countries include: Poland,

[88] The CPI was calculated using Laspeyres formula.
[89] The highest annual inflation rate in the sample of 1500% a year belongs to Croatia in 1993.
[90] Countries-applicants had to fully comply with *Copenhagen criteria*, which include chapters on judiciary and fundamental rights, justice, freedom *and* security, company law, intellectual property law, and more.

Croatia, Slovenia, Slovakia, Lithuania, Hungary, Czech Republic, Romania and Estonia.[91,92]

3.4.2 Empirical strategies and analysis

3.4.2.1 The model

Let us now consider the balanced panel data on 26 European countries where the annual crimes rates were recorded over 15 years, discussed in sub-section 3.4.1. Let the unit of observation (country) be denoted by i, $i = 1 \dots N$, where $N = 26$ and the year by t, $t = 1 \dots T$, where $T = 15$. The total count of observations is the amount of countries times the number of years, or $N \cdot T = 26 \cdot 15 = 390$. In the model, binary explanatory variables to be denoted by D and the rest of the control variables by x. Each variable to be indexed by i and t. The impact of the event on crimes to be estimated by the model of the form:

$$crimes_{i,t} = \beta_0 + \beta_1 D^1_{i,t} \cdot D^2_t + \beta_2 x^1_{i,t-1} + \beta_3 x^2_{i,t-1} + \beta_4 x^3_{i,t-1} + \beta_5 D^3_i + \mu_t + \varepsilon_{i,t} \tag{3.1}$$

where the dependent variable $crimes_{i,t}$ is the level of crimes recorded per 100,000 citizens in country i at year t. The crime rates are explained by the following independent variables.

A variable $D^1_{i,t}$ is a Catholic super-majority binary variable that takes upon a value of one if the percentage of Catholics in country i at year t exceeds the threshold of 70% of the population. Alternatively, if the percentage of Catholics falls below 70%, a value of zero is assigned to $D^1_{i,t}$.

A variable D^2_t is a binary variable that identifies the presence of the religious event shock. As such, it is assigned a value of one when the year is 2000, and zero otherwise. That is, $D^2_{year=2000} = 1$ and $D^2_{year\neq 2000} = 0$.

[91] Germany was not coded as ex-Communist, as West Germany exceeded East Germany by territory and population sizes.

[92] Poland and Romania joined the European Union in 2007, and the rest of the countries in 2004. The application process to obtain a candidate status and later on a full membership took years.

The interaction term, $D^1_{i,t} \cdot D^2_t$, is placed to isolate the impacts of the event on predominantly Catholic countries, as it takes a value of one only when a country i has at least 70% of Catholics in the population at year t *and* the year is 2000.[93]

All the controls to be used in the analysis, indicated by x, are extracted for the year prior the annum crimes levels were recorded, effectively making all the independent variables denoted by $x_{i,t-1}$ predetermined/exogenous to $crimes_{i,t}$. This, in turn, eliminates potential endogeneity and/or reverse causality issues between the crimes levels recorded at t and the vectors of explanatory variables. In other words, an explanatory variable measured at year $t-1$ could impact the crimes levels at year t, but not the opposite direction.

A variable $x^1_{i,t-1}$ denotes the percentage of Catholics in country i at year $t-1$. The reason for adding an independent variable of the exact share of Catholics in the population alongside with the Catholic super-majority binary variable is to create a separation of Catholicism related influences on crimes levels, at all times, from the impacts of the one-time event, if there are any. The Catholic shares of the populations are considered at $t-1$, as in most of the countries the percentage of Catholics changed over time at a slow rate, as was shown by Figures 3.18 and 3.19.[94,95]

A variable $x^2_{i,t-1}$ is the urban population share in country i at year $t-1$. This variable represents the percentage of the population concentrated in the cities. Such concentration, when increasing, is expected to be positively correlated with the amount of crimes recorded. When the urban population share is taken into account at $t-1$, potential reverse causality issues, arising from, for instance, higher crimes levels that could potentially cause urban

[93] The countries under the treatment are the first 10 countries enumerated in Table 3.3, with percentage of Catholics higher than 70% of the population in 2000. Same countries maintained the Catholic super-majority ranking in 1999, leading to $D^1_{i,2000} \cdot D^2_{2000} = 1 \Leftrightarrow D^1_{i,1999} \cdot D^2_{2000} = 1$. Moreover, if a softer definition of super-majority to be applied, e.g. 66.67% of the country population identify themselves as Catholics instead of 70%, the list of countries under the treatment would remain unchanged.

[94] Kinks, observed for Slovakia, Luxembourg, Czechia and Netherlands, do not exceed 2% change in Catholic shares, in absolute value.

[95] Replacing the shares at $t-1$ with the contemporary ones would not change the results of the analysis qualitatively.

residents to move out from the cities during the same year, are avoided.

A variable $x^3_{i,t-1}$ is the difference in inflation rates, calculated between the years $t-1$ and $t-2$. The logic behind using as a control variable the change in CPI and not the raw inflation rate itself, is that the change in CPI could reflect better on how the fluctuations, especially sharp, in CPI would impact crimes levels.[96,97]

The binary variable D^3_i is a Post-Communism indication variable. When takes upon a value of one, it separates a Soviet era historical heritage European countries might carry, in terms of criminal behaviours, from the rest of the countries.

The variable μ_t indicates time fixed effects, while $\varepsilon_{i,t}$ is the error, with mean zero and assumed to display cluster heterogeneity at the year level.

3.4.2.2 Empirical results

In order to assess the impacts of the religious event in focus on crimes levels, model (3.1) from previous sub-section was empirically estimated. The estimation results are reported in Table 3.9, where in each column of the table additional explanatory variable is added.

Column (1) examines the basic case where only Catholicism related independent variables are incorporated in the analysis. The purpose of examining Catholic shares together with the Jubilee impacts in predominantly Catholics countries is to separate the influences of the criminal behaviour patterns of all Catholics, at all times, approximated by the religious shares of the populations, from the Jubilee celebration related shift in criminal activities count, if there is any. By column (1) estimation results, Catholics committed less crimes

[96] For example, the relatively low and persistent inflation, observed recently in many European countries for long periods of time, adjusted the public expectations to continue to experience similar levels of inflation in the future, especially when the Central Banks openly confirmed their inflation targets. When such expectations are not realized, and the inflation rose (dropped) more than expected, crimes, especially property crimes, could increase (decrease).

[97] Alternative controls of GDP per capita and unemployment rate, at $t-1$, were considered, but did not add much of explanatory power to the model, nor provided significant results and/or changed the main findings on the Great Jubilee of 2000 impacts. A first lag of the unemployment rate, when estimated, found marginally (at 10% level) positively significant in explaining crimes levels.

than other religious/secular denominations, on average, over the time period sampled and especially during the Great Jubilee of 2000 event's celebration in predominantly Catholic countries. The latter finding is of particular interest, as the event's impact on crimes levels in Catholic super-majority countries found to be negative and significant at 1% level.

