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(Moral) philosophy and (moral) theology can function as (behavioural) science: a methodological framework for interdisciplinary research

Fabio Zagonari[1]

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Abstract
In this paper I present two examples in which environmental moral rules, obtained from religious precepts (e.g., the dignity of non-humans and harmony with nature in Hinduism or Buddhism, stewardship in Judaism, trusteeship and parsimony in Islam, love of neighbours in Christianity) or ethical principles (e.g., responsibility for nature, responsibility for future and current generations, and aversion to inter- and intra-generational inequality) can be matched with observed behaviours to test assumptions, insights, or both. In particular, traditional scientific tests (i.e., validation vs. calibration for reliability; out-of-sample estimations vs. numerical simulations for feasibility) and recent scientific tests (i.e., invariance under observations vs. interventions for robustness of relationships; holism vs. individualism for aggregation requirements; and causal mechanisms vs. evolutionary processes for stability of equilibria) are applied to these examples to demonstrate how moral philosophy and theology (respectively) can function as instances of empirical behavioural science (i.e., by assessing observed actions in real contexts using scientifically sound procedures). Thus, this paper provides a standardised methodology for problem-solving contexts (i.e., achieving local and global sustainability) and knowledge-practicing contexts (i.e., testing the empirical content of moral rules) to support interdisciplinary research by integrating concepts and cross-validating models from different fields of inquiry.

Keywords Morality · Ethics · Philosophy · Theology · Behavioural science · Interdisciplinary research

1 Introduction

The moral philosophy literature suggests that, due to a lack of observations, intuition in reflective equilibrium should play a role in the selection of a moral theory that resembles the role played by observations in the selection or development of scientific theory (e.g., Eggleston 2014). However, this does not solve the indeterminacy problem, in which a

✉ Fabio Zagonari
fabio.zagonari@unibo.it

[1] Dipartimento di Scienze Economiche, Università di Bologna, Via Angherà 22, 47921 Rimini, Italy

given set of intuitions might generate several moral theories that satisfy reflective equilibrium's conception of how a moral rule must answer to or harmonize with the relevant set of intuitions. In addition, the moral phenomenology literature (e.g., Lacey 2013) suggests that moral theorizing must be *wide* (i.e., it must deal with moral experiences that are broadly shared), *independent* (i.e., it must be sufficiently autonomous from moral theories or pre-formed moral judgments), and *robust* (i.e., it must help to distinguish between competing moral theories). However, to make moral phenomenology useful and logically self-consistent, this field must refer to a moral ontology of the human person (i.e., to an understanding of the nature of morality in human beings) based on well-being, virtue, freedom, responsibility, and phronesis (i.e., wisdom relevant to practical matters). For clarity, in the rest of this paper, I will use *moral* to refer to behavioural rules (i.e., do's and don'ts, right or wrong, acceptable or unacceptable) that could be suggested either by religion or moral theology (i.e., religious precepts) or by ethics or moral philosophy (i.e., ethical principles).

In this context, the *first* purpose of the present study was to suggest a *scientific* methodology for selecting wide, independent, and robust moral rules, within a positive or normative perspective, by relying on objective rankings determined using traditional and recent scientific tests. Note that I will not apply reductionism (i.e., I will not attempt to reduce human behaviour to simple chemical or physical principles or go back to chemical interactions; Chappel 2017), but I will assume that individuals consciously or unconsciously try to reduce their pain or increase their well-being. Moreover, I will disregard the problem of a lack of empirical evidence regarding the presence of character traits such as honesty, courage, or compassion (Papish 2017), since the moral rules suggested by intuition might not be based on virtues. Finally, I will not rely on the introspective attention of philosophers to their own moral deliberations to provide feedback from tests of moral thinking by cognitive scientists (Rini 2015). I will instead use individual or aggregated observed behaviours in real or experimental contexts.

To do so, I will present two examples in which moral rules related to the natural environment, obtained from religious precepts and philosophical principles, are matched with observed behaviours to test assumptions, insights, or both. The first example relates to my previous study of moral philosophy (Zagonari 2018a), which provides insights into how secular principles can achieve local and global environmental sustainability. The second example relates to my previous study of moral theology (Zagonari 2018b), which provides insights into how religious precepts can guide efforts to achieve local and global environmental sustainability.

The *second* purpose of the present study will be to apply two types of test to these examples: traditional scientific tests (i.e., validation vs. calibration for reliability; out-of-sample estimations vs. numerical simulations for feasibility) and recent scientific tests (i.e., invariance under observations vs. interventions for robustness of relationships; holism vs. individualism for aggregation requirements; and causal mechanisms vs. evolutionary processes for stability of equilibria). The results will demonstrate how moral philosophy and theology can function as instances of behavioural science. For clarity, I will consider behavioural science to be an *empirical* science (i.e., to assess observed actions in real contexts using scientifically sound procedures) rather than a pure science (i.e., a consistent set of axioms) to account for the gap between belief and action. In the study context, this gap represents the difference between environmental attitudes or intentions and the associated environmental behaviours (e.g., Lange et al. 2018; Da Costa Filho et al. 2017; Liobikiene and Juknys 2016; Lavergne and Pelletier 2015). I will exclude studies on self-stated actions in real contexts (e.g., Gutsche 2019; Wang and Lin 2017) and on observed actions in experimental contexts (e.g., He and Zhan 2018; Hwang 2018).

The *third* purpose of the present study was to show that moral rules and behavioural models can be mutually supportive. In other words, I will show that moral philosophy and theology can be supported by behavioural science, which can test their feasibility (i.e., whether there are realistic parameter values such that an ethical principle or religious precept can achieve a given goal, if properly implemented) and their reliability (i.e., whether an ethical principle or religious precept is strongly related to a specified goal, if statistically estimated). I will also show that behavioural science can also be supported by moral philosophy and theology, which can increase its significance as an empirical science (i.e., to provide determinants of behaviour) and can be supported by political economy (i.e., whether these precepts promote desirable pro-environmental behaviour). To make this more concrete, consider the many university courses, faculties, and departments in Theology Science or Religious Science around the world (e.g., Java, Iran, Italy, Germany, Mexico, Turkey). In these contexts, scientific methodologies should be applied to test for reliability. The approach is also applicable to recent written texts by religious leaders (e.g., Pope Francis' *Laudato Si'* in 2015, Patriarch Bartholomew's *Creation Care and Ecological Justice* in 2015), in which political goals are pursued. In these contexts, scientific methodologies should be applied to test for feasibility and reliability. Similarly, consider recent behavioural science articles on household waste recycling, such as Meng et al. (2019) writing on ethics in China, and Yang and Huang (2018) writing on religions in China. In these examples, secular and religious moral rules are shown to be strong determinants of behaviours. Also consider recent articles on policies to increase household waste recycling. For example, Linder et al. (2018) and Sorkun (2018) wrote on ethics in Sweden and Turkey, respectively, and Lakhan (2018) and Intahphuak et al. (2017) wrote on religions in Canada and Thailand, respectively. They highlighted the impacts of secular and religious moral rules on behaviours.

To do so, I will adopt an instrumentalist approach to morality (Moehler 2014), in which concepts and theories are valuable not because they are true, but rather because they effectively explain phenomena (i.e., in a positive analysis) or predict phenomena (i.e., in a normative analysis). I chose this approach because it can combine the extreme diversity of environmental behaviours with a common end (i.e., protection of the Earth). Moreover, I will focus on methodological approaches in the literature by disregarding specific insights about specific issues and focusing on more general analyses. Finally, I will speak of universal *applicability* rather than of universal *practice* (Forschler 2017), since some agents could miss the sustainability rule (i.e., the fact that a principle or a precept is theoretically applicable in a given situation does not mean that it will be implemented in practice).

The *fourth* purpose of the present study will be to provide a standardised methodology by applying to these examples the reciprocal validation of different methods, the relationships between methods at different scales, the sequence of various methods, combinations of concepts and theories, and transformation of the problem. This will include both traditional and recent scientific tests to support an interdisciplinary approach to research that is consistent with the fields involved in an analysis.

