

## Article

# Pope Francis vs. Patriarch Bartholomew to Achieve Global Environmental Sustainability: Theoretical Insights Supported by Empirical Results

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**Abstract:** This paper theoretically examines and empirically assesses the ethical statements by Pope Francis and Patriarch Bartholomew in terms of their ability to achieve global environmental sustainability. The theological discussion of environmental precepts in documents/speeches based on the recent academic literature suggests that (absolute feasibility) Pope Francis pursues unfeasible environmental and social goals (personal fulfillment, poverty reduction, population growth), whereas Patriarch Bartholomew pursues feasible environmental goals (meeting God's will, following God's law); (relative feasibility) Pope Francis suggests unclear and inconsistent values, whereas Patriarch Bartholomew suggests clear and consistent values; (absolute reliability) Pope Francis relies on many instruments close to alternative attitudes to the environment (happy sobriety, contemplative style, human rights), whereas Patriarch Bartholomew rests on few instruments close to unambiguous concerns for the environment (happiness from sanctity, asceticism, duties to community); (relative reliability) Pope Francis suggests broad behavioral rules, whereas Patriarch Bartholomew suggests targeted behavioral rules. The statistical analysis of documents/speeches as if they are environmental regulations (using "sin") based on dynamic panel data shows that Patriarch Bartholomew > Pope Francis in absolute feasibility; Patriarch Bartholomew > Pope Francis in relative feasibility; Pope Francis > Patriarch Bartholomew in absolute reliability; and Patriarch Bartholomew > Pope Francis in relative reliability. Pope Francis and Patriarch Bartholomew together reduced the global average per capita use of the Earth's resources by 5% per year.

**Keywords:** Pope Francis; Laudato Si'; Patriarch Bartholomew; global sustainability; theological discussion; statistical analysis



**Citation:** Zagonari, F. Pope Francis vs. Patriarch Bartholomew to Achieve Global Environmental Sustainability: Theoretical Insights Supported by Empirical Results. *Sustainability* **2023**, *15*, 13789. <https://doi.org/10.3390/su151813789>

Academic Editor: Marc A. Rosen

Received: 19 June 2023

Revised: 9 September 2023

Accepted: 12 September 2023

Published: 15 September 2023



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## 1. Introduction

The increasing damage to the environment and human society caused by climate change suggests that global sustainability is an urgent problem ([www.sdgindex.org/reports/2018](http://www.sdgindex.org/reports/2018), accessed on 1 January 2023). In other words, we must act now, even if technology can be improved rapidly, consumption preferences can be changed, and populations begin to decrease, we cannot afford to wait for these processes to succeed.

The literature has recently begun to emphasize the role of ethics in achieving global environmental sustainability [1–3]. In particular, two main groups of environmental ethics can be identified: secular and religious ethics. Secular ethics focus on our responsibility to nature, responsibility to future generations, perceptions of the rights of humans and non-humans, and beliefs in inter- and intra-generational equity [4]. Religious ethics has a different focus in each religion [5]. For example, we could simplistically emphasize stewardship in Judaism, trusteeship and parsimony in Islam, maintaining equilibrium (where each single organism is respected) in Hinduism, avoiding pain for sentient animals in Buddhism, and loving neighbors (where creatures are designed by God for human use) in Christianity [6–8]. Note that secular and religious ethics offer complementary strategies to achieve global environmental sustainability in the long and short terms, respectively [9].

The observed failures of international agreements on climate change suggest that the unsustainability of global society is a practical problem (i.e., one related to actual practice rather than to beliefs; [www.sdgindex.org/overview](http://www.sdgindex.org/overview), accessed on 2 January 2023). In other words, it is not enough for an ethical principle or precept to be consistent and to be intended to move the world away from unsustainable practices, the principle or precept must also provide behavioral rules that are feasible (i.e., realistically successful) and reliable (i.e., practically trustworthy), positive (i.e., do that, possibly supported by reward) or negative (i.e., do not do that, possibly supported by punishment), to achieve sustainability through the application of consistent ethical concepts to achieve realistic equilibrium conditions.

Both the methodological literature (e.g., [10]) and the applied literature (e.g., [11]) support the idea that sustainability must adopt an interdisciplinary approach (i.e., it cannot be analyzed from a purely scientific or a purely ethical perspective, but it must include many perspectives). In particular, the encyclical *Laudato Si'* (2015) ([w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco\\_20150524\\_enciclica-laudato-si.html](http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html), accessed on 3 January 2023) by Pope Francis (Jorge Mario Bergoglio, Pope of the Catholic Church and Bishop of Rome, since 2013) supports an inter-disciplinary approach: “A science which would offer solutions to the great issues [such as sustainability] would necessarily have to take into account data generated by other fields of knowledge, including philosophy and social [both secular and religious] ethics” (§110) (italics text is mine). Indeed, the encyclical has been presented as an excellent opportunity to trigger a conversation between science and religion, as well as secular ethics about sustainability [12]. Similarly, since 1995 Patriarch Bartholomew I (Dimitrios Arhondonis, Ecumenical Patriarch of the Eastern Orthodox Church and archbishop of Constantinople, since 1991) has convened several symposia bringing together scientists, NGOs, and religious leaders [13].

The purposes of this paper is to apply a scientific approach to compare Pope Francis and Patriarch Bartholomew as representatives of the Catholic and Orthodox Churches about environmental issues in terms of absolute feasibility (i.e., did they specify compatible goals which can be realistically implementable?) and relative feasibility (i.e., who stated more consistent ethical values which can be realistically prioritized?), as well as in terms of absolute reliability (i.e., did they advocate alternative instruments which can be practically implemented?) and relative reliability (i.e., who suggested more focused behavioral rules which can be practically implemented?).