However, the former finding is challenged when additional controls are incorporated, as the Catholic shares estimated coefficient switched sign from negative in column (1) to positive in column (2), after the urban population share was added.[98] As expected, an urban population share[99] found significant and positively correlated with the levels of crimes recorded, likely due to the fact that crowded environments, such as cities, offer more opportunities for criminal activities to take place. The estimated coefficient of the Great Jubilee of 2000 impacts declined by more than half in absolute value, from column (1) to column (2), but remained negative and significant at 1% level.

In column (3), raising inflation at $t-1$ estimated to have a positive correlation with crimes recorded at t, at 5% significance level, while the rest of the coefficients maintained the magnitudes and significance levels similar to column (2) estimation results. It is worth noting that years of very high inflation, and drastic changes in inflation rates, were observed in a few post-Soviet countries at the beginning of the sampled period. In consistency with this observation, incorporating a binary variable of Post-Communism, in column (4), weakened the magnitude and the significance level of the change in inflation rate estimated coefficient. Moreover, the ex-Soviet countries were assessed to have substantially lower crimes recorded levels than other countries in the sample. One plausible conjecture of the social nature underlying this finding can be that under stricter, less democratic regimes a fear of severe

[98]One explanation to this fact could be that detailed definitions of an abundance of sins, shaped and polished by the Catholic Church doctrine over centuries, became with time integral parts of civil criminal codes in predominantly Catholic countries. More bad deeds defined as criminal, in turn, caused the overall count of crimes to level up, in a distinctive way in different Catholic countries. Nonetheless, this explanation requires further examination and out of scope of this chapter.

[99]At $t-1$.

Table 3.9: Fixed effects estimates of crimes: the Jubilee Year event effect.

Dependent variable: crimes per 100,000 inhabitants	(1)	(2)	(3)	(4)
$Catholic\ supermajority_{i,t} \cdot Jubilee_{2000}$	-6.48***	-2.59***	-2.49***	-3.00***
	(0.43)	(0.69)	(0.73)	(0.70)
$Catholic\ share_{t-1}$	-0.25***	0.06***	0.06***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)
$Urban\ population\ share_{t-1}$		2.25***	2.25***	2.00***
		(0.06)	(0.06)	(0.07)
$Change\ in\ inflation\ rates_{t-1}$			1.01**	0.08*
			(0.37)	(0.42)
$PostCommunism_i$				-9.83***
				(0.01)
Year FE	Y	Y	Y	Y
R^2	0.08	0.50	0.50	0.52
$R^2 - adjusted$	0.04	0.05	0.05	0.50
σ_u^2	152.68	124.26	168.44	142.74
σ_e^2	3,064	2,265	2,260	2,230
ρ	0.002	0.003	0.006	0.004
AIC	7,353	7,118	7,026	7,017

Notes. The unit of observation is crimes per 100,000 citizens in country i at year t. All columns include a constant. Standard errors, reported in parentheses, adjusted for cluster heteroscedasticity at the year level. Asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. R^2-adjusted is extracted using equivalent *areg* command. σ_u^2 is the variance of the annual fixed effects, while σ_e^2 is the variance of the idiosyncratic error. ρ indicates the fraction of variance due to fixed effects. Post-estimation Akaike Information Criterion (AIC) calculated for each column. All the coefficients reported and the standard errors related, except inflation rates change, are divided by 100, as shares in the data were given as numbers and not percentages. Super-majority stands for higher than 70% share of Catholics in the population. $n = 390$ in columns (1) and (2) and $n = 385$ in columns (3) and (4) due to a few missing observations for inflation rates in post-Communism countries. For column (4) full specification of model (3.1), within variation accounts for 0.52, while between variation equals 0.29.
RESULTS: The impact of the Great Jubilee of 2000 event on crimes levels in predominantly Catholic countries is negative and significant.

prosecution kept the crimes recorded at moderate level. Years after the Soviet regimes were supplanted by democratic ones, and all the Post-Communism countries in the sample joined the European Union, this fear could still persist in the parts of the populations mature enough to remember the past law enforcement methods. The magnitude and significance of the estimated coefficient on ex-Communism binary variable, together with the explanatory power it contributed to the model, is the evidence of the importance of the Soviet heritage influence on crimes levels measured relatively recently. If such comparison is appropriate, and for this study only, being an ex-Communist country is estimated to suppress crimes levels three times more than a major religious event of remission of sins, as the coefficient on ex-Communism exceeded minus 9, while the Jubilee of 2000 impact coefficient reached minus 3 only, in 2000. In terms of the countries involved, the list of the ex-Soviet countries does not align with Catholic super-majority representatives, as only five out of ten mostly Catholic nations had a Communist past.[100]

In all columns of Table 3.9, including column (4), crimes recorded per 100,000 inhabitants, in predominantly Catholic countries, estimated to be negatively impacted by the occurrence of the Great Jubilee of 2000 event and the related custom of indulgences. To quantify this finding, it is of help to calculate by how much, in total, the crimes in the Catholic super-majority countries were predicted to decline in 2000. Summarizing the populations of the treatment group countries,[101] 169.75 million of people were potentially impacted by the event in focus. As the average impact of the Great Jubilee of 2000 in these countries was estimated to equal close to minus 3 per 100,000 citizens, in column (4), for an overall population of 169.75 million in predominantly Catholic countries this would accumulate to a total reduction of 509,250 crimes in 2000.[102]

[100]Poland, Croatia, Slovenia, Lithuania and Slovakia. The non-Catholic ex-Soviet countries are: Czech Republic, Romania and Estonia. Hungary was a simple-majority Catholic country in 2000, and treated here as a control group unit of observation.

[101]First ten countries listed in Table 3.3.

[102]Recall that the estimated coefficients in Table 3.9 were divided by 100 out of convenience.

The residuals from the full model (3.1) specification regression, listed in Table 3.9, column (4), when plotted, exhibited stationarity over time.

Fixed effects annual coefficients, complementary to Table 3.9, column (4), estimation results, are enumerated in Table 3.10. All the coefficients reported are relative to the baseline year of 1993, a first year of the sampled period. Out of annual impacts estimated, of particular importance is the coefficient on the year of 2000. In general, the estimated coefficient on the beginning of the new millennium year could potentially accumulate any influences on all religious/secular denominations criminal behaviours shifts, e.g. if people believed that the world is about to end in 2000 and decided to commit more (or less) crimes.[103] While all the annual effects reported in Table 3.10 are negative, the coefficient on the year 2000 is between the three lowest in absolute value and closest to zero. In other words, the annual estimated impact of the year 2000 on crimes recorded levels in all countries in the sample, on average, is one of the least negative, relatively to the baseline year of 1993. To illustrate this graphically, Figure 3.20 plots the annual fixed effects estimated coefficients from Table 3.10. As evident from the plot, the annual estimated coefficient on year 2000 is higher than of surrounding years. In addition, the second widest, after 1995, confidence interval indicates higher uncertainty in 2000 for all countries in the sample.