Note that I will focus on a specific moral judgement, rather than on a general moral judgement based on unifying features such as content, phenomenology, force, form, function, and neurological mechanisms (Sinnott-Armstrong and Wheatley 2014). Moreover, if my approach is applied to society, this amounts to considering political economy as a moral science (Tribe 2017). Indeed, the suggested approach is based on changing stakeholder values as an appropriate policy to achieve sustainability. Finally, I will focus on the application of only one moral environmental rule at a time to simplify the analysis,

although the same methodology could be applied to multiple religious precepts or ethical principles simultaneously in contexts such as health care (Padela 2013; Levin 2012).

2 Background

2.1 The literature

Interdisciplinary research is a recent topic in the philosophy of science (MacLeod and Nersessian 2016; Tobi and Kampen 2018). In particular, some of the theoretical literature focuses on the need for, or the desirability of, conceptual and methodological integration to face some problems, together with possible detrimental implications for the fields involved (Politi 2017, 2018). The social studies within the empirical literature investigate team coordination, collaboration, and integration in specific fields. Examples include Piso et al. (2016) on fog science and Drago et al. (2018) on the health profession. In contrast, methodological studies within the empirical literature identify and rationalise research practices in specific contexts. Examples include MacLeod and Nagatsu (2018) on environmental sciences, Anderson et al. (2015) on sustainability problems, and MacLeod (2018) on ecology and economics or molecular and systems biology. However, we still lack context-specific, standardised routines for how to determine the optimal sequence for application of various methods, how to anchor methods at different scales, how to validate one method with another, and how to relate concepts, theories, and explanations from different fields (MacLeod and Nersessian 2016). In other words, we need a methodological framework for interdisciplinary sciences, although this framework will depend to some extent on the fields involved. In the present study, I will examine standardised methodological solutions by relying on strong consistency of simplifying assumptions and model structure with available data and parameter values. The contexts involved are detailed in Sect. 2.2.

Note that a general methodological framework should be preferred to an adaptive problem-solving based on interactive and incremental methodological adaptation and problem transformation: the former will depend on the specific disciplines that must be integrated to solve a particular problem, whereas the latter could depend on attitudes to problems and modes of working by researchers in a particular case study. Moreover, apart from interdisciplinary collaborations that arise from common interests or a common dataset, the major source of interdisciplinary research involves complex problem-solving or knowledge-for-practice searching. Achieving local and global sustainability is an example of problem-solving, whereas testing the empirical content of a moral rule is an example of knowledge-practicing. Finally, many alternative diversity indexes have been suggested (Wagner et al. 2011) to measure interdisciplinarity: the variety, balance, and disparity of citing or cited publications within a top-down structuralist approach (e.g., Abramo et al. 2018): this is closer to cognitive interdisciplinarity; entropy and between measures applied to co-authors within a bottom-up spatialist approach (e.g., Leydesdorff et al. 2018): this is closer to a social interdisciplinarity.

2.2 The contexts

From a logical point of view, the purpose of this paper is to provide a "positive existence" statement (i.e., to demonstrate that the statement in the paper's title is true in some cases). Consequently, in this section, I will first describe the two contexts that I will consider in the

following sections by showing that they are both based on *measurable* variables (Heilmann 2015) for an individual or for a representative individual at a national level. I will discuss the issues related to representative individuals in Sect. 4.2.

Zagonari (2018a) applied ethical principles (e.g., responsibility for nature, responsibility for future and current generations, and aversion to inter-generational and intra-generational inequality) to a behavioural model based on a Cobb–Douglas utility function for a representative individual at a national level. Next, it measured moral rules using national-scale data about a nation's perceived responsibility for nature based on expenditures for nature conservation, the perceived responsibility for future generations based on the expenditures in green R&D, the perceived responsibility for current generations based on expenditures on aid to developing countries, aversion to intra-generational inequality based on the Gini index, and aversion to inter-generational inequality based on the ratio of public debt to GDP. Afterward, it calibrated the resulting model to explain current aggregate behaviours in terms of the ecological footprint and GDP. Lastly, it searched for the changes in ethical principles that were required to achieve global sustainability, and ranked ethical principles in terms of their feasibility and consistency by characterising the model's solutions in terms of both efficiency (i.e., Pareto, Kaldor-Hicks) and equity (i.e., Harshani, Arneson, Dworkin, Sen, Rawls).

Zagonari (2018b) applied religious precepts to a behavioural model for a representative individual at a national level based on the following dominant features of several main global religions: the dignity of non-humans and harmony with nature in Hinduism or Buddhism, stewardship in Judaism, trusteeship and parsimony in Islam, and the love of neighbours in Christianity. In this context, it measured moral rules based on national-scale data: the current use of the environment for each unit of consumption, which represents the per capita use of the environment for representative individuals. It then calibrated the model to explain current aggregated behaviours in terms of ecological footprint and GDP, searched for the changes in religious precepts required to achieve sustainability (i.e., a reduction in the importance attached to consumption, a maximum per capita use of the environment for representative individuals, an increase in the importance attached to the environment within the local or global community). It finally ranked the religious precepts in terms of their feasibility, reliability, consistency, and replicability by characterising solutions in terms of a country's industrialisation level (i.e., for pre-industrial, industrial, and post-industrial countries).

Note that a Cobb–Douglas utility function is the simplest function that can be tested (i.e., it applies a parsimony criterion), since it is log-linear, where intuition is replaced by plausibility (e.g., a larger proportion of income is assumed to be spent on the interventions that are considered to be most valuable.

3 Traditional scientific tests

In Sect. 2, I highlighted the measurable variables at a national level that can be used to characterise the contexts in which ethical principles and religious precepts can be used to explain individual behaviours. I will discuss issues related to interactions among individuals in Sect. 4.3. Thus, scientific tests can be performed in both contexts that I discussed in Sect. 2.2. In this section, I will distinguish which scientific tests can be *generally* performed in social and behavioural sciences on one side (see Fig. 1 in Sect. 3.1), and in moral philosophy and theology on the other side (see Fig. 2 in Sect. 3.2). Note that I will focus on

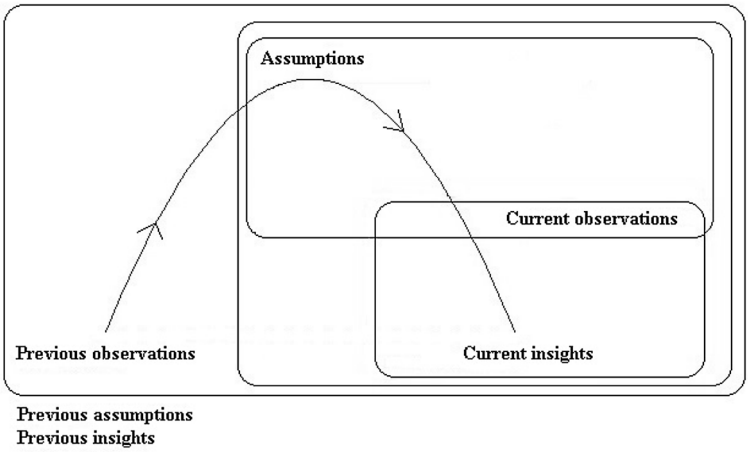

Fig. 1 Holistic overview of the relationships among observations, assumptions, and insights, with possible tests in behavioural and social sciences. Current observations can be used to test assumptions, insights, or both, but previous observations, assumptions, and insights can also be included to support this analysis. The increasing and decreasing sections of Oldroyd's (1986) "arch of knowledge" represent induction and deduction, respectively. The largest box represents the tests of both assumptions and current insights based on both previous and current observations of a phenomenon. The larger medium box represents the tests of both assumptions and current insights based on current observations of a phenomenon. The smaller medium box represents the tests of assumptions based on current observations of a phenomenon. The smallest box represents the tests of current insights based on current observations of a phenomenon