Note that the proposed interdisciplinary approach, in which both ethics and science are involved, implies that documents by Pope Francis (the main encyclical letter *Laudato Si'*) and by Patriarch Bartholomew (the many Ecumenical Letters, publications, speeches and addresses) are not dogmatic letters, but rather political letters (i.e., scientific truths cannot be accepted without doubt) for Anthropocene (i.e., a geological epoch characterized by a significant human impact on Earth's ecosystems) [14]. Consequently, I will assess Pope Francis and Patriarch Bartholomew by applying criteria suitable for a political perspective (i.e., the consistency between the stated goals or constraints and the suggested policy instruments) [15].

Moreover, consistently with Pope Francis and Patriarch Bartholomew, I will perform a cross-country rather than a within-country analysis. As for Pope Francis, see “The worst impact of climate change will be probably felt by developing countries in coming decades (§25); “Water continues to be wasted, not only in the developed world but also in developing countries which possess it in abundance” (§30) [16]. As for Patriarch Bartholomew, see “nations” in his speeches and statements (e.g., his joint statement with Joan Paul II in 2002 and his speech at the Japan conference in 2005) [17].

Finally, although global environmental sustainability has been specified differently by different scientific, philosophical, and theological theories, I will assume that these alternative perspectives are compatible and can be summarized and quantified based on the concept of an ecological footprint (i.e., the biologically productive area needed to provide all services that an individual uses) [18]. In other words, the stated objective (i.e.,

global environmental sustainability) is measured in terms of the sustainable per capita use of the Earth's resources.

In summary, like [5,19], this paper represents an example of interdisciplinary science (i.e., getting hypotheses about environmental ethics from the analyses of texts by Pope Francis and Patriarch Bartholomew, depicting these hypotheses within a theoretical model, applying mathematics to check for feasibility of those environmental ethics to achieve global sustainability, applying statistics to check for reliability of the relationships between environmental ethics and behaviors). In particular, interdisciplinary science is here characterized as an abductive rather inductive science [20] (i.e., its hypotheses are not based on observations, but on axioms such as "Catholic and Orthodox environmental ethics can affect environmental concerns and behaviors"), an observational rather than experimental science [21] (i.e., casual relationships are not identified by implementing experiments, but by applying statistical tests to data on estimated ethics and observed behaviors in 218 countries from 1995 to 2019), a contextual rather than topical science [22] (i.e., the tested relationships are presumed to depend on time periods and sampled countries), and a normative rather than positive science [23] (i.e., the feasible and reliable relationships aim at suggesting to what extent Pope Francis and Patriarch Bartholomew can help achieve global sustainability rather than at explaining Catholic and Orthodox environmental behaviors).

Note that Mrchkovska et al. [24] address a similar research question (i.e., to what extent Pope Francis as an institutional authority affects the willingness to support a public petition for a meat tax sponsored by an NGO), but they inaccurately apply an experimental approach to a contextual issue in Italy, by relying on a small sample of 1200 survey observations.

## 2. Methods

In this section, I summarize the main ethical statements by Pope Francis and Patriarch Bartholomew, by examining them in terms of the absolute and relative feasibility and reliability to achieve global environmental sustainability. Note that I will refer to *Laudato Si'* for the environmental ethics by Pope Francis. Indeed, this encyclical letter can be assumed to be a direct and official summary in English of his thoughts expressed in previous and subsequent written and oral communications (many in Italian and Spanish) (for example, see the discourses on climate change among public and politicians in US as discussed by [25]). In contrast, the environmental ethics by Patriarch Bartholomew have been expressed in many ecumenical letters, publications, speeches and addresses (often in Greek) and they have not been officially summarized in a comprehensive document (apart from [26]). Thus, I will refer to the indirect literature on his thoughts by relying on the authors' translations into English.

However, ethical statements must be quantifiable and grounded on significant quantitative relationships with ethical values and behavioral rules to be characterized as feasible and reliable, respectively (i.e., hypotheses obtained from theology must be tested by applying mathematics and statistics) [27]. Thus, in Section 3, I will develop an analytical model to be estimated by referring to the dataset specified in Supplementary Materials SI. Note that the population potentially guided by Pope Francis is nearly 24% of the world's population in the 64 countries where Catholics are in the majority, whereas the population potentially affected by Patriarch Bartholomew is nearly 4% of the world's population in the 13 countries where Orthodoxy is the majority religion.

### 2.1. Absolute Feasibility

As for absolute feasibility, statements by Pope Francis in Supplementary Materials SII.1 (i.e., keywords are personal fulfillment, poverty reduction, population growth) are expected to be empirically infeasible (i.e., many incompatible goals).

In contrast, statements by Patriarch Bartholomew in Supplementary Materials SII.1 (i.e., keywords are meeting God's will, following God's law) do not need to be proven to be empirically feasible (i.e., few focused goals) [28].

Note that social goals are supported as a prerequisite to environmental sustainability [29] by Pope Francis and disregarded by Patriarch Bartholomew [30]. Moreover, creation should be distinguished from the environment [31]. Finally, humans are above other animals as priests of creation for Patriarch Bartholomew rather than managers (Judaism) or trustees (Islam) of nature (i.e., man related to nature not by what he does, but by what he is) [32].

The statements by Patriarch Bartholomew on consumerism denial (e.g., “we fail to distinguish between what we want and what we need”) and ecological justice (e.g., “the environmental crisis is a form of social injustice”) [33] are similar to the statements by Pope Francis in Supplementary Materials SII.1 on consumerism denial (i.e., reducing the use of Earth resources by reducing the consumption of goods) and ecological justice (i.e., reducing the use of the Earth’s resources by taking into account capability, historical responsibility, and sovereignty).

Note that growing population [34] and combating poverty [35] are assumed by Pope Francis to be constraints that are unrelated to sustainability.