To summarize the main results for the panel data analysis of model (3.1), presented by Tables 3.9 and 3.10, an estimation of the Great Jubilee of 2000 impacts on the Catholic super-majority countries criminal activities levels showed that the crimes recorded per 100,000 citizens in 2000 declined in treated by the Great Jubilee event countries, where the vast majority of the population followed the Roman Catholic Church doctrine and the Jubilee related custom of obtaining a remission of sins.

[103] During the year of 2000 a UNESCO peaceful initiation, targeting all nations, took place.

Table 3.10: Fixed effects estimates of crimes: Annual coefficients.

Dependent variable: crimes per 100,000 inhabitants		
Year	1994	-3.09***
		(0.09)
	1995	-3.14***
		(0.41)
	1996	-4.23***
		(0.16)
	1997	-4.21***
		(0.01)
	1998	-2.85***
		(0.01)
	1999	-2.93***
		(0.01)
	2000	-1.95***
		(0.04)
	2001	-2.88***
		(0.01)
	2002	-1.49***
		(0.02)
	2003	-1.40***
		(0.02)
	2004	-2.29***
		(0.02)
	2005	-3.95***
		(0.02)
	2006	-4.86***
		(0.02)
	2007	-5.38***
		(0.02)

Notes. Annual fixed effects complementary to Table 3.9, column (4), estimation results. The unit of observation is crimes per 100,000 citizens in country i at year t. Standard errors, reported in parentheses, adjusted for cluster heteroscedasticity at the year level. Asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. 1993 is omitted as a default baseline year in Stata. All the coefficients reported, and the standard errors related, are divided by 100.

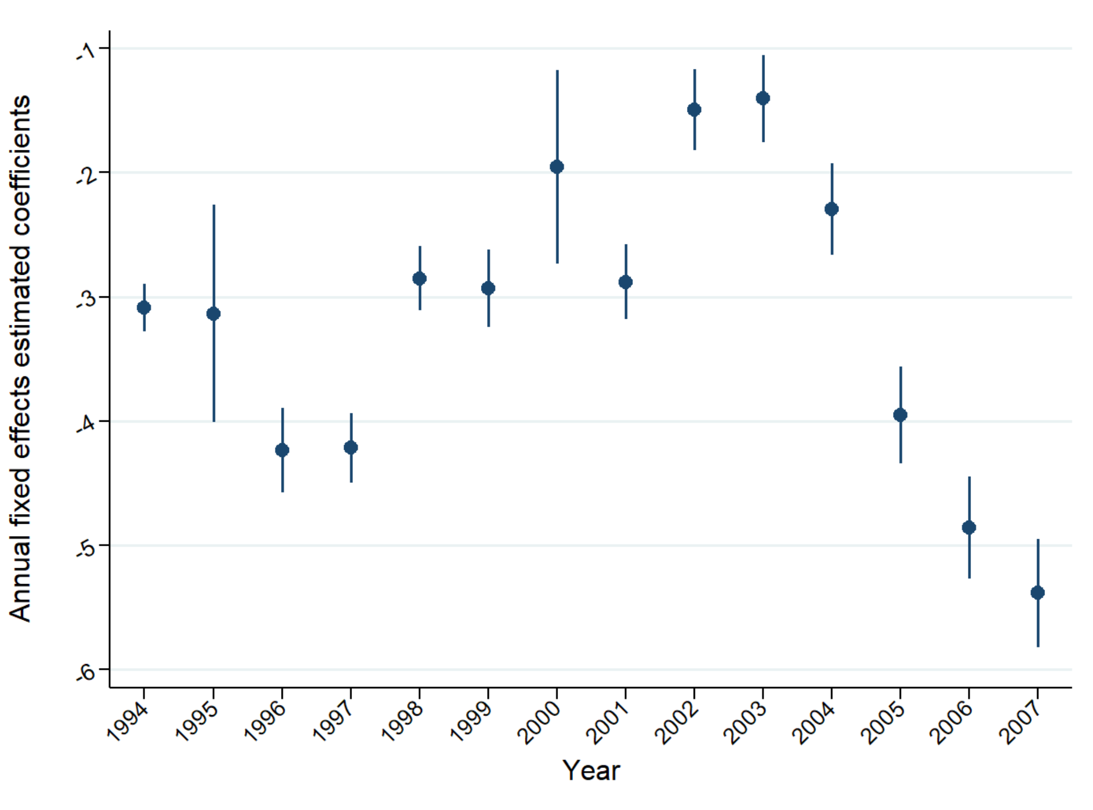

Figure 3.20: Annual fixed effects coefficients, Table 3.10.
Notes. Vertical lines indicate the 95 percent confidence intervals. All the coefficients are relative to the baseline year of 1993.

3.4.2.3 Alternative specification

In order to strengthen the validity of the main result on the Great Jubilee of 2000 impacts obtained in the previous sub-section, an alternative treatment group of countries to be proposed as a replacement to the Catholic super-majority set of countries, i.e. an extended list of Catholic simple-majority nations, following model (3.1).

Expanding the Catholic treatment group of countries to include simple majority candidates would show how the estimated coefficient on the Great Jubilee of 2000 event impacts could change under declining average percentage of Catholics in the target populations. On the other hand, half of the population identified as Catholic, in each country, is still a fraction substantial enough to detect the impacts of the event on crimes levels, if there are any. Thus, two more countries with the next high Catholic shares in the population to be added into the original treatment list of countries, effectively extending the treatment group to include twelve countries instead of ten and shrinking the control group by two units of observation. These countries are France and Hungary, which had a fraction of Catholics in the population higher than 50%+1, but lower than 70%, in 2000.[104] For empirical estimation, model (3.1) was modified accordingly, by replacing the super-majority variable, $D^1_{i,t}$, with the simple majority indicator, $D^4_{i,t}$, *ceteris paribus*, leading to the following model:

$$crimes_{i,t} = \beta_0 + \beta_1 D^4_{i,t} \cdot D^2_t + \beta_2 x^1_{i,t-1} + \beta_3 x^2_{i,t-1} + \beta_4 x^3_{i,t-1} + \beta_5 D^3_i + \mu_t + \varepsilon_{i,t} \tag{3.2}$$