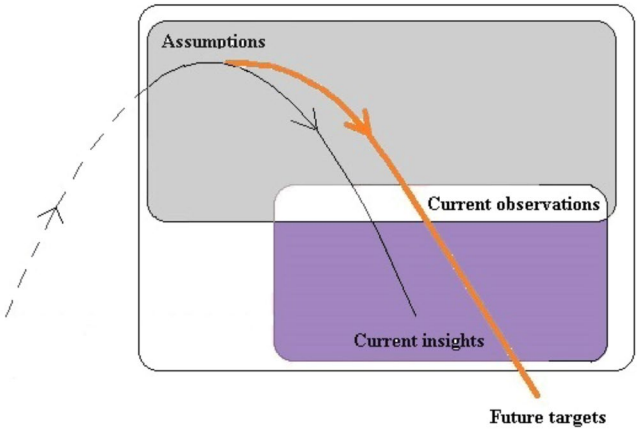

Fig. 2 Holistic overview of the relationships among observations, assumptions, and insights, with possible tests in moral philosophy and theology. Current observations can be used to test assumptions, insights, or both. The black and orange decreasing sections of Oldroyd's (1986) "arch of knowledge" represent deductions at current and changed parameter values, respectively. Thicker arrows denote greater reliability, and the endpoints of the arrows denote their feasibility. The grey and violet boxes represent, respectively, the tests of assumptions and the tests of current insights based on current observations of a phenomenon. (Color figure online)

moral philosophy and theology, since the behavioural science is generally accepted to be a science. Next, I will identify which *specific* scientific tests have been performed or can be performed in the two contexts (see Table 1 in Sect. 3.2) by presenting alternative solutions if traditional scientific tests are impossible.

3.1 Behavioural and social science

In Sect. 2.2, I showed that sustainability is linked to individual environmental and social behaviours. *Behavioural science* primarily involves the systematic analysis of human (and animal) actions through study of the past, controlled observation of the present, and disciplined experimentation (i.e., empirical data) to investigate the decision process and communication strategies in a social system. Examples of sub-disciplines of this science include psychology (here, mainly for philosophical rules), anthropology (here, mainly for religious rules), and cognitive science (here, mainly for adaptive learning aimed at reducing surprises). *Social science* is primarily concerned with societies and the relationships among individuals within a society, and in this field, quantitative approaches construct empirically falsifiable models (i.e., a system of interacting and interdependent entities, real or abstract). The goal is to understand and potentially modify social phenomena by applying statistical analysis to achieve valid and reliable general insights. These insights can be based on evidence from questionnaires, field-based data collection, archival database information, and laboratory-based data collection. Examples are psychology (here, mainly for philosophical rules), anthropology (here, mainly for religious rules), and sociology (here, mainly for relationships between current and future generations).

Although all scientific statements are subject to tests of coherence, agreement with the data, comprehensiveness, and parsimony (Eichner 1983), there is no consensus on the essential features needed to justify a scientific method in general, and the methods of social

Table 1 Statistical analysis refers to reliability, whereas numerical simulation refers to feasibility. The bold, italics and bold italics (the grey, violet and orange areas, respectively, in Fig. 2) represent reliability of determinants, reliability of impacts, and feasibility, respectively

	Context	Moral philosophy	Moral theology
Tests of assumptions			
Statistical analysis	Real	**Zagonari** (2018a)	**Zagonari** (2018b)
	Experimental		
Numerical simulations	Real		
	Experimental		
Tests of insights			
Statistical analysis	Real	*Zagonari (2019)*	*Zagonari (2019)*
	Experimental		
Numerical simulations	Real	***Zagonari*** *(2018a)*	***Zagonari*** *(2018b)*
	Experimental		

Statistical analysis refers to reliability, whereas numerical simulation refers to feasibility. Colours in the table refer to the areas with the same colours in Fig. 2: the bold, italics and bold italics represent reliability of determinants, reliability of impacts, and feasibility, respectively. Zagonari (2019) Only religious ethics can help achieve global environmental sustainability, Environment, Development and Sustainability (under review) and available from the author on request

sciences in particular. Here, I will adopt a *dualist* approach in which the researcher and the research subject are viewed as independent entities (i.e., ontologically, reality is external; epistemologically, knowledge is objective). Moreover, I will rely on the *individualistic objectivity* of science, which I will define as the following of rules. These include rules that only testable statements are meaningful, that statistical methods can be used for generalization, and that causal mechanisms underlie all phenomena (Hedstrom and Ylikoski 2010). I will not rely on the social objectivity of science, which is considered a consequence of the organizational characteristics of scientific communities (Lopez Cerezo 2015); that is, consensus within the scientific community defines what beliefs are considered to be objective. Finally, I will adopt a pragmatic approach in which scientific theories are evaluated based on whether they are useful rather than based on whether they are true (i.e., using research evidence to support policy recommendations).

Figure 1 presents a holistic framework for the use of scientific tests in the behavioural and social sciences. It is based on the "arch of knowledge" (Oldroyd 1986), combined with boxes to depict alternative tests based on alternative observations.

3.2 Moral philosophy and theology

In Sect. 2.2, I formalized the moral rules in philosophy and theology based on measurable variables that were characterised mathematically in my previous research (Zagonari 2018a, b). My goal was to illustrate how observed social behaviours in a current scenario (e.g., environmentally friendly behaviour in terms of the per-capita ecological footprint) can be explained so that possible behaviours in future equilibria (e.g., due to an increase in responsibility towards nature) can be predicted. I will discuss issues related to equilibrium stability in Sect. 4.3. Figure 2 presents my proposed framework for scientific tests in moral philosophy and theology. However, comparing Fig. 2 with Fig. 1 highlights two methodological problems.

First, assumptions cannot be based on previous observations, assumptions, and insights (i.e., previous observations, assumptions, and insights, as well as the largest white box in Fig. 1, are missing in Fig. 2). This is because assumptions are based on ethical principles and religious precepts. However, the dogma of inductive reasoning, in which science must start from observations and proceed to generalisation and ultimately to theories, has been challenged since (Popper 1962). In contrast, the need for verification (Dewey 1938) and for falsification (Popper 1935) based on observation of particular facts remains applicable in both philosophical and theological contexts. Note that comparisons between current observations and insights do not depend on the dogma of truth. In other words, the success of the insights in describing or predicting the world is more important than any abstract considerations about their truth.

This first methodological problem can therefore be neglected, and the approach adopted in this paper can still be treated as an empirical science. Note that moral philosophy and theology, as a consistent set of axioms, are not empirically grounded. For example, the existence of the Devil or the truth of original sin is not based on empirical evidence. Although observed human behaviour could be consistent with these axioms, it is consistent with many other axioms such as evolutionary theory. Here, I suggest scientific tests to choose between axioms (e.g., religious precepts or ethical principles on sustainability) both in positive terms (i.e., based on the explanatory power of the observed behaviours) and in normative terms (i.e., based on the ability to achieve goals such as sustainability).

Second, the purpose of the analysis is not to explain many (past) observations of the same phenomenon (i.e., the grey area in Fig. 2) and use that explanation to predict its (future) dynamics (i.e., the violet area in Fig. 2). Instead, the goal is to estimate the relative effectiveness of the (future) actions (here, modified parameter values) that are required to achieve sustainability (i.e., the orange arrow in Fig. 2). This occurs in a real context identified by a single (present) observation. My analysis later in this section will refer to Zagonari (2018a) on the sustainability status of the economies of OECD or non-OECD countries, and to Zagonari (2018b) on the sustainability status of countries with a single dominant religion or no dominant religion. In other words, current observations must measure the relative effectiveness of alternative moral rules to predict the consequences of some parameter changes. I will discuss the robustness of this relationship in Sect. 4.1. Note that I will provide external evaluation criteria (e.g., equity, consistency, replicability, efficiency) to compare the alternative equilibria suggested by social scientists, in which individuals are not required to agree on these criteria. Thus, the adopted approach is related to political economy.

Consequently, the processes that are usually performed to validate a model must be rephrased. That is, the relationship between assumptions and current observations (the grey area in Fig. 2) must be amended. Indeed, the usual validation procedures for *choosing* a model are to identify a sub-sample of the observations; endogenously parameterize the model (e.g., by choosing parameter values that minimize the distance between the observed or empirical values and the simulated or theoretical values); and evaluate the estimation error of the model (i.e., measure the extent to which the model explains that data). This approach cannot be applied in the present context because the black arrow in Fig. 2 can be modelled using current data, but there are no current data available to model the effects of changing parameter values to create the orange (future) path in that figure. In other words, in terms of Fig. 2, the black descending arrow can be tested with current observations, but the orange arrow cannot, although the distance between the black and orange arrows represents the value changes required to achieve the future targets.