## 2.2. Relative Feasibility

As for relative feasibility, statements by Pope Francis in Supplementary Materials SII.2 support unclear and inconsistent values, so they are expected to be empirically infeasible (i.e., priorities are not specified). Note that many statements can be shown to be theoretically inconsistent with ecology (e.g., §69, §84, §140). In particular, the concept of species is assumed to be a substitute for the concept of organism (i.e., the encyclical focuses on individual organisms rather than on the more ecologically important concept of species), in accordance with the biblical tradition (*Matthew 6, 26*). However, the respect for each single organism is different from the respect for a species, and the survival of individuals is not required to achieve preservation of the species or global sustainability [36]. Indeed, sustainability, defined in the context of social and ecological resilience [37] refers to species rather than individuals within an eco-centric approach.

In contrast, statements by Patriarch Bartholomew in Supplementary Materials SII.2 support clear and consistent values, so they are expected to be empirically feasible (i.e., priorities are specified) [33]. Note that eco-centric deep ecology should be distinguished from the theo-centric deep ecology of Patriarch Bartholomew, where ecological interdependencies are coupled with a common telos of all beings [31].

Patriarch Bartholomew is not innovative, since he is close to pre-modern religions [31], while Pope Francis is not innovative since he combines many religious approaches. In particular, sentence §9 is quoted from Greek Orthodoxy. For example, St. John Chrysostom states that “Creation is beautiful and harmonious, and God has made it all just for your sake. He has made it beautiful, grand, varied, and rich” (On Providence); St. Symeon of Thessalonika states that “The Divine Liturgy [celebrating the perception and the very presence of heaven on Earth] constitutes the holy of holies” (On the Holy Liturgy); and St. Gregory of Nyssa states that “Christ emptied himself, so that nature might receive as much of him as it could hold” (On the Psalms). Sentences §12 and §232 come from Judaism. For example, *Deuteronomy* (22:6–7): “6 If thou find as thou walkest by the way, a bird’s nest in a tree, or on the ground, and the dam sitting upon the young or upon the eggs: thou shalt not take her with her young: 7 But shalt let her go, keeping the young which thou hast caught: that it may be well with thee, and thou mayst live a long time”; *Leviticus* (19:23): “during the first three years of growth, the fruits of newly planted trees or vineyards are not to be eaten”; *Leviticus* (27:27): “The firstborn, which belongs to the Lord, no one is able to sanctify or vow, whether it is an ox, or a sheep, they are for the Lord; and *Leviticus* (27:30): “All the tithes of the land, whether from grain, or from the fruits of trees, are for the Lord and are sanctified to him. Sentence §42 is close to Hinduism, e.g., the *Bhagavad-Gita* of the Mahabharata (5:18): “See the presence of God in all, and treat all species with respect”, and the *Vishnu Purana* (3:8:15): “God, Kesava, is pleased with a person who does not harm or destroy other non-speaking creatures or animals”) [38].

### 2.3. Absolute Reliability

As for absolute reliability, statements by Pope Francis in Supplementary Materials SII.3 (i.e., the keywords are happy sobriety, contemplative style, human rights) are expected to be empirically reliable (i.e., many instruments close to alternative attitudes to and concerns for the environment). In other words, Pope Francis suggests that the epistemological paradigm behind science and technology should be replaced by knowledge gained through the contemplation of nature's beauty [39].

Similarly, statements by Patriarch Bartholomew in Supplementary Materials SII.3 (i.e., keywords are happiness from sanctity, ascetism, duties to community) are expected to be empirically reliable (i.e., few instruments close to a specific attitude to and concern for the environment) [40].

Note that Pope Francis and Patriarch Bartholomew are similar in statements about ecological sin. As for Patriarch Bartholomew, examples include committing a crime against the natural world, such as climate change, pollution, deforestation, is a sin, where the Earth's devastation is not the consequence of sin but its content (Santa Barbara speech in 1997). As for Pope Francis, examples are as follows. To commit a crime against the natural world is a sin against ourselves and a sin against God (§8). Accept the world as a sacrament of communion (§9). Saint Francis asked that part of the friary garden always be left untouched, so that flowers and herbs could grow there (§12). Because all creatures are connected, each must be cherished with love and respect, for all of us as living creatures are dependent on one another (§42). We live in a common home which God has entrusted to us (§232). In other words, Pope Francis rejects an anthropocentric axiology and endorses an anthropocentric epistemology [41].

### 2.4. Relative Reliability

As for relative reliability, statements by Pope Francis in Supplementary Materials SII.4 suggest broad behavioral rules (i.e., an unsuccessful compromise of Catholic traditions over time), where Pope Francis represents a new age of religiously inspired environmental sustainability for the Catholic church [42,43], although previous Popes also referred to environmental issues (e.g., John Paul II called for "a global ecological conversion" in *Redemptor Hominis*, 1979; and Benedict XVI stressed that "the economic and social costs of using up shared environmental resources must be fully borne by those who incur them, not by other people or future generations" in *Caritas in Veritate*, 2009) [44,45].

In contrast, statements by Patriarch Bartholomew in Supplementary Materials SII.4 suggest focused behavioral rules (i.e., a successful compromise of Orthodox traditions over space), where environmental issues have a long tradition in the Orthodox church [46].

Note that many statements by Pope Francis can be shown to be theoretically inconsistent with philosophy (e.g., §159 and §162). Indeed, the concept of solidarity (the concerned attitude towards the poor and the vulnerable in Pope Francis and articulated in terms of friendship or social charity in the Catechism of the Catholic Church 1939) is assumed to be a substitute for the concept of equity, in accordance with the Catholic tradition (St. Thomas, *Summa Theologiae*). However, solidarity (a virtue that is grounded on mutual obligation and shared effort to social cohesion, and manifested in sharing spiritual and material goods in the Catechism of the Catholic Church 1949) is difficult to apply to future generations (i.e., unspecified representative individuals), and it is impossible to measure (i.e., an attitude or virtue rather than a specified behavior or outcome), whereas equity, in its alternative definitions and units, can be measured to test for the reliability of the advocated and implemented policies [47]. Moreover, sentences such as §50 and §211 by Pope Francis suggest an analysis based on social cohesion and responsibility [48], in contrast with a tight policy to achieve sustainability, such as the "polluter-pays" or the "polluter-stops-polluting" principles, that are based on rights and duties [49]. Finally, statements such as §92 and §130 by Pope Francis about an individual animal's dignity are not required to achieve global sustainability. Indeed, the encyclical letter *Laudato Si'* assumes that animals have some (sort of) rights, not stated explicitly, in accordance with the Catholic tradition (Catechism of the