The results from estimating model (3.2) are presented in Appendix B, Tables 11 and 12, in a fashion similar to Tables 3.9 and 3.10 for model (3.1). That is, Table 11 focuses on main explanatory variables estimated coefficients, while Table 12 complements for the annual fixed effects results.[105]

As shown by Table 11, all the estimated coefficients, with the exception of the Great Jubilee of 2000 impacts, are very similar, by magnitude, sign and significance, to the results obtained previously in Table 3.9. Same is true for Table 12, that represents annual fixed effects coefficients for Table 11, column (4) and shows results very close to Table 3.10 estimated coefficients. However, the main coefficient of interest on the impacts of the Great Jubilee of 2000 religious event on Catholic countries crimes levels differs substantially from Table 3.9 to Table 11 estimation results. More precisely, the estimated impact of the Jubilee event on Catholic countries crimes levels declined in all columns of Table 11 in comparison to the parallel columns of Table 3.9. In particular, comparing results in columns (4) of both tables, the estimated coefficient on the Jubilee event decreased, in absolute value, from negative 3 (in Table 3.9) to negative 2.26 (in Table 11). In all modelled specifications in both

[104] See Table 3.3 for details.
[105] For Table 11, column (4) full specification of model (3.2).

tables, the estimated impact of the event in focus maintained significance at 1% level.

When model (3.1) was replaced by model (3.2), the total population in the enlarged group of twelve potentially treated countries grew by 69.43 million people, a difference referred to France and Hungary inhabitants count combined. For the Catholic simple-majority treatment group of 239.18 million citizens, total crimes recorded were estimated to decline by close to 540,547 crimes, in 2000. Quantitatively, diluting the average percentage of Catholics in the treatment group countries by adding 69.43 million people, or 40.9%, from "less Catholic" countries, increased the total estimated crimes reduction by 31,297 crimes, or 6.1% only, while in the initial ten super-majority group of countries the average percentage of Catholics was 80.04%, versus 74.55% in the extended simple-majority group of twelve countries.

With regards to the main finding obtained on the impact of the Great Jubilee of 2000 on crimes recorded behaviour in predominantly Catholic countries, an alternative specification performed in this sub-section did not undermine the empirical validity of the discovery that the religious event in focus had a negative and significant impact on crimes levels. Furthermore, the influence of the event found diminishing with declining average percentage of Catholics in the potentially treated populations in Europe.

3.5 Concluding remarks

In this chapter, the impacts of the Catholic Jubilee Year religious event, and the related custom of the remission of sins, on crimes levels recorded in Catholic countries, were examined. The empirical investigation started with looking at the historical time series on Italian crimes recorded annually for years 1888-2013. During this time period, eight Jubilee Year events were celebrated by the Catholics of Italy, offering a convenient opportunity to observe one country population under a few religious shocks of the same nature. The time series analysis showed that, for at least half of the Jubilee Year occasions, criminal offences count declined right before or during the event, then plateaued for three years. After the relative stability period, the number of crimes recorded corrected upwards, approximately reaching pre-event levels. In the case of the Great Jubilee of 2000, the decrease during the event was so substantial, that after the event was over crimes levels first partially corrected, then stabilized.

In the context of mandatory conditions apply to obtain the Jubilee indulgence, such observed criminal behaviour of Catholics can be interpreted as follows. The initial decline in crimes recorded could reflect the detachment of the faithful from all sins, while the following stabilization would be related to the promises made not to sin again, which were kept for a limited period of time only. The criminal plateau levels, distinctive around each Jubilee event, probably indicated the level of ”subsistence” crimes at that time, as if the professional thieves and other criminals, who made a living from committing crimes, could not avoid the minimal criminality, even if religious.[106] The following correction upwards could be associated with a compensation for the lasting abstention from crimes, or just to a ”fading away” impact of the event.

In Italy, the pattern observed around the religious event in focus is very well defined, of a particular ”double-top” shape, familiar from the technical analysis of financial data. Repeatedly detecting such a complex structure around a specific religious event for a macro indicator like crimes levels, measured annually at the country level, offers an opportunity to incorporate the technical analysis alongside with fundamental approach, in policy making, especially when the timing of the pattern occurrence and its' duration are known. In this particular case, the pattern can be rationalized.

While it is inappropriate for the author to express an opinion on how to hold such events, when and how frequently, some policy recommendations, in a pure civil sense, can

[106] Speaking technical analysis language, such a stage in trading is called ”support”, indicating the level where the demand is strong enough to stop the stock falling any further. Here, the support is expressed in the amount of crimes committed.

still be made. In particular, an allocation of public funds, assigned to law enforcement and incarceration budgets, could be optimally adjusted, in accordance with the crimes recorded pattern expected to occur around the event. To accommodate the estimated effects, if desired, is feasible, as the event is declared well in advance prior its' occurrence and/or historically scheduled to be held every round twenty-five years.[107] To give a concrete example for such potential adjustment, a following policy recommendation could be considered. When the crimes are foreseen to decline on a religious basic in a particular Jubilee year, less police resources allocated would be able to handle the law violations, while when an upward correction in crimes count is expected to develop, more officers on the streets could provide an adequate protection for the citizens.

The second part of the study was implemented as conditional analysis, where the same religious occasion influences were investigated using a panel dataset on European countries crimes recorded around the Great Jubilee of 2000 planetary event. In the longitudinal data sample, predominantly Catholic countries served as treated units of observation, while the rest of the countries performed as a control group. In this case, the same one-time religious occasion's impacts were studied across nations. The event in focus found to have a negative and significant impact on crimes recorded in treated countries, in 2000. Furthermore, the magnitude of the estimated coefficient of the event occurrence on crimes levels weakened when the set of the treated units of observation was extended to include countries with lower percentage of Catholics in the population.

Additional macro-economic indicators, when added as independent variables into the analysis, provided expected signs and revealed significant in explaining crimes recorded data patterns. Specifically, urban population shares, change in inflation rates and continuous Catholic shares estimated to be positively correlated with the amounts of crimes committed per annum, while being an ex-Communism country suppressed the levels of criminal offences

[107]In Italy.

recorded.

To finalize the concluding remarks for the study, the Jubilee Year event's impacts on crimes levels were examined using different empirical approaches over two distinctive datasets, extracted from two independent statistical bureaus: ISTAT and EuroStat. The types of crimes included by the two bureaus varied substantially. In Italian historical time series, multiple events were observed over a long period of time, while in the panel dataset a unique event of the same spiritual nature was celebrated in many European countries, settled by religiously heterogeneous populations. In both cases, the empirical examination results showed that criminal offences patterns of Catholics change in the time-proximity to the event and the related massive distribution of the remission of sins. More specifically, crimes committed were estimated to decline during or prior the event, for both datasets.