Next, the usual process of *testing* a model (i.e., identify an out-of-sample dataset and compare it with the predictions of the model previously parameterized using a different sub-sample) must be reinterpreted. That is, the white box including grey and violet areas in Fig. 2 must be amended. Indeed, there are no future observations of variables (i.e., GDP and ecological footprint) with changed values that could be used to perform any statistical analysis. Zagonari (2018a) and Zagonari (2018b) suggest that sustainability cannot be achieved at current values of the moral parameters, and that parameter changes will be required. In other words, current insights based on assumptions and current observations highlight that sustainability will never be achieved at current moral values.

This second methodological problem can be solved with two steps: statistical analysis to test the reliability of parameter estimates for representative individuals, followed by numerical simulation to test the feasibility of the results at equilibrium. Table 1 summarizes the actual and possible tests based on Zagonari (2018a) and Zagonari (2018b). In this context, *reliability* refers to statistical and practical significance (i.e., the thickness of the decreasing arrows in the arch of knowledge), and *feasibility* refers to the ability to achieve given targets (i.e., the end of the decreasing orange arrows in the arch of knowledge).

The *reliability* of relationships between assumptions and current observations can be estimated by statistical analyses based on the whole sample (i.e., the thickness of the black arrow within the grey area), by comparing the estimated parameters in terms of their statistical significance and practical significance, which can be defined as the relative size compared with other parameters. For example, Zagonari (2018a) performed statistical analysis and found that,

of the nine parameters analysed, two were plausible and significant; two were significant, but implausibly large; three were plausible, but non-significant; one was plausible, but non-significant; and one was significant, but implausibly large. Similarly Zagonari (2018b) found that, of the five parameters analysed, three were plausible and significant, and two were plausible, but non-significant. However, these statistical analyses could not produce reliable parameter values to be used in numerical simulations because the sample was too small and unbalanced.

Validation is then replaced by calibration with no uncertainty. That is, the parameters are fixed at their current average values (which explain the current observed variables) by assuming that the observed parameter values that depict current observations are the most plausible a priori. Note that Bayesian frameworks have been increasingly used to link model calibration with uncertainty estimation (e.g., Bayesian Monte Carlo, Markov-chain Monte Carlo, generalised-likelihood uncertainty estimation). This is done by computing the distribution of model predictions and obtaining uncertainty estimates, although these Bayesian frameworks have been criticized from a theoretical perspective based on the subjectivity involved in adopting a likelihood measure and in choosing threshold values to distinguish behavioural from non-behavioural parameter sets. These frameworks have also been criticized operationally because both convergence and efficiency depend on the sample selection, burn-in period, proposed statistical distributions, and scale factors. See Breinholdt et al. (2013) and Chaudhary and Hantush (2017) for recent applications of these approaches to environmental modelling. In other words, the present model explains a single observation with no error, since the parameters are exogenously calculated to depict this observation. Note that, instead, a dimensional analysis is performed (i.e., all variables associated with parameters to be changed use a consistent set of units).

Second, the *feasibility* of the results is estimated by numerical simulations based on the whole range of values for a parameter. That is, it includes all possible changes in parameter values for the orange arrow in Fig. 2 that ends in future targets. In particular, the model predicts the future sustainability scenarios with no error, since calculations are presented over the whole variable space to ensure the absence of alternative solutions. Note that the approach in Zagonari (2016), which is based on applying two differential equations to happiness and health at times t and t-1, could also be used as an example, since the adoption of alternative ethical rules (i.e., Aristotle, Epicurus, Zeno, and Kant) can be tested with differences in happiness and health levels after accounting for income and other variables. Moreover, additional tests can be performed on the marginal impacts of some ethical principles in the sustainability context under consideration in this paper. Finally, Viganò (2017) adopted a similar approach by showing that neuroscience supports Adam Smith's prudence theory as an effective guide for agents who must make decisions when well-being is at stake.

Combining the first and second steps leads to four possible scenarios: reliable and feasible, reliable and unfeasible, unreliable and feasible, and unreliable and unfeasible. Note that Zagonari (2018a) shows dissonant reliability and feasibility rankings, whereas Zagonari (2018b) shows consonant reliability and feasibility rankings.

4 Recent scientific tests

In Sect. 3, I stressed that some traditional scientific tests cannot be performed in the philosophical and theological contexts under consideration in this paper. That is, the usual processes for choosing and testing a model cannot be directly applied, although the reliability of parameter estimates for representative individuals can be checked by means of

statistical analyses, and the feasibility of the results at equilibrium can be checked by means of numerical simulations. However, the moral philosophical and theological contexts involve three issues that the philosophy of science has recently addressed for the social and behavioural sciences: robustness of relationships, requirements for aggregation, and stability of equilibria. Consequently, in Sect. 4.1, I will describe the *robustness of the relationships* between religious precepts or ethical principles and pro-environmental behaviour by discussing invariance under observations versus interventions. That is, I will discuss to what extent the reliability of direct impacts from ethical principles and religious precepts on pro-environmental behaviours can be supported by the psychological and anthropological literature, and to what extent the feasibility of future equilibria can be supported by the psychological and anthropological literature on the indirect impacts of ethical principles and religious precepts on pro-environmental behaviours. In Sect. 4.2, I will identify the *requirements for aggregation* by discussing the issue of holism versus individualism (i.e., to what extent a society's behaviour can be properly depicted by referring to an average (representative) individual). In Sect. 4.3, I will specify the *stability of equilibria* by discussing causal mechanisms versus evolutionary processes. That is, I will discuss to what extent individual and social forces drive a society away from, or keep the society oriented around, a final equilibrium that arises from value changes if some people do not show pro-environmental behaviour according to a suggested moral rule. In this analysis, I will show that the robustness, aggregation, and stability conditions are met by the proposed approach.

4.1 Invariance under observations versus interventions

Since sustainability is linked to individual environmental behaviours, I will refer to the empirical psychological and anthropological literatures to find support for the reliability and feasibility of the relationship between ethical principles and religious precepts on pro-environmental behaviours.

Note that the integration of evidence produced by different methods to sustain the same hypothesis, claim, or results is often referred to as methodological triangulation (e.g., Kuorikostki and Marchionni 2016). Moreover, in terms of Fig. 2, reliability refers to forces that explain the orange arrow (i.e., *direct* impacts on the relationship between ethical principles or religious precepts and pro-environmental behaviour), whereas effectiveness refers to policies that move the orange arrow away from the black arrow to achieve future targets (i.e., *indirect* impacts on the relationship between ethical principles or religious precepts and pro-environmental behaviour). Finally, the concept of religious decline (e.g., Franck and Iannacone 2014), in which the social importance of religion in shaping the behaviour of individuals has decreased over time, might make ethical principles become more important than religious precepts.

Research in psychology aims to identify non-inborn individual motivations based on experiences and objectives (together with incentives) that lead towards pro-environmental behaviour of individuals and their attitudes (e.g., an innate individual behaviour is to increase consumption). In contrast, research in anthropology aims to identify social values based on traditions and perceptions (together with education) that lead towards non-innate pro-environmental behaviour and attitudes of groups (e.g., an innate social behaviour is to increase the population). In other words, psychology assumes a universalist process of cognition that is not strongly affected by cultural differences, and focuses on alternative contents of cognition to identify relationships such as those between religious experiences and pro-environmental behaviour of individuals. In

contrast anthropology assumes no distinction between the process and content of cognition, and identifies behaviours that are affected by belonging to a group.

Note that I will apply invariance in *observations* rather than invariance in *interventions* (Russo 2014). This is often the case in the social sciences, in which case a policy intervention (here, to achieve value changes) aims to change the status quo (here, to achieve sustainability) rather than to test the reliability of a relationship. In particular, reliability refers to the strength of policy interventions, whereas feasibility refers to their usefulness. Moreover, the Lucas critique, in which a policy might be ineffective because people react to it and behave differently from their behaviour before the intervention, is not relevant here, since the policy consists of changing behaviours (i.e., the causal structure does not change). In this case, the strength of the invariance of the causal relationship increases for both religious and ethical rules because the prevalence of non-consequentialism motivations (i.e., the individual acts in a certain way because they believe they must) increases relative to that of consequentialism motivations (i.e., the individual acts because they feel that they get more benefit from the action). Finally, I refer to experimental relationships within a pragmatist paradigm, under which scientific claims are inferred from diverse bodies of evidence that include, but do not require, experiments (Reiss 2015).