Catholic Church, 2418) [50]. However, the rights of non-humans may not contribute to conservation of nature (i.e., it is unnecessary to consider the rights of individual organisms to plan conservation activities) [51], where the rights of non-humans include the rights of species (i.e., speciesism), the rights of non-humans who experience pain and suffering (i.e., sentientism), and the rights of any life form [52]. By attaching value to each individual plant or animal [53], to communities [54], or to biological diversity and ecological integrity [55], these rights can extend from the very small (individuals) to the very large (ecosystems).

### 2.5. Hypotheses to Be Tested

Although Pope Francis was realistically accurate in highlighting that global sustainability is a collective action problem (e.g., “the urgent challenge to protect our common home” in §13) [56] and in stressing that technological innovation cannot be its solution but a change in values is required (e.g., “compulsive consumerism as an effect of the techno-economic paradigm” in §203) [57], Section 2 reached the following hypotheses about feasibility to be tested in Section 3:

- Pope Francis is expected to perform worse than Patriarch Bartholomew in absolute feasibility (i.e., many social and environmental goals in Pope Francis are incompatible).
- Pope Francis is expected to perform worse than Patriarch Bartholomew in relative feasibility (i.e., unclear and inconsistent values by Pope Francis cannot be prioritized).

Note that Section 3 will also show that Pope Francis is empirically inaccurate in stating that intra-generational equity must be preliminary to inter-generational equity to cope with global unsustainability (§48) (i.e., reducing inequality mean within countries to reduce the use of Earth resources) and in stating that inequality across countries caused global unsustainability (i.e., reducing inequality variance between countries to reduce the use of Earth resources) (§51) [58].

Although Pope Francis was practically accurate in highlighting that a collective action problem can be solved within a deontological approach (i.e., environmental virtue ethics based on respect, benevolence, moderation, humility, compassion, courage, and simplicity in §85) and a teleological approach (i.e., environmental virtue ethics focuses on prosperity and flourishing in §88) [9], Section 2 reached the following hypotheses about reliability to be tested in Section 3:

- Pope Francis is expected to perform better than Patriarch Bartholomew in absolute reliability (i.e., many different rules by Pope Francis approach many people).
- Pope Francis is expected to perform worse than Patriarch Bartholomew in relative reliability (i.e., many broad rules combined with many incompatible goals in Pope Francis do not achieve a specific objective).

Note that the few clear and consistent values prioritized as well as the few targeted and unambiguous rules suggested by Patriarch Bartholomew justify the smaller number of citations from his speeches and documents provided in Section 2.

## 3. Results

In this Section, I will evaluate the main ethical statements by Pope Francis and Patriarch Bartholomew in terms of feasibility and reliability, by testing the hypotheses highlighted in Section 2. Note that I assume that God is one source of moral values and norms, together with other sources, and religious environmental ethics can help in coping with global unsustainability [59]. Moreover, although Pope Francis represents a single voice within the Catholic Church, with multi-level actors [60], whereas Patriarch Bartholomew is *primus inter pares* within the Orthodox Church, with some unsolved coordination problems [30], I identified a common ethical statement as a policy instrument in the use of the word “sin”. In particular, Patriarch Bartholomew in his Santa Barbara speech in 1997 and Pope Francis in his encyclical letter *Laudato Si'* in 2015. Finally, I will measure reliability in terms of environmental impacts rather than in terms of academic citations [61] or in terms of internal consensus in religious communities [62].

In particular, in all sub-sections below, I refer to the following theoretical model:

$$U = INC^\alpha E^{-\beta} INE^{-\gamma}$$

where  $U$ ,  $INC$ ,  $E$  and  $INE$  represent, at the individual level, the welfare level, the income or consumption level, the use of environmental resources, and the income inequality level, respectively, whereas  $\alpha$ ,  $\beta$  and  $\gamma$  represent the consumption preferences, the environmental concerns, and the inequality concerns, respectively. Note that variables and acronyms are summarized in Appendix A (Table A1).

Consistently, its logarithmic form can be expressed as follows:

$$\ln U = \alpha \ln INC - \beta \ln E - \gamma \ln INE \quad (1)$$

Note that Pope Francis and Patriarch Bartholomew could affect the environmental concerns  $\beta$  directly and the use of Earth resources  $E$  indirectly (i.e., a larger  $\beta$  implies a smaller  $U$  to be compensated by a smaller  $E$ ).

Sections 2.1 and 2.2, about feasibility, assume similar values of  $\gamma$  for Catholic and Orthodox believers, by searching for realistic values of  $\beta$  (i.e.,  $\beta$  in  $[0, 0.2]$ ) that solves the following equations for realistic values of  $\alpha$  (i.e.,  $\alpha$  in  $[0.5, 1]$ ):

$$\beta_{cat} = \alpha_{cat} (\ln[INC_{cat}]/\ln[E^*]) - \gamma_{cat} (\ln[INE_{cat}]/\ln[E^*]) - (\ln[U_{cat}]/\ln[E^*]) \quad (2a)$$

and

$$\beta_{ort} = \alpha_{ort} (\ln[INC_{ort}]/\ln[E^*]) - \gamma_{ort} (\ln[INE_{ort}]/\ln[E^*]) - (\ln[U_{ort}]/\ln[E^*]) \quad (2b)$$

where  $E = E^*$  depicts the per capita long-run sustainable use of Earth resources at the world level. Note that a larger  $\alpha$  (for given  $INC$  and  $E^*$ ) must be compensated by a larger  $\beta$  (to have the same welfare level), while a larger welfare level is achieved otherwise. In contrast, a smaller  $\alpha$  (for given  $INC$  and  $E^*$ ) must be compensated by a smaller  $\beta$  (to have the same welfare level), while a smaller welfare level is achieved otherwise.