This observation contradicts the hypothesis that suggests the faithful, when given the opportunity to cancel the afterlife punishment for sinning, would commit more bad deeds. According to Catholic doctrine, this fact can be explained as follows: when forgiven and the punishment is cancelled, Catholics entirely clean their spiritual debt and move from the stage of fearing God's judgement to a renewed and better connection with God - a phase of love. The threat of Purgatory is removed, at least temporarily, and the gates of heaven are now open. To achieve this transition, the faithful are willing to make and keep promises not to sin again for as long as they can, indicating that fear may not be the only motivation for sinning or not sinning.[108] The theoretical model presented in chapter II, would not capture the richness of Catholic doctrine, even if adjusted to include an assignment of a random and/or anticipated indulgence across individuals and/or time; to do so would require a different modelling approach to emphasize the uniqueness of the "post-forgiveness" stage.

[108] This is in line with Campante and Yanagizawa-Drott's (2015) study, which examined the impacts of Ramadan on economic growth and subjective well-being. They found that longer fasting hours reduce productivity but make the faithful happier, as if they are willing to make sacrifices in terms of physical life's utility to obtain a "good standing" with God.

From an empirical point of view, the religious event in focus could be studied from additional socio-economic angles. Firstly, volunteering and charitable giving are expected to thrive in the time-proximity to the event, as Catholics were directly instructed to be involved in "good works." Secondly, family matters could also benefit. For instance, a small "baby boom" could occur if more couples avoided abortions right after the remission of sins. Looking at the demographic dimension, we could also investigate whether there are fewer cases of divorces, and if elderly individuals are admitted to long-term care facilities less frequently by their families.[109] Additionally, could we find empirical evidence of increased organ donations, happiness, innovation, and productivity around the event?

On a larger scale, the results of the study indicate that a deeper rethinking of the concept of forgiveness and its consequences, especially when obtained from the almighty God, is required. While this study attempts to make a modest contribution to this important matter, many questions related to this topic are still open for future research.

[109] Recall "Honour your Mother and Father" from the 10 Commandments.

Conclusion

This thesis studied the choices religious agents make when they believe to be punished for sinning in the afterlife. The study was conducted on two courses: theoretical and empirical. The theory suggested a novel approach to modelling principal-agent type of problems in the dual-self realm, when the principal is religious. The empirical examination focused on a major religious event's impacts on a socio-economic outcome of crimes levels.

Chapter I reviewed the Behavioural Economics literature on the models related to the framework developed in the next chapter.

In Chapter II, a newfangled, three-dimensional approach to constrained optimization problems was presented. In the model, the planner has the ability to alter doer's choices by manipulating bundled pay-offs of goods and leisure consumption in a case that two states of the world, of sinning and non-sinning, will realize. By doing so, the controller of the resources endogenously manipulates the very probability of the states of the world to occur. However, her options are limited by the initial endowment of wealth and leisure available.

According to the model's solutions, the very rich planner will always have sufficient resources of alternative consumption of goods to offer the doer in the case of non-sinning, effectively substituting the joy from sin with adequate consumption of other goods. The less wealthy, but fearing the future punishment for sinning, planner, will use leisure as a threatening tool. The poor and moderately God-fearing planner will optimally allow consumption of all sin.

Stepping aside from religious concepts, the model suggested could be equally applied to any damaging in the future consumption/deed, with no adjustments required. In addition, it directly connects the lack of wealth with more impulsive behaviours to be observed. The solutions of the model explain a few behavioural phenomena that otherwise are hard to rationalize.

Chapter III looked at the religious agents choices from a different angle. For the empirical investigation, a religious shock caused by the Catholic Jubilee Year event's celebration on crimes recorded levels was examined on two different datasets: Italian time series and European longitudinal dataset. In Italy, the criminal offences count recorded in the time-proximity to the event repeatedly exhibited a particular pattern, allowing for further interpretation on the impacts of the event and policy recommendations. In Europe, the crimes levels declined during the Great Jubilee of 2000 celebration in predominantly Catholic countries. The analysis on both datasets, obtained from different statistical bureaus and measured over distinctive types of crimes, led to the same conclusion that the crimes levels decreased in the time-proximity to the religious event and the related custom of remission of sins.

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Chapter 3

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Appendices

Appendix A: Chapter 2

PROOF OF PROPOSITION 1:

I. Line segment $V_1 - V_2$

On the line segment connecting $V_1 = (0,0,0)$ and $V_2 = (c,0,0)$, the allocations of y and z are held constant at zero, while x varies. Parametrizing the change in x by $\lambda = 0 \ldots\ c$, we obtain: $EU_\lambda = \dfrac{c+1+\lambda}{g}(\lambda+1)$. This function has a maximum at $\lambda = c$, making the vertex $V_2 = (c,0,0)$ preferred over any point on the line segment $V_1 - V_2$.

II. Line segment $V_2 - V_3$

On the line segment between $V_2 = (c,0,0)$ and $V_3 = (c,c,0)$, $x = c$ and $z = 0$. The value of y changes from zero and c. In terms of utility, while moving from V_3 to V_2, such change can be expressed as: $EU_\lambda = \dfrac{c+1+\lambda}{g}(c+1) + \left(1 - \dfrac{c+1+\lambda}{g}\right)(c-\lambda)$, where $\lambda = 0 \ldots\ c$. This function is convex in λ, and the maximum/maxima will occur at the end points where $y = 0$ and/or $y = c$. Using the expected utilities expressions for $EU_{V_2} = \dfrac{(2c+1)(c+1)}{g}$ and $EU_{V_3} = \dfrac{c+1}{g} + c$, from Table 1, it can be shown that $EU_{V_2} \geqslant EU_{V_3}$ when $g \leqslant 2(c+1)$ (or $p_{V_3} \geqslant 0.5$). Depending on parameters values, both vertices are valid candidates for obtaining the local optimum.

III. Line segment $V_3 - V_4$

On the line segment connecting $V_3 = (c,c,0)$ and $V_4 = (0,c,0)$, $y = c$ and $z = 0$ are held constant, while x is changing. Parametrizing the change in x by $\lambda = 0 \ldots c$, we obtain: $EU_\lambda = \dfrac{1+\lambda}{g}(\lambda+1) + \left(1 - \dfrac{1+\lambda}{g}\right)c$. This function is increasing in λ, with a maximum at $\lambda = c$. The local maximum of the segment is $V_3 = (c,c,0)$.

IV. Line segment $V_1 - V_4$

While moving from $V_1 = (0,0,0)$ to $V_4 = (0,c,0)$, y changes from zero to c, *ceteris paribus*. Parametrizing the change in y, we obtain: $EU_\lambda = \dfrac{c+1-\lambda}{g} + \left(1 - \dfrac{c+1-\lambda}{g}\right)\lambda = \dfrac{(\lambda-1)(\lambda-c-1)}{g} + \lambda$, where $\lambda = 0 \ldots\ c$. This function reaches maximum at end points of V_1 or V_4. For $g \geqslant 2c+1$, by Assumption 5, it can be shown that $EU_{V_4} = \dfrac{1-c}{g} + c > EU_{V_1} = \dfrac{c+1}{g}$, making $V_4 = (0,c,0)$ a dominant allocation over the segment.