Tables 2 and 3 summarise some recent (2013–2019) empirical psychological and anthropological papers that support the existence of direct and indirect relationships between ethical principles and religious precepts and the pro-environmental behaviours they encourage. Indeed, corroboration of a direct relationship lets us rely on robust parameters, whereas corroboration of an indirect relationship lets us rely on controlled value changes. Note that pro-environmental behaviour is often based on an unidentified and abstract target such as future generations (Kogut and Ritov 2015). Moreover, I disregarded anecdotal and speculative anthropology research because it did not meet my criteria (i.e., that it must be based on reliable empirical data). Finally, Gifford and Nilson (2014) highlight that in estimating the impacts of religions, one should account for the problem of self-reported pro-environmental behaviour. To account for this problem, I eliminated studies that did not provide external validation of self-reports.

Table 2 suggests that the psychological literature supports the *direct* relationships depicted by my model's parameters to a greater extent than the anthropological literature. Note that the focus is on the change in moral values rather than on a change in emotions, such as the feelings of guilt and shame described by Rees et al. (2015), although the extent to which people feel emotionally connected to the natural world also leads to stronger reactions when they are confronted with environmental damage. Moreover, because organisations and corporations are neither religious nor philosophical agents, I disregarded studies of their behaviour and their effect on individual behaviour (e.g., Lu et al. 2017); however, because their effects are not negligible, they should be accounted for in future research. Finally, I focused on behaviour rather than evaluation (e.g., Bender et al. 2016) or intention (Barbarossa et al. 2018).

Table 3 suggests that the anthropology literature supports *indirect* relationships to a lesser extent than the psychology literature.

Note that although the *theoretical* literature (e.g., Sen 2006) suggests that behaviours could result from the interaction of multiple (calibrated and chosen or given and discovered) identities, I have referred only to *empirical* relationships based on observations. Moreover, more detailed data would allow a test of invariance in sub-samples (e.g., based on ethnicity or gender) for both ethics, the focus of psychology, and religions, the focus of anthropology (Downes 2016). Finally, although the *theoretical* literature (e.g., Baumard

Table 2 The recent (2013–2019) empirical literature on factors that support a *direct* impact of religious precepts or ethical principles on pro-environmental behaviour

	Psychology suggests a focus on	Anthropology suggests a focus on
Religions	Yang and Huang (2018): effects of Christianity on private environmental behaviours Arli and Tjiptono (2017): Muslim and Christian intrinsic and extrinsic religious motivations Clements et al. (2014): environmental concerns Garfield et al. (2014): spiritual oneness Gifford and Nilson (2014): environmental concerns and pre-requisites (e.g., knowledge, childhood experiences, activity choices, personality, and perceived behavioural control) Peifer et al. (2016): attendance at religious ceremonies versus biblical literalism Zaleha (2013): nature veneration	Taylor et al. (2016): synagogue or church attendance and the importance of religion in daily life
Ethics	Meng et al. (2019): environmental awareness Landry et al. (2018): helplessness versus concern Meleady and Crisp (2017): climate change inaction due to perceiving future generations as not being part of the individual's group Tam and Chan (2017): cross-cultural differences in the gap between concern and behaviour Unanue et al. (2016): prioritizing intrinsic life goals (e.g., self-development and community involvement) Reese et al. (2014): immediate situational circumstances to reduce use of guest towels during hotel stays Sanguinetti (2014): connection to nature and community in co-housing Van der Werff et al. (2013): feelings of moral obligation	–

and Boyer 2013) suggests that some religions are not moral, I have focused on *moral* religions.

4.2 Holism versus individualism

Section 4.1 showed that the robustness conditions are likely to be met by the relationships under consideration. However, Sect. 3.2 suggested that these relationships should be tested with aggregated data based on the assumption of a representative individual at a national level. Thus, I will now discuss aggregation conditions (holism), although the focus should

Table 3 Recent (2013–2019) empirical literature on factors that support an *indirect* impact of religious precepts and ethical principles on pro-environmental behaviour (i.e., by *controlled* aspects of precepts or principles)

	Psychology suggests a reliance on	Anthropology suggests a reliance on
Religions	Intahphuak et al. (2017): teaching responsibility during religious ceremonies Lakhan (2018): supporting recycling behaviours during religious speeches	Rolston (2016): local environmental beliefs Sponsel (2016): protect sacred places
Ethics	Ferraro and Miranda (2013): combining technical information, moral suasion, and social comparisons in water conservation information campaigns Kaida and Kaida (2016): information campaigns to reduce pessimism Mallett and Merchiori (2016): information campaigns to build a water-saver identity Soliman and Wilson (2017): reliance on lay theories of change Busic-Sontic et al. (2017): low-cost habits Linder et al. (2018): information intervention Sorkun (2018): informational influences	Kopnina (2016): ecological education Taylor et al. (2016): feelings in environmental movements (e.g., connectedness to nature, attachment to a place, affinity to nature, spiritual oneness with nature) Witt and Taylor (2017): social and environmental justice in environmental movements (e.g., the disproportionate burden and risk for poor and marginalised communities caused by pollution and other forms of environmental degradation)

be on defining representative individuals based on the smallest community to account for the many interactions at individual levels (Kincaid 2015).

In terms of ethical principles, the condition required to perform such aggregation (i.e., combining all the data to describe a representative individual) is likely to be met, since moral environmental behaviours are often based on habit and on mimicking group behaviours (i.e., emulating the behaviours of the society in which the individual lives). Moreover, in a democratic country, if the majority of the population opposes a governmental policy (e.g., environmental protection), it will not support that political party in subsequent elections; conversely, if the majority of the population is uncomfortable with a given social status (e.g., the degree of inequality), it will support a political party that tries to change that status in subsequent elections. Finally, it is becoming increasingly common for researchers to rely on individual data obtained from surveys (Shariff et al. 2014) thereby making the aggregation issue decreasingly important.

In terms of religious precepts, the aggregation conditions are likely to be met; that is, it is appropriate to consider the overall attitude of a religion to be a weighted average of the attitudes of its individual members. This is because religious environmental behaviour is often based on tradition or on emulating the attitudes of the members of one's religious community, and 91% of all countries have a single dominant majority religion. In addition, it is increasingly common for researchers to apply ethnic, linguistic, and religious stratification in sampling to measure cultural diversity (Patsiurko et al. 2012).

Note that Milkoreit (2015) discusses the spread of moral obligations towards climate change from diplomats, politicians, and nongovernmental organizations to the general population (i.e., mimicry). Moreover, if an individual does not share specific religious rules with other members of their religion, we can assume that they will either leave the religion or eventually be excluded from it. Finally, Fumagalli (2016) discusses the pros and cons of paternalism for environmental issues.

4.3 Causal mechanisms versus evolutionary processes

Section 4.2 showed that aggregation conditions are likely to be met at the level of a national representative individual in the religious and ethical contexts under consideration in this paper. However, these contexts are characterized by interactions among individual behaviours. Thus, I will now discuss the effects of intentional and non-intentional individual behaviours on the stability of pro-environmental behaviours. Indeed, to compare alternative moral rules in terms of their effectiveness (i.e., their ability to achieve a given measured goal), we must assume a similar stability of alternative future scenarios. Otherwise, the first and most effective moral rule could be preferred even if it is unstable (i.e., individuals will move away from that behaviour after a short period if some people stop following the rule), whereas the second-most effective moral rule should be preferred if it is stable.