Sections 2.3 and 2.4 about reliability assume that differences of Catholic and Orthodox believers with respect to other believers or non-believers as well as the impacts of Pope Francis and Patriarch Bartholomew can be represented by vertical shifts in Equation (1) once solved for the use of Earth resources  $E$ , by searching for significant values of (dummy) variables representing Catholic and Orthodox believers (i.e.,  $Cat$  and  $Ort$ ) and significant values of (dummy) variables representing impacts of Pope Francis and Patriarch Bartholomew (i.e.,  $PF$  and  $PB$ ) based on the following equation:

$$\ln E = (\alpha/\beta) \ln INC - (\gamma/\beta) \ln INE - (1/\beta) \ln U + Cat + Ort + PF + PB \quad (3)$$

Note that, within the feasibility framework, a larger environmental concern  $\beta$  means that, for a given environmental status  $E$ , a smaller welfare level is achieved. In contrast, within the reliability framework, significant and negative values of  $Cat$  and  $Ort$  mean that, for a given environmental concern  $\beta$ , a smaller use of Earth resources  $E$  is observed for Catholic and Orthodox believers with respect to other believers and non-believers, respectively, whereas significant and negative values of  $PF$  and  $PB$  mean that Pope Francis and Patriarch Bartholomew reduced the use of Earth resources for Catholic and Orthodox believers, respectively.

### 3.1. Absolute Feasibility (i.e., Existence of Realistic $EF \leq 1.7$ or $\beta \geq 0$ )

This subsection addresses the following research question: at the current per capita level of sustainable use of Earth resources (i.e.,  $EF^* = 1.7$ ), is it possible in terms of EF for everybody in the world to follow the Pope Francis's suggestions? The answer is no.

I will test my hypothesis about the absolute feasibility of Pope Francis specified in Section 2.5 (i.e., many incompatible goals) by estimating the between-effect linear regression

using panel data (i.e., 218 countries, 5450 observations from 1995 to 2019) based on the relationship between life expectancy at birth (*LEB*) and enrolment in secondary school (*ESS*) versus the use of the Earth's resources (the ecological footprint, *EF*). Note that Patriarch Bartholomew does not need to be proven to be absolutely feasible, since he pursued focused environmental goals. Table 1 shows that a 1 year increase in *LEB* and a 1% increase in *ESS* would result in an increase in per capita *EF* by 0.032 and 0.028 ha, respectively (i.e.,  $EF = 0.032 \text{ LEB} + 0.028 \text{ ESS} - 0.770$ ). For example, to achieve 100% *ESS* and an *LEB* of 78 years, we need  $EF = 0.032 \times 100 + 0.028 \times 78 - 0.770 = 4.526$  ha, which is much larger than the global sustainable level (i.e., 1.7 ha) (i.e.,  $EF_{\text{cat}} = 4.526 > 1.7$ ), although it is smaller than the average level in OECD countries in 2015 (i.e., 5.74 ha). At a global level, *LEB* increased by 0.50% per year from 2000 to 2015, *ESS* increased by 1.46% per year from 2000 to 2015, and the within country inequality (the value of the Gini index, *INE*) did not change from 2000 to 2015 (Table 2).

**Table 1.** Ecological footprint (*EF*) as a function of life expectancy at birth (*LEB*) and enrolment in secondary school (*ESS*). CON = the constant term.  $R^2 = 0.224$ ;  $F(2, 215) = 52.25$ ,  $p < 0.001$ .

EF	Coef.	Robust Std. Err.	t	$p >  t $	[95% Conf. Interval]	
LEB	0.0321523	0.0078394	4.10	0.000	0.0167004	0.0476043
ESS	0.0289469	0.0043919	6.59	0.000	0.0202902	0.0376036
CON	−0.7701263	0.4696888	−1.64	0.103	−1.695911	0.1556581

**Table 2.** Means and Standard Deviations (SD) of EF (Ecological Footprint) (ha), INC (gross domestic product GDP, PPP) (USD per capita), INE (Gini index), LEB (Life Expectancy at Birth) (years), ESS (Enrollment at Secondary Schools) (%), population (Million) for all countries combined (World) and for Catholic and Orthodox majority countries (Cat and Ort) (i.e., these religions were followed by more than 50% of the citizens) in 2000, 2005, 2010, 2015 and in the 1995–2019 period.

	2000	Mean EF	SD EF	Mean INC	SD INC	Mean INE	SD INE	Mean LEB	SD LEB	Mean ESS	SD ESS	POP Mil
Ort		3.10	1.59	7.461	5.92	32.52	4.71	71.29	3.74	62.13	43.46	268
Cat		2.71	2.90	10.665	11.73	39.98	6.93	61.08	24.71	52.12	43.56	914
World		2.61	2.61	10.493	15.11	38.41	6.84	62.07	20.06	46.44	42.43	6092
2005												
Ort		3.50	1.41	10.984	7.27	32.52	4.71	72.01	4.00	76.82	34.59	261
Cat		2.89	3.01	13.400	14.39	39.98	6.93	62.41	25.06	63.69	43.01	977
World		2.83	2.78	13.126	17.86	38.41	6.84	63.13	20.72	53.77	42.65	6489
2010												
Ort		3.46	1.29	15.149	8.10	32.52	4.71	73.54	3.57	74.47	43.05	257
Cat		2.73	2.74	15.937	16.51	40.27	7.04	63.54	24.98	63.55	44.27	10,645
World		2.80	2.66	16.162	20.18	38.41	6.84	64.89	20.78	53.34	44.65	68,986
2015												
Ort		3.14	1.01	17.491	6.96	32.52	4.71	74.84	3.10	89.73	27.90	256
Cat		2.81	1.52	18.475	19.48	40.29	7.13	67.08	22.83	66.82	47.19	1125
World		3.01	2.09	17.785	20.54	38.41	6.84	66.73	20.33	56.62	47.74	7320
1995–2019												
Ort		3.36	1.27	12.942	8.64	32.52	4.53	72.02	8.91	72.36	39.65	261
Cat		2.78	2.62	14.358	16.28	40.13	6.96	63.75	23.97	57.45	46.23	1011
World		2.78	2.56	14.227	19.06	38.41	6.82	63.86	20.82	48.75	45.22	6660