By transitivity, when $V_2 \succ V_3$ *and* $V_3 \succ V_4$, $V_2 \succ V_3 \succ V_4 \Rightarrow V_2 \succ V_4$.

Alternatively, if $V_3 \succ V_2$ *and* $V_2 \succ V_1$, then $V_3 \succ V_2 \succ V_1 \Rightarrow V_3 \succ V_1$.

Subsections I to IV constitute a proof for the "floor" of the constraint box from Figure 2.1, where $z = 0$.

V. Line segment $V_4 - V_8$

On the line segment $V_4 - V_8$, z changes. Moving from $V_8 = (0,c,1)$ to $V_4 = (0,c,0)$, $EU_\lambda = \dfrac{\lambda}{g} + \left(1 - \dfrac{\lambda}{g}\right)(c-\lambda) - \left(1 - \dfrac{\lambda}{g}\right)(-\lambda G)$, where $\lambda = 0 \ldots\ 1$. This function is convex in λ, with optimal solutions at end points. As V_8 found earlier the worst bundle to obtain the outcome of non-sinning by the planner ($p_{V_8} = 0$), $V_4 = (0,c,0)$ dominates the segment.

$V_1 - V_5$ segment is excluded from the analysis as not belonging to $x = c$ and/or $y = c$ walls.

The rest of the proof, for the vertices with $z = 1$ and related line segments (the "ceiling" of the constraint box from Figure 2.1), is conducted in a similar fashion.

VI. Line segment $V_5 - V_6$

On the line segment connecting $V_5 = (0,0,1)$ and $V_6 = (c,0,1)$, x changes,*ceteris paribus*.[110] Enlarging x by $\lambda = 0 \ldots\ c$, we obtain: $EU_\lambda = \dfrac{c+\lambda}{g}(1+\lambda) + \left(1 - \dfrac{c+\lambda}{g}\right)(1-G)$. This function is convex in λ, with a maximum where $\lambda = c$, making $V_6 = (c,0,1)$ dominant over all other points of the segment.

VII. Line segment $V_6 - V_7$

While moving from $V_7 = (c,c,1)$ to $V_6 = (c,0,1)$, only y varies. Parameterizing the change in y by λ, we obtain: $EU_\lambda = \dfrac{c+\lambda}{g}(c+1) + \left(1 - \dfrac{c+\lambda}{g}\right)(c-\lambda+1-G)$, where $\lambda = 0 \ldots\ c$. This function is convex in λ and will have maximum/maxima at end points. It can be shown that $EU_{V_6} = \dfrac{2c(c+G)}{g} + 1 - G > EU_{V_7} = c + \dfrac{cG}{g} + 1 + G$ if $G > 1$. Otherwise, $V_7 = (c,c,1)$ is preferred.

[110] As in $V_1 - V_2$ case.

VIII. Line segment $V_7 - V_8$

While moving from $V_8 = (0, c, 1)$ to $V_7 = (c, c, 1)$, x is increasing. Parametrizing the change in x, we obtain: $EU_\lambda = \frac{\lambda}{g}(1 + \lambda) + (1 - \frac{\lambda}{g})(c + 1 - G)$, where $\lambda = 0 \ldots\ c$. This function reaches maximum where $\lambda = c$, making the vertex $V_7 = (c, c, 1)$ preferred allocation over the segment.

When $G > 1$, if $V_6 \succ V_7$ *and* $V_7 \succ V_8$, $V_6 \succ V_7 \succ V_8 \Rightarrow V_6 \succ V_8$ by transitivity.

Alternatively, when $0 < G \leqslant 1$, if $V_7 \succ V_6$ *and* $V_6 \succ V_5$, then $V_7 \succ V_6 \succ V_5 \Rightarrow V_7 \succ V_5$.

IX. Line segment $V_5 - V_8$

On the line segment connecting $V_5 = (0, 0, 1)$ and $V_8 = (0, c, 1)$, y changes, *ceteris paribus*. Parametrizing the change in y, we obtain: $EU_\lambda = \frac{c - \lambda}{g} + \left(1 - \frac{c - \lambda}{g}\right)(\lambda + 1) - \left(1 - \frac{c - \lambda}{g}\right)G$, where $\lambda = 0 \ldots\ c$. After algebraic rearrangements, it can be shown that this function is increasing in λ and reaches maximum at $V_8 = (0, c, 1)$.

Out of all the vertices and the related segments of the constraint box, four vertices found dominant, under different values of parameters: $V_2 = (c, 0, 0)$, $V_3 = (c, c, 0)$, $V_6 = (c, 0, 1)$ and $V_7 = (c, c, 1)$. These vertices, and the related line segments, share a common allocation of $x = c$, i.e. the global maximum/maxima will lie on $x = c$ wall.

Graphically, the directions of the utility improvements will look like in Figure 21.

PROOF OF PROPOSITION 3:

The probability not to sin, as defined by equation (3.3), is $p(x, y, z : c, g) = \frac{x + 1 - y - z + c}{g}$. Substituting for an allocation of $V_2 = (c, 0, 0)$ into the probability function, we obtain: $p(c, 0, 0) = \frac{2c + 1}{g} \geqslant 1$. When $2c + 1 \geqslant g$, the probability not to sin equals to one, i.e. sin is avoided with certainty. This result is independent of G. Moreover, $c + 1 > g$ would suffice to avoid sinning, as the probability function in equation (3.3) was initially standardized by adding c, in order to solve for the non-trivial cases. This standardization did not change the optimal solutions qualitatively, as the planes of $(x + 1 - y - z)$ were maintained.