Note that I will rely more heavily on systematic and causal explanations (Runhardt 2015) than on evolutionary models (Rosenberg 2017). Indeed, *first*, I assume that deviation from a social rule is unlikely to be random; since randomness is assumed by evolutionary models, this suggests that evolutionary models are less relevant. Instead, deviation depends on the social context even if the deviation might be unintentional (Tenbrunsel and Chugh 2015). Consequently, the observed social rule might not be the most effective rule. In other words, a one-to-one relationship between sociology and biology is difficult to support due to the existence of intentional social behaviours and strategies and the lack of these

behaviours and strategies in biology. *Second*, I will use an evolutionary approach for coordination problems related to environmental actions for two reasons: because the equilibrium does not depend on how many people follow a given rule, since each individual must agree with their opponents, and because coordination towards a given equilibrium could be irrelevant, so that deviation can be assumed to be random. *Third*, I will *not* rely on evolutionary explanations of the origins and prevalence of religions (Pyysiainen and Hauser 2010) as either an intuitive social rule (i.e., it refers to the principle of proportionality) or as a perfectly informed social rule (i.e., God can see anything), where moral rules are more easily communicated with narratives or visual arts (Baumard and Boyer 2013) than with analytical and imperfectly informed ethics (e.g., Pythagoreans, Stoics), because these evolutionary models assume a too-long time horizon to depict the value changes required to achieve sustainability.

In particular, the focus on moral environmental behaviours (e.g., waste separation to increase the efficiency of recycling programs, purchase of green products) lets us distinguish *strategic* stability, in which individuals are likely to perpetuate the same environmental decision, from *evolutionary* stability, in which all individuals other than deviators converge on pro-environmental behaviours. This approach supports the use of a game theory framework applied to preservation of the commons (e.g., Rommel et al. 2015), in which barriers and catalysts to fostering pro-environmental behaviours (e.g., Quimby and Angelique 2011) are linked to ethical principles and religious precepts.

Table 4 presents individual pay-offs for four alternative couples of decisions in terms of all permutations of pro- and anti-environmental behaviour. In this table, the couples can be defined in terms of game theory: reward (R), in which individuals cooperate to achieve a greater reward at the cost of some mutual sacrifice; temptation (T), in which one individual makes a selfish choice to improve their reward; sucker (S), in which an individual who chooses a pro-social response suffers for that choice; and punishment (P), in which both individuals suffer from their selfish choices. Of course, these choices also depend on ethical and religious values.

Note that because I have assumed aggregation at a national scale to produce a representative individual, I will not rely on a morally committed and altruistic opinion leader in this analysis (Srinivasan 2012); however, because their effects are not negligible, they should be accounted for in future research. Moreover, I will not consider situations of mutually exclusive or directly conflicting environmental actions (Klein et al. 2017). Finally, structural models are not relevant in this context, since a single relationship is analysed between religious precepts or ethical principles and a corresponding environmental behaviour or

Table 4 Possible interactions between individual pro- and anti-environmental behaviours in a game theory context

	Player 2	
	Pro-environment	Anti-environment
Player 1		
Pro-environment	R, R	S, T
Anti-environment	T, S	P, P

Couples are presented as actions chosen by Player 1 and Player 2

Categories of response: *T* temptation, *R* reward, *S* sucker, *P* punishment

attitude (Wunsch et al. 2014), and since the reversed relationship (i.e., from pro-environmental behaviours to religious precepts or ethical principles) is less relevant in this context.

Ethical principles is likely to affect the payoffs as follows, with various policy implications:

- P is large if consumer knowledge and awareness are small (e.g., if individuals are not aware of the economic and social consequences of climate change): information campaigns could then decrease P.
- R is small if consumers do not believe in the efficacy of their individual behaviour in mitigating the impact on the environment (e.g., if they feel marginal and irrelevant in coping with global environmental issues) or if they have a sense of fatalistic helplessness (e.g., if they feel they cannot do anything because it is too late): information campaigns could then increase R.
- R is small if green consumerism is expensive (e.g., high prices of green products), if it requires sacrifice (e.g., longer walks to use public transportation), and if it implies mindfulness (e.g., remembering to bring their own bags to the market): the implementation of waste facilities, market policies, and incentives (e.g., a tax credit for installing solar panels) could increase R.
- T is large if social pressure and feeling accountable are small for the consumer (i.e., if they do not care about criticism from their neighbours): negative feedback about factors such as higher household energy consumption than that of an individual's neighbours could reduce T.
- T is large if public facilities are lacking (e.g., poor spatial distribution of waste recycling facilities) or if green markets are non-competitive (e.g., high prices of green foods): implementation of waste facilities, market policies, bans (e.g., incandescent bulbs), or fines (e.g., a plastic bag fee in stores) could reduce T.
- S is small if social responsibility or moral awareness are small or if social conformity is large (i.e., if the consumer feels stupid by behaving pro-environmentally, when other people do not): responsibility campaigns could increase S.

Religious precepts are likely to affect the payoffs as follows, with various policy implications:

- R is small if the religious environmental rules are unknown: sermons could decrease T minus R by increasing the promised rewards (e.g., you must behave pro-environmentally because sacred texts make this a prerequisite for virtuous behaviour).
- T is small if disapproval by the religious community is implemented: sermons could decrease T minus R by improving community enforcement (e.g., it is defined as a sin to behave anti-environmentally).
- S is large if community responsibility is large (e.g., the individual does not feel stupid by behaving pro-environmentally when other people do not, since religious precepts encourage an individual's pro-environmental behaviour; on the contrary, the individual feels better than others): sermons could therefore increase S.
- P is large if pessimism (e.g., the individual cannot do anything, it is too late) or helplessness (e.g., it is unchangeable fate) prevail: sermons should prevent these feelings.

In terms of *ethical values*, responsibility to nature is depicted by a larger R and a smaller T; distributive justice towards current and future generations in both developed and developing countries is depicted by a smaller P; and responsibility to current generations in

developing countries and future generations in both developed and developing countries are depicted by a larger S and a smaller P, respectively. In terms of *religious values*, the sacredness of nature (i.e., trusteeship in Islam, equilibrium in Hinduism or Buddhism) is depicted by a larger R; concern for current and future generations (i.e., stewardship in Judaism and brotherhood in Christianity) is depicted by a smaller P; and concern for one's community is depicted by a smaller T and by a larger S.

Note that I have made the following simplifying assumptions:

- There is no time variable (i.e., this is a static analysis), so an individual chooses their behaviour "forever" rather than choosing one behaviour at one time and a different behaviour at other times. However, conformity with group norms and routine are relevant in this context.
- Feelings do not depend on the number of people that the individual faces, otherwise S should be smaller, with a larger number of people behaving anti-environmentally when an individual behaves pro-environmentally. However, social pressures arising from ethical rules are likely to be relevant (i.e., a small T) in a small community (e.g., churches, neighbourhoods).
- There is no positive time discount factor, otherwise R would be smaller or could be small (i.e., benefits to the environment of an individual's pro-environmental behaviour might only be observed in the far future by future generations) and P would be larger or could be large (i.e., costs to the environment of an individual's anti-environmental behaviour might only be observed in the far future by future generations). However, awareness of impacts on the environment could reduce the time discount factor to 0 or would reduce the time discount factor.

Note that I have used a symmetrical payoff matrix (i.e., individual *i* is facing individual *j*) rather than an asymmetrical payoff matrix (i.e., individual *i* would be facing other individuals *i'*), since individual *i* faces other individuals rather than an average individual. In particular, I depicted the effects of positive social pressure (i.e., support for pro-environmental behaviour) as a function of the proportion of the population who behave differently in (T, R) couples using a smaller T minus R, and depicted negative social pressure (i.e., disapproval of anti-environmental behaviour) as a function of the proportion of the population who behave differently in (P, S) couples using a smaller P minus S. Moreover, consequentialist and non-consequentialist behaviours are combined in a single matrix, because behaviours change continuously in alternative contexts in which the relative importance of utilities and values differ (Irlenbusch and Villeval 2015). Note that here, I have defined "consequentialist" to mean the belief that an action is evaluated by its consequences rather than by its inherent attributes. Finally, a repeated game based on this static matrix is not realistic (e.g., agent *i* should face the same agent *j* in implementing a pro- or anti-environmental behaviour), and this would reinforce the obtained insights (e.g., a pro-environmental behaviour will prevail if the time discount factor is small enough).