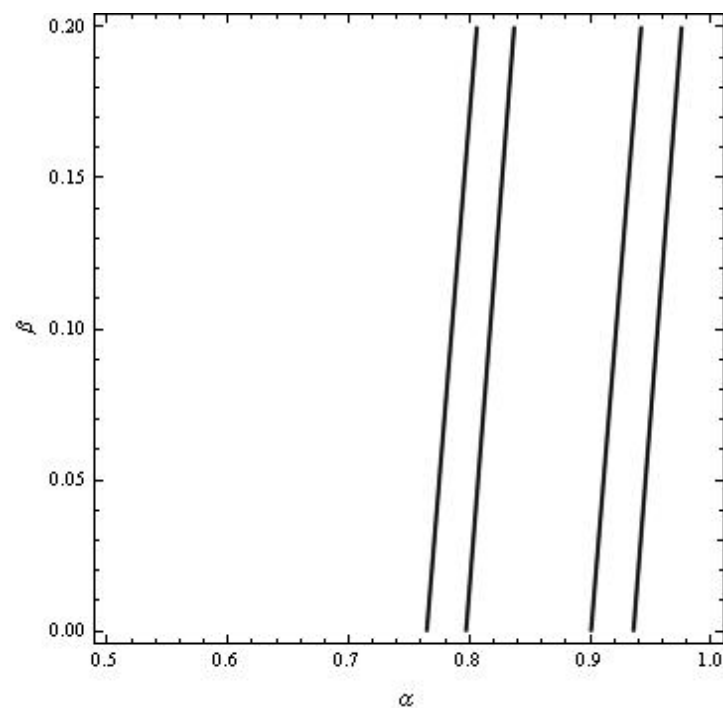
Note that rejecting consumerism and improving ecological justice as goals shared by Pope Francis and Patriarch Bartholomew were missed and partially achieved, respectively. Indeed, by applying changes in percentages at a global level to avoid the impacts of different levels in different countries, Table 2 shows that *INC* increased by 4.63% per year from 2000 to 2015, whereas *EF* differences across countries decreased by 1.32% per year from 2000 to 2015 (i.e., as a linear interpolation, standard deviation  $EF = 46.311 - 0.0218 \text{ year}$ ), although



$EF$  increased by 1.02% per year from 2000 to 2015 (i.e., as a linear interpolation, mean  $EF = 0.0209 \text{ year} - 39.162$ ).

This conclusion is supported by the analytical model discussed above, where the research question addressed in this subsection can be rephrased as follows: at the current level of welfare, is it possible in terms of  $\beta$  for Catholic believers to follow the Pope Francis's suggestions to achieve a sustainable use of Earth resources ( $EF^* = 1.7$ )? The answer is no.

Figure 1 suggests that Catholic believers should be characterized by a larger environmental concern than Orthodox believers for each consumption preference (i.e.,  $\beta_{\text{cat}} > \beta_{\text{ort}}$  for each  $\alpha$ , although  $\alpha_{\text{cat}} = 0.62 < \alpha_{\text{ort}} = 0.70$  based on the average values of consumption shares in 1995–2019 from the World Bank dataset). Moreover, Figure 1 suggests that Catholic believers will never become sustainable at the current welfare level (i.e.,  $\beta_{\text{cat}}$  should be negative since  $\alpha_{\text{cat}} = 0.62$ ) (i.e.,  $\beta_{\text{cat}} < 0$ ). Finally, Figure 1 suggests that a larger concern for inequality requires a larger consumption preference to achieve the same welfare level (i.e., larger values of  $\gamma$  cannot be compensated by larger values of  $\beta$ ).



**Figure 1.** Values of  $\beta$  for realistic values of  $\alpha$  for Catholic believers (lines above) and Orthodox believer (lines below) to achieve sustainability ( $EF = 1.7$ ) at the same current welfare level if  $\gamma = 0.1$  (couple of lines on the left) and  $\gamma = 0.2$  (couple of lines on the right).

Note that, for Catholic and Orthodox believers, welfare levels are fixed at 5.78 and 5.00, respectively, by referring to data on life satisfaction in the world happiness reports from 2000 to 2019. Next, by referring to Table 2, for Catholic and Orthodox believers,  $INC$  levels are fixed at 14.358 and 12.942, while  $INE$  levels at 40.13 and 32.52, respectively.

In summary, Catholic believers, to a greater extent than Orthodox believers, should accept a lower welfare level (i.e., a smaller  $U$ ) or should attach a larger satisfaction to the same consumption level (i.e., a larger  $\alpha$ ) to achieve a sustainable use of Earth resources.

### 3.2. Relative Feasibility (i.e., Existence of Realistic $\Delta EF \leq 0$ or $\Delta \beta \geq 0$ )

This subsection addresses the following research question: due to the social goals pursued by Pope Francis, is there a plausible  $\Delta EF < 0$  for Catholic believers to reduce the use of Earth resources towards sustainability? The answer is no.