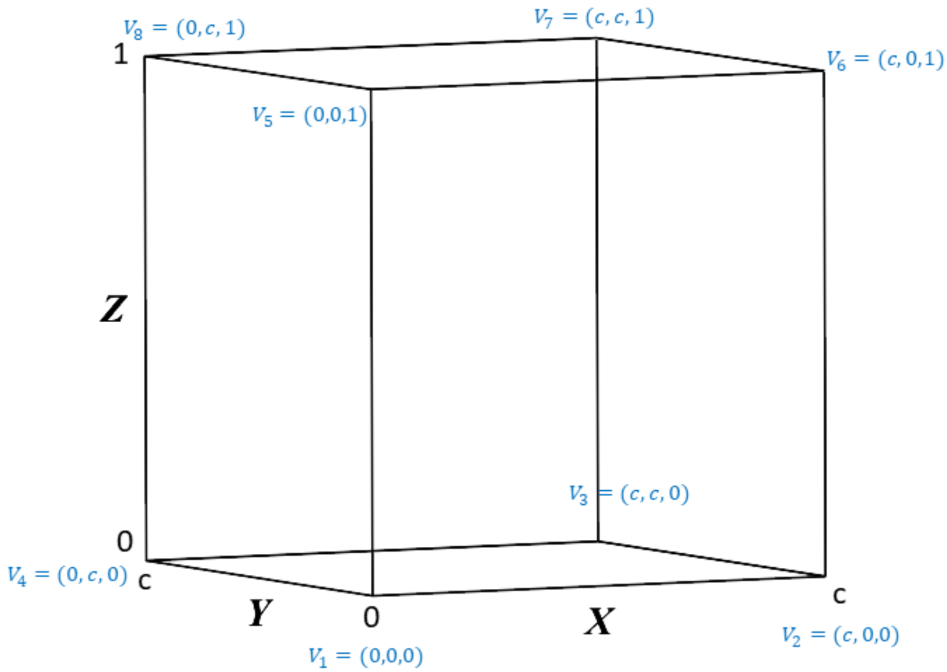

Figure 21: Expected utility improvement at $x = c$ wall.

PROOF OF PROPOSITION 4:

When $G > 1$, $V_6 \succ V_7$, from proof of Proposition 1(VII). On the line segment connecting $V_2 = (c, 0, 0)$ and $V_6 = (c, 0, 1)$, $x = c$ and $y = 0$, while z changes from zero to one. Parametrizing the change in z, we obtain: $EU_\lambda = \frac{2c+1-\lambda}{g}(c+1) + \left(1 - \frac{2c+1-\lambda}{g}\right)\lambda - \lambda G$, where $\lambda = 0 \ldots 1$. This function is decreasing in λ, making $V_2 = (c, 0, 0)$ a local maximum of the line segment. When $V_2 \succ V_6$ and $V_6 \succ V_7$, $V_2 \succ V_6 \succ V_7 \Rightarrow V_2 \succ V_7$ by transitivity.

On the line segment connecting $V_7 = (c, c, 1)$ and $V_3 = (c, c, 0)$, z declines, while x and y are held constant. By parametrizing the change in z, we obtain: $EU_\lambda = \frac{c+\lambda}{g}(c+1) +$

$\left(1 - \frac{c+\lambda}{g}\right)(c + (1-\lambda)(1-G))$, where $\lambda = 0 \ldots 1$. This function is convex in λ, with two optimal solutions: $V_7 = (c, c, 1)$ and $V_3 = (c, c, 0)$. When $G > 1$, $EU_{V_3} = \frac{c+1}{g} + 1 > EU_{V_7} = c + 1 + \frac{cG}{g} - G$. Otherwise, $V_7 = (c, c, 1)$ is preferred. $V_3 = (c, c, 0)$ is dominant over the line segment $V_3 - V_7$ when $G > 1$.

The relationship between $V_2 = (c, 0, 0)$ and $V_3 = (c, c, 0)$ is defined by proof of Proposition 1(II).

The $G > 1$ case is shown in Figure 22.

PROOF OF PROPOSITION 5:

From proof of Proposition 1(VII), $V_7 \succ V_6$ when $0 < G \leqslant 1$.

On the line segment connecting V_7 with V_3 there are two optimal solutions: $V_7 = (c, c, 1)$ and $V_3 = (c, c, 0)$, by proof of Proposition 4. For the $0 < G \leqslant 1$ case, it can be shown that when $G > \frac{g-c-1}{g-c}$, $V_3 = (c, c, 0)$ dominates. Otherwise, $V_7 = (c, c, 1)$ is preferred.

The relationship between $V_2 = (c, 0, 0)$ and $V_3 = (c, c, 0)$, on the line segment $V_2 - V_3$, is defined by proof of Proposition 1(II), regardless of G.

The $0 < G \leqslant 1$ case is shown in Figure 23.

PROOF OF PROPOSITION 2:

Propositions 3, 4 and 5, and the related proofs, combined, constitute a complete proof for Proposition 2.

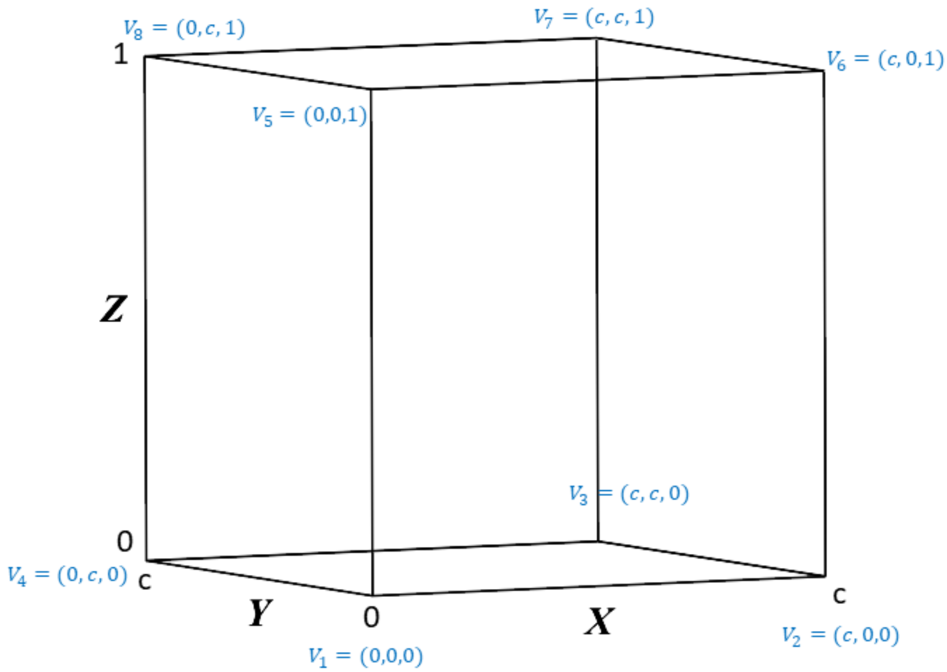

Figure 22: Expected utility improvement for $G > 1$ case.