In terms of *game solutions*, dominant strategies lead to a couple of pro-environmental behaviours if $T < R$ and $P < S$. There is mixed behaviour if $T > R$ and $P < S$. There is a single behaviour if $T < R$ and $P > S$, in which case simple evolutionary dynamics based on a binomial chance to deviate (i.e., to behave differently from the equilibrium according to a fixed probability) would identify the attraction basin (i.e., the initial values of T minus R and of P minus S that lead to a single long-run [anti, anti] equilibrium) in which anti-environmental behaviour will prevail (i.e., P minus S > R minus T), and would identify the attraction basin (i.e., the initial values of T minus R and P minus S that lead to a

single long-run [pro, pro] equilibrium) in which pro-environmental behaviour will prevail (i.e., P minus S < R minus T). In particular, individuals will follow an environmental moral rule (i.e., a [pro, pro] equilibrium and an [R, R] outcome) if they are consequentialist, by comparing the benefits from obeying the rule (e.g., public benefits for current and future generations, current approval by people inside the religious or non-religious community) with the costs of obeying the rule (e.g., time-consuming implementation, payment of a state penalty if the rule is broken, current disapproval by people outside the religious or non-religious community) and if the benefits are larger than the costs (Lange et al. 2014). Alternatively, if the benefits are smaller than the costs (Hobman and Fredericks 2014), individuals will follow the same environmental rule if they are not consequentialist (Helm et al. 2018; De Dominicis et al. 2017; Klein et al. 2017; Culiberg 2014), but secular laws or institutions or moral values suggest that behaviour.

Note that mimicry and habitual behaviours do not affect payoffs; they only affect decisions. In contrast, social support (i.e., R minus T is larger because R is larger and T is smaller) has impacts on both payoffs and decisions. Moreover, a non-consequentialist behaviour would decrease T minus R by increasing R (the individual feels happy by behaving pro-environmentally) and decreasing T (the individual feels guilty by behaving anti-environmentally), and would decrease P minus S by increasing S so that it is close to R (the individual does not care about what others do, since they are doing what they feel they must do); actually, the individual feels happy, since they feel better than others by following a religious rule. Finally, technological advances can make *some* pro-environmental behaviours redundant (e.g., if waste separation is not required anymore): this is depicted by an increase in P. In other words, the prevalence of a given ethical or religious rule is locally stable at a given technological level.

In terms of movement *towards equilibrium*, Fig. 3 depicts the impacts of ethical principles using arrows (i.e., a relatively larger horizontal motion to the left whenever ethics affects payoffs by reducing T minus R, and a relatively smaller vertical motion towards the bottom whenever ethics affects payoffs by reducing P minus S), with the starting point assumed to be in the top right quadrant (i.e., a single unsustainable behaviour). In particular, interventions can reduce T minus R and P minus S, thereby achieving environmental sustainability, by implementing laws, such as self-focus procedures to reduce idling of

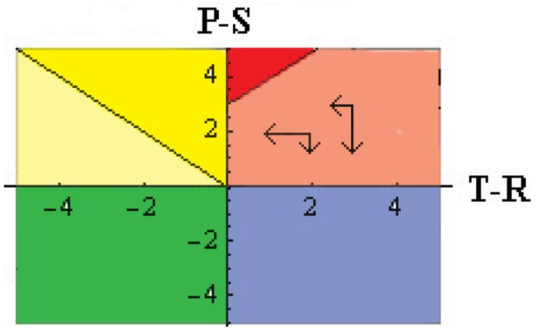

Fig. 3 Possible equilibria in a game theory context: P, punishment, S, sucker; T, temptation; R, reward. R minus P = 3. Dark red = prisoner's dilemma, light red = anti-environmental behaviour, blue = mixed actions, green = pro-environmental actions, dark yellow = a single coordinated action toward anti-environmental behaviour, and light yellow = a single coordinated action toward pro-environmental behaviour. (Color figure online)

engines for long periods while waiting at rail crossings, as in Meleady et al. (2017). This can also be achieved by implementing game-based approaches to reduce household electricity consumption, as in Ro et al. (2017); implementing incentives to purchase appliances with Energy Star labels (which indicate high energy efficiency) or government taxes or bans, as in Sachdeva et al. (2015); implementing institutions, such as corporate environmental responsibility, as in Ruepert et al. (2017); and implementing market competition for green products, as in Jo and Shin (2017). Moreover, ethical principles can increase R by making the prisoner's dilemma less likely, and can reduce T minus R and P minus S by making environmental sustainability more likely. This can be achieved by encouraging desirable norms and beneficial social dynamics during waste management, as in Gould et al. (2016). It can also be achieved by encouraging multiple uses of reusable grocery bags related to environmentalist and anti-environmentalist behaviours due to wanted and unwanted social identity as a consequence of these behaviours, as in Brick et al. (2017); encouraging moral obligation during pro-environmental behaviours, as in Nguyen et al. (2016); and encouraging social norms such as guest commitments to reuse hotel towels, as in Terrier and Marfaing (2015). Finally, once achieved, a sustainable equilibrium is likely to be stable because social pressures are likely to reinforce environmental ethics through peer support, such as adopting photovoltaic cells if your neighbours did or reusing hotel towels if other guests do, as in Sachdeva et al. (2015). Stability is also likely because individual behaviours are likely to be driven by habits, such as pro-environmental actions sustained over long time periods, as in Chatelain et al. (2018); by spillover effects on water conservation if household behaviours are perceived to be similar, as in Kneebone et al. (2018); by spillover effects across different pro-environmental behaviours, as in Carfora et al. (2017); by spillover effects between pro-environmental behaviours if the resources required to perform them are perceived to be similar, as in Margetts and Kashima (2017); and by spillover effects from green purchasing to other low-cost behaviours, as in Lanzini and Thogersen (2014).

In terms of movement *towards equilibrium*, Fig. 3 depicts the impacts of religious precepts using arrows (i.e., a relatively smaller horizontal motion to the left whenever religious precepts affect payoffs by reducing T minus R, and a relatively larger vertical motion towards the bottom whenever religious precepts affect payoffs by reducing P minus S), with the starting point assumed to be in the top right quadrant (i.e., a single unsustainable behaviour). In particular, religious precepts are likely to reduce the likelihood of a prisoner's dilemma scenario (i.e., R is large), since it makes people choose among potential partners to shun defectors, and thereby favours reciprocators (Baumard and Boyer 2013). Moreover, since individuals are generally more committed to values that they deem to be personally chosen than they are to socially imposed values, religious precepts are likely to favour pro-environmental behaviour in countries where religiosity is not imposed on everyone (Stavrova and Siegers 2014). Finally, religious precepts are likely to favour cooperation (i.e., T minus R and P minus S are both small) by presenting punishment, misfortune included, as a way to restore fairness rather than a way to deter cheating (Baumard and Boyer 2013).

In terms of comparisons of *movement towards equilibrium*, religious precepts are likely to reduce P minus S to a smaller extent than ethical principles, and religious precepts are likely to reduce T minus R to a larger extent than ethical principles.

In terms of the *expected equilibrium*, ethical principles are likely to produce mixed behaviours (i.e., some individuals behave pro-environmentally and some do not) if T minus R is positive and P minus S is negative, although interventions such as incentives, taxes, fines, or controls (i.e., a reduction of T) are likely to increase the percentage of people who

behave pro-environmentally. Note that many moral rules can be simultaneously observed at equilibrium, since different ethical rules can coexist within different communities, with support or disapproval coming from the reference community. In terms of the *expected equilibrium*, religious precepts are likely to lead to a coordinated equilibrium (i.e., either all individuals behave pro-environmentally or all individuals do not) if T minus R is negative and P minus S is positive and small; alternatively, they are likely to lead to a cooperative equilibrium (i.e., all individuals behave pro-environmentally) if both T minus R and P minus S are negative. Note that many moral rules can be simultaneously observed at equilibrium, since different religious rules can coexist within different communities, with support and disapproval for different rules coming from different parts of the reference community.

In terms of the *overall impacts* of religious precepts and ethical principles, Fig. 3 depicts both *starting points* and *expected equilibria*. Note that social pressure from religious communities on non-religious communities or between different religious communities is not required, but it would make pro-environmental behaviour more likely (Halevy et al. 2015).