I will test my hypothesis about the relative feasibility of statements by Pope Francis vs. Patriarch Bartholomew specified in Section 2.5 (i.e., unclear and inconsistent values

by Pope Francis vs. clear and consistent values by Patriarch Bartholomew) by referring to Table 2. In particular, Table 2 summarizes the means and standard deviations of the main variables used in this paper (i.e.,  $EF$ , income  $INC$  as measured by the per capita GDP PPP, inequality  $INE$  as measured by the Gini coefficient,  $LEB$ ,  $ESS$ , and population  $POP$ ) for all countries combined and for Catholic and Orthodox majority countries in some years (i.e., 2000, 2005, 2010 and 2015) and in the whole period (i.e., from 1995 to 2019).

The measures of social goals pursued by Pope Francis provide conflicting insights:  $INC$  increased by 4.88% per year from 2000 to 2015 in Catholic countries, which was less than the average value of 8.96% in all Orthodox countries (i.e., Pope Francis performed better than Patriarch Bartholomew),  $INE$  increased by 0.05% per year from 2000 to 2015 in Catholic countries, which was greater than the average near-zero change that occurred in all Orthodox countries (i.e., Pope Francis performed worse than Patriarch Bartholomew),  $LEB$  increased by 0.65% per year from 2000 to 2015 in Catholic countries, which was greater than the average value of 0.33% in all Orthodox countries (i.e., Pope Francis performed better than Patriarch Bartholomew),  $ESS$  increased by 1.88% per year from 2000 to 2015 in Catholic countries, which was less than the average value of 2.96% in all Orthodox countries (i.e., Pope Francis performed worse than Patriarch Bartholomew), and population increased by 1.54% per year from 2000 to 2015 in Catholic countries, which was more than the average value of  $-0.28\%$  in all Orthodox countries (i.e., Pope Francis performed better than Patriarch Bartholomew from the Pope Francis's perspective, but Pope Francis performed worse than Patriarch Bartholomew from the Patriarch Bartholomew's perspective). In contrast, measures of the environmental goals pursued by Patriarch Bartholomew provide consistent insights. Mean  $EF$  increased by 0.25% per year from 2000 to 2015 in Catholic countries, which was greater than the average value of 0.09% in all Orthodox countries (i.e., Patriarch Bartholomew performed better than Pope Francis), with  $EF_{cat} = -6.967 + 0.0049$  year versus  $EF_{ort} = -1.991 + 0.0027$  year, as linear interpolations (i.e.,  $\Delta EF_{cat} = 0.0049 > \Delta EF_{ort} = 0.0027 > 0$ ).

Note that the standard deviation of  $EF$  was smaller in Orthodox than in Catholic countries (i.e., Patriarch Bartholomew performed better than Pope Francis), although it decreased by 3.17% per year from 2000 to 2015 in Catholic countries, which was greater than the average value of 2.43% in all Orthodox countries (i.e., Patriarch Bartholomew performed worse than Pope Francis), with the standard deviation of  $EF_{cat} = 117.25 - 0.0572$  year versus  $EF_{ort} = 35.919 - 0.0173$  year, as linear interpolations.

This conclusion is supported by the analytical model discussed above, where the research question addressed in this subsection can be rephrased as follows: is there a plausible  $\Delta\beta > 0$  for Catholic believers to achieve a sustainable use of Earth resources at the current welfare level? The answer is no.

By referring to the  $INC$  levels in Table 2 with  $E = E^* = 1.7$ , it is obtained that  $\partial\beta/\partial\alpha = 5.02$  for Catholic believers and  $\partial\beta/\partial\alpha = 4.82$  for Orthodox believers for each value of  $\alpha$ . However, the consumption preferences  $\alpha$  for both Catholic and Orthodox believers are decreasing (i.e.,  $\alpha_{cat} = 62.986 - 0.0566$  year versus  $\alpha_{ort} = 71.692 - 0.1678$  year). Thus, the environmental concerns for Orthodox believers, to a greater extent than for Catholic believers, should decrease (i.e.,  $\Delta\beta_{cat} = \Delta\alpha_{cat} (\partial\alpha_{cat}/\partial\beta_{cat}) = -0.0566/5.02 = -0.0112$  versus  $\Delta\beta_{ort} = \Delta\alpha_{ort} (\partial\alpha_{ort}/\partial\beta_{ort}) = -0.1678/4.82 = -0.0348$ ).

### 3.3. Relative Reliability (i.e., Significant Negative Impacts on $\Delta EF$ )

This subsection addresses the following research question: due to the differences in the pursued social goals, did Patriarch Bartholomew significantly reduce  $EF$  to a greater extent than Pope Francis? The answer is yes.

Indeed, I will show that the gross negative impact on  $\Delta EF$  by Patriarch Bartholomew (i.e.,  $|-2.194|$ ) is larger than the gross negative impact on  $\Delta EF$  by Pope Francis (i.e.,  $|-0.174|$ ). I will also show that the net negative impact on  $\Delta EF$  by Patriarch Bartholomew for Orthodox believers (i.e.,  $|-0.164| = |-2.194 + 2.030|$ ) is larger than the net negative impact on  $\Delta EF$  by Pope Francis for Catholic believers (i.e.,  $|-0.071| = |-0.174 + 0.103|$ ).

I will test my hypothesis about the relative reliability of Pope Francis vs. Patriarch Bartholomew specified in Section 2.5 (i.e., many different instruments combined with many incompatible objectives in Pope Francis vs. few targeted instruments combined with few aimed objectives in Patriarch Bartholomew) by estimating the random-effect linear regression using panel data (i.e., 181 countries, 4525 observations from 1995 to 2019) based on the following equation:

$$EF_t = CON + \ln INC_t + INE_t + Cat_t + Ort_t + PF_t + PB_t + EF_{t-1} + \varepsilon_t \quad (4)$$

where  $EF_t$  is the per capita Ecological Footprint and represents the environmental status at time  $t$ ,  $CON$  is the constant term,  $\ln INC_t$  is the logarithm of the per capita income (GDP expressed as purchasing power parity [PPP]) at time  $t$  and depicts the Kuznets curve (i.e., the relationship between economic output and environmental status);  $INE_t$  is the Gini index at time  $t$  and depicts the inequality within each country;  $Cat_t$  and  $Ort_t$  are the percentages of Catholic and Orthodox believers at time  $t$ , respectively, and depict the Catholic and Orthodox uses of the Earth's resources with respect to the world average of other religions and cultures;  $PF_t$  and  $PB_t$  are the percentages of Catholic and Orthodox believers from 2015 and 1997, respectively (i.e., the years when Pope Francis and Patriarch Bartholomew firstly used the word "sin", respectively), and catch the possible impact of Pope Francis and Patriarch Bartholomew on Catholic and Orthodox environmental behaviors;  $EF_{t-1}$  is the environmental status at time  $t-1$  and includes possible other goals with environmental consequences pursued in the previous year; and  $\varepsilon_t$  represents the residual error term.