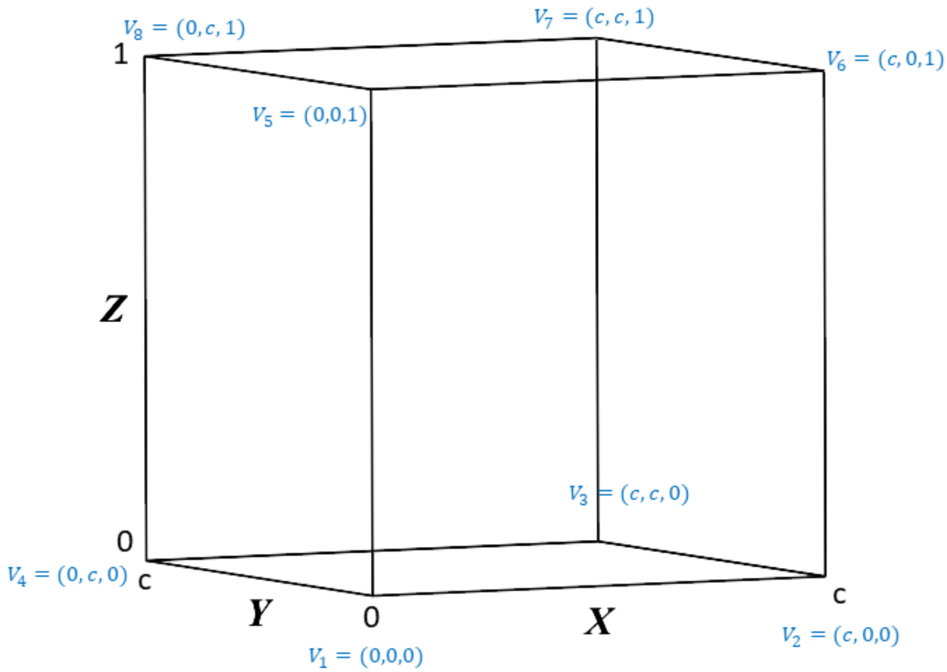

Figure 23: Expected utility improvement for $0 < G \leqslant 1$ case.

Additional notes and alternative ways of working with rectangular cuboids as constraint boxes. For any interior point located inside the constraint box, point S, three coordinates can be identified, i.e. x_S, y_S and z_S. By drawing a line for each coordinate, horizontal or vertical, the constraint box can be divided, or cut, into eight smaller rectangular cuboids, when the only common allocation for all eight smaller boxes is the point S_{x_S,y_S,z_S}.

If the boxes are separated spatially, for each one of the smaller boxes, point S will become a vertex.

The optimization problem of the planner can be solved for each smaller box using firstly

Proposition 1 and the related proof, with or without rescaling the parameters. For each smaller box, the utility improvements will be identical to Figure 21. Combining back the smaller cuboids into the bigger one, will reduce the solution of the optimization problem for the bigger box to $x = c$ wall. Alternatively, the problem can be solved for for any four smaller boxes out of eight with a common side, when applicable by the problem in hand.
This way it can be shown that an interior solution is never optimal without assuming first the need to move toward $x = c$ and/or $y = c$ walls. In addition, this would make the whole discussion on probability planes and their behaviour inside the constraint box redundant.
To complete the solution for the $x = c$ side of the bigger box, Propositions 4 and 5 (and the related proofs), can be applied, depending on the value of G.
If the point S_{x_S,y_S,z_S} lies on one of the edges of the box, the problem is simplified, as the bigger box can be cut into four smaller boxes, instead of eight, or Proposition 1 solution could be directly applied, as point S_{x_S,y_S,z_S} already belongs to one of the line segments evaluated by the proof of Proposition 1. This approach can be extended to other geometrical shapes and/or dimensional spaces.[111] The probability planes, still present at the vertices of the boxes and the $x = c$ side of the bigger box, can take other functional forms. The expected utilities of the vertices for all sizes of boxes can be compared using transitivity, if desired.

[111]For three-dimensional spaces, parallelepipeds, rhododendrons, triangular prisms and pyramids could be considered, if they can be made from a number of smaller identical shapes.

Appendix B: Chapter 3

Table 11: Fixed effects estimates of crimes: the Jubilee Year event effect.

Dependent variable: crimes per 100,000 inhabitants	(1)	(2)	(3)	(4)
$Catholic\ majority_{i,t} \cdot Jubilee_{2000}$	-3.64***	-2.43***	-2.33***	-2.26***
	(0.40)	(0.66)	(0.70)	(0.65)
$Catholic\ share_{t-1}$	-0.25***	0.06***	0.06***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)
$Urban\ population\ share_{t-1}$		2.26***	2.26***	2.00***
		(0.06)	(0.06)	(0.07)
$Change\ in\ inflation\ rates_{t-1}$			1.01**	0.08*
			(0.37)	(0.42)
$PostCommunism_i$				-9.81***
				(0.07)
Year FE	Y	Y	Y	Y
R^2	0.08	0.50	0.50	0.52
$R^2 - adjusted$	0.04	0.05	0.05	0.50
σ_u^2	144.86	125.13	168.86	142.30
σ_e^2	3,065	2.265	2,260	2,231
ρ	0.002	0.003	0.006	0.004
AIC	7,353	7,118	7,026	7,017

Notes. The unit of observation is crimes per 100,000 citizens in country i at year t. All columns include a constant. Standard errors, reported in parentheses, adjusted for cluster heteroscedasticity at the year level. Asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. R^2-adjusted is extracted using equivalent *areg* command. σ_u^2 is the variance of the annual fixed effects, while σ_e^2 is the variance of the idiosyncratic error. ρ indicates the fraction of variance due to fixed effects. Post-estimation Akaike Information Criterion (AIC) calculated for each column. All the coefficients reported and the standard errors related, except inflation rates change, are divided by 100, as shares in the data were given as numbers and not percentages. Majority stands for higher than 50%+1 share of Catholics in the population. $n = 390$ in columns (1) and (2) and $n = 385$ in columns (3) and (4) due to a few missing observations for inflation rates in post-Communism countries. For column (4) full specification of model (2), within variation accounts for 0.52, while between variation equals 0.29.

Table 12: Fixed effects of crimes per 100,000 citizens: Annual coefficients.

Dependent variable: crimes per 100,000 inhabitants		
Year	1994	-3.09***
		(0.09)
	1995	-3.14***
		(0.41)
	1996	-4.23***
		(0.16)
	1997	-4.21***
		(0.01)
	1998	-2.86***
		(0.01)
	1999	-2.94***
		(0.01)
	2000	-2.06***
		(0.04)
	2001	-2.88***
		(0.01)
	2002	-1.50***
		(0.02)
	2003	-1.41***
		(0.02)
	2004	-2.30***
		(0.02)
	2005	-3.96***
		(0.02)
	2006	-4.86***
		(0.02)
	2007	-5.38***
		(0.02)

Notes. Annual fixed effects complementary to Table 11, column (4), estimation results. The unit of observation is crimes per 100,000 citizens in country i at year t. Standard errors, reported in parentheses, adjusted for cluster heteroscedasticity at the year level. Asterisks ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. 1993 is omitted as a baseline default year in Stata. All the coefficients reported, and the standard errors related, are divided by 100.