In terms of *comparisons of starting points* between ethical principles and religious precepts, both are assumed to be in the top right corner of Fig. 3 (i.e., a single unsustainable behaviour), with religious precepts characterized by smaller P minus S and T minus R than is the case for ethical principles. Indeed, appearing virtuous to others is more important for theists, and can be depicted by a smaller T minus R for the religious precepts context. Reverence of theists for an omniscient and punitive God can be represented by a smaller T. The more parochial moral attitudes for theists can be depicted by a larger T if people from different groups interact. The less likely engagement of believers in utilitarian analysis of the situation or, similarly, the more likely slowness of believers in resolving the cognitive conflict between two occasionally opposing moral principles can be represented by a smaller T minus R (Shariff et al. 2014). Moreover, believers are more likely to claim that moral rules are objectively true (Yilmaz and Bahcekapili 2015). Finally, a behaviour displayed for moral reasons could improve the moral standing of the group as a whole in inter-group settings, even if it differs from the average behaviour within a group, so long as the different behaviour is positively evaluated by the group (Cramwinckel et al. 2015).

In terms of *comparisons of expected equilibria* between ethical principles and religious precepts, religion is likely to reduce the likelihood of a prisoner's dilemma scenario to a greater extent than ethics (i.e., R is larger), since it makes people choose among potential partners so as to shun defectors and favour reciprocators (Baumard and Boyer 2013). Moreover, since individuals are generally more committed to values that they deem to be personally chosen rather than socially imposed, religion is likely to favour pro-social behaviour in countries where religiosity is not imposed on everyone (Stavrova and Siegers 2014). Finally, religious precepts are likely to favour cooperation to a greater extent than ethical principles by presenting punishment, misfortune included, as a way to restore fairness rather than as a way to deter cheating (Baumard and Boyer 2013).

I will conclude this analysis with some final remarks. First, it is not possible to assume that one set of rules will replace another set of rules (i.e., unity of ethical or religious moral rules), since both ethical and religious rules can coexist within different communities. For example, a member of a religious or non-religious group cares less about the behaviour of members of other religious or non-religious communities than about the behaviour of their fellows. This effect depends on the degree of support and disapproval by the reference community, although disappointment of members belonging to a different community can also be depicted by referring to individual feelings rather than community feelings. Second, all religious, political, and organisational leaders can help to define shared community

morals, but the moral climate enacted by these leaders within a group might be more predictive than formal regulations or moral codes of individual moral choices, since shared moral standards define the group and affect social identities of members of the group (Ellemers and Van der Toorn 2015). Third, any equilibrium based on a single ethical rule (i.e., with a given percentage of the population implementing a given moral behaviour) can be stable, although it might fail to achieve environmental sustainability. Fourth, I did not rely on the "better so true" argument (Preston-Roedder 2014), in which "it would be better if a certain moral theory were true" implies that "the theory is true", regardless of our belief or actions in accord with the moral theory. Fifth, any equilibrium based on the interactions of many ethical rules (i.e., with different percentages of the population implementing different moral behaviours) can be stable, although it might fail to achieve environmental sustainability.

5 Conclusions

In this paper, I show that moral philosophy and theology can be seen as forms of empirical behavioural science if the focus is on *specific* moral behaviours in *specific* contexts. Assumptions cannot be deduced from observations if secular and religious moral rules are obtained from philosophical and sacred texts, respectively. Nonetheless, the focus on pro-environmental behaviour let me accomplish the following goals: apply a behavioural model; measure parameters and behaviours at individual or national levels; test for the reliability of relationships at current moral values based on statistical analyses of significance and size of parameters as well as based on a literature review of factors supporting direct impacts in alternative contexts; test for the feasibility of results under changed values of the various moral parameters based on numerical simulations over the whole domain of parameters or solutions as well as based on a literature review of the factors that support indirect impacts in alternative contexts; and account for aggregation and stability issues.

Note that the purpose of quantification is to improve the objectivity of an analysis, thereby revealing new insights by harnessing the power of mathematics and statistics to detect key factors or processes that might otherwise be missed. For example, it can help us detect which religious or secular moral rule is more effective in achieving sustainability. Moreover, the purpose of a mathematical approach is to make the analysis more objective once the underlying subjective assumptions have been clearly defined, thereby allowing future researchers to modify the assumptions if they want to explore the consequences of these changes. Finally, the use of an overall mathematical framework supports objective comparisons, and it can subsequently be expanded in future research to compare different schools of thought within different religious or philosophical cultures.

In addition, this paper represents a novel contribution to moral philosophy and theology by *associating* these fields of thought with empirical behavioural science. Indeed, if a specific value change is required to improve an individual's or a society's status, its effectiveness must be tested in terms of individual well-being or social sustainability. This implies that a behavioural model must be developed to explain the current observed behaviour and to simulate alternative scenarios if religious or ethical values are changed. In short, moral philosophy and theology, in their main objective to suggest behavioural rules, need support from science to measure their effectiveness. However, behavioural models of pro-environmental behaviours such as household waste recycling (i.e., time-consuming actions), organic food consumption (i.e., money-spending

actions), or household energy conservation (i.e., time-consuming and money-spending actions) suggest that either religious or secular moral rules are crucial determinants. In short, science, in accord with its main objective (to explain observed behaviours), needs moral philosophy and theology for its predictions to have empirical content.

Note that the world's great religions may have survived for centuries not because they *explain* observed behaviour at social and individual levels, but because they *suggest* behavioural rules at a social level and because they provide a justification for life, in general, and for suffering and injustice, in particular, at the individual level. Consequently, economists, sociologists, or psychologists who identify themselves as supporters of (for example) the Islamic finance doctrine or the Catholic social doctrine, implicitly or explicitly support economics, sociology, and psychology as doctrines rather than sciences. That is, they suggest behavioural models, at social or individual levels, rather than *empirical* explanations of observed behaviours, at social or individual levels. In other words, these scholars equate economics, sociology, and psychology to moral philosophy and theology, and do not require empirical tests of these behavioural rules. In contrast, my analysis suggests that moral philosophy and theology *should be* empirically tested by equating these disciplines to behavioural sciences.

Therefore, the main contributions of the present paper are fourfold. First, science can help moral philosophy choose among alternative moral rules, both in positive terms (based on their explanatory power) and in normative terms (based on their ability to achieve goals). Note that there are examples in the history of science where moral philosophy or moral theology helped science choose among alternative theories (e.g., alternative versions of Darwinism). Second, the application of traditional and recent scientific tests let me show that moral philosophy and theology can be seen as empirical behavioural sciences. Consider, for concreteness, the increasing numbers of university courses, faculties, departments in Theology or Religious Science around the world. Third, moral philosophy and theology must be combined with behavioural science to become equivalent to political economy, because a tight relationship between moral rules and behaviour must be feasible, reliable, and stable in order to affect the real world. Consider, for example, the social and environmental goals pursued in 2019 by Pope Francis and the Grand Imam of Al-Azhar, Ahmed el-Tayeb in Human Fraternity for World Peace and Living Together. Note that sustainability as a social goal, is crucial both from a normative perspective (i.e., survival of a society is better than its loss) and from a positive perspective (i.e., if a society disappears, it is not possible to observe the behavioural rules that characterise it). Similarly, behavioural science needs moral theology and philosophy to support its empirical content (e.g., household waste collection depends on the prevailing ethical rules), since behaviour evolves over time according to the theological or philosophical interpretations of observed events. Note that there is increasing evidence that religions can favour pro-environmental behaviours (e.g., household waste recycling increases if it is preached in religious ceremonies). Fourth, this paper provides a methodological framework for interdisciplinary research by relying on traditional and recent scientific tests: the suggested methodology is obviously related to a specific context (i.e., moral philosophy and theology combined with behavioural science) and focused on solving a specific problem-solving context (i.e., global environmental sustainability) and a knowledge-practicing context (i.e., the empirical content of a moral rule).

In future research, the same general methodological approach could be applied to alternative combinations of disciplines that are relevant in alternative problem-solving or knowledge-practicing contexts by relying on alternative traditional and recent scientific tests.

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