Note that I adopted a random effect in this analysis rather than a between effect, since Pope Francis and Patriarch Bartholomew could potentially affect environmental behaviors by all Catholic and Orthodox believers in the world, not only on those living in majority Catholic and Orthodox countries. Moreover,  $INE$  is assumed to affect the environmental status consistently with Pope Francis, whereas  $LEB$  and  $ESS$  are assumed to not affect the environmental status, also consistently with Pope Francis. Finally,  $EF$  is not weighted by the country's population, since Pope Francis and Patriarch Bartholomew are compared in terms of the environmental ethical values and behavioral rules prevailing in Catholic and Orthodox countries (e.g.,  $\Delta EF_{it} = EF_{it} PF_t$ ,  $\Delta EF_{it} = EF_{it} PB_t$ ), regardless of the relative population living in these countries.

Table 3 presents the results of this analysis for relative reliability (i.e., Equation (4)).

**Table 3.** The relative impacts of Pope Francis (PF) and Patriarch Bartholomew (PB) on the environmental status based on random-effect linear regression (Equation (1)).  $CON$  = the constant term;  $EF_t$  = the per capita ecological footprint at time  $t$ ,  $\ln INC_t$  = logarithm of the per capita GDP (purchasing power parity) at time  $t$ ;  $INE_t$  = the Gini inequality index at time  $t$ ;  $Cat_t$  and  $Ort_t$  = the percentages of Catholic and Orthodox believers at time  $t$ , respectively;  $PF_t$  and  $PB_t$  = the percentages of Catholic and Orthodox believers from 2015 and 1997, respectively;  $EF_{t-1}$  = the per capita ecological footprint at time  $t-1$ . Number of observations = 4525; number of countries = 199; number of years = 25 (1995–2019).  $R^2 = 0.903$ ;  $\chi^2(7) = 16,824.01$ ,  $p < 0.001$ ,  $\sigma_u = 0$ ,  $\sigma_e = 0.58605136$ ,  $\rho = 0$ .

$EF_t$	Coef.	Robust Std. Err.	$z$	$p >  z $	[95% Conf. Interval]	
$\ln INC_t$	0.1711196	0.0308222	5.55	0.000	0.1107092	0.23153
$INE_t$	−0.0061362	0.0022495	−2.73	0.006	−0.0105451	−0.0017272
$Cat_t$	0.1033975	0.0666355	1.55	0.121	−0.0272055	0.2340006
$Ort_t$	2.030395	0.2941557	6.90	0.000	1.453861	2.60693
$PF_t$	−0.1740155	0.0737485	−2.36	0.018	−0.3185599	−0.0294711
$PB_t$	−2.194985	0.2788466	−7.87	0.000	−2.741514	−1.648455
$EF_{t-1}$	0.8798509	0.0163814	53.71	0.000	0.8477439	0.9119578
$CON$	0.3222064	0.0986295	3.27	0.001	0.1288962	0.5155166

Note that I introduced the lagged  $EF_{t-1}$  term rather than estimating with the Arellano–Bond model due to the small variability of many variables (i.e., small differences) and

achieved the same purpose of excluding the correlation between the dependent variable at time  $t$  and the independent variables at time  $t$ . This method is supported by the value of  $\rho = 0$  (i.e., pooled data estimation = panel data estimation). Moreover, I evaluated the impacts of the documents and speeches by Pope Francis and Patriarch Bartholomew as if they were environmental laws or regulations (i.e., I applied a regime switching model (e.g., [63])). Finally, I did not introduce the time variable (year), since my goal was to estimate the impacts of Pope Francis and Patriarch Bartholomew with respect to initial levels of  $EF$ , rather than with respect to the (un-weighted) world trend. That is, I first estimated the differences between environmental behaviours based on various (secular or religious) values across countries, then I evaluated the consequences of Pope Francis and Patriarch Bartholomew on the weighted world average of the per capita use of the Earth's resources by applying the population percentages of believers living in these countries.

Thus, the main insights can be summarized as follows:

- The presence of a Kuznets curve was confirmed (i.e., the use of the Earth's resources increases with income, but at a decreasing rate).
- A larger inequality (i.e., a larger proportion of poor people) significantly ( $p < 0.006$ ) worsened the environmental status; the rich consume more than the poor.
- Orthodox and Catholic believers were significantly ( $p < 0.001$ ) and non-significantly ( $p = 0.121$ ) above other religions and cultures in terms of their use of the Earth's resources, respectively.
- Both PF and PB had a significant impact ( $p = 0.018$  and  $p < 0.001$ , respectively) and a beneficial impact (negative coefficients) on the use of the Earth's resources, although Pope Francis slightly compensated for the larger use of resources characterizing Catholic believers (i.e.,  $0.103 - 0.174 = -0.071$ ), whereas Patriarch Bartholomew definitely compensated for the greater use of resources characterizing Orthodox believers (i.e.,  $2.030 - 2.179 = -0.149$ ).
- The crucial role of other goals pursued by different countries based on various (secular or religious) values was confirmed (i.e., the use of the Earth's resources in the previous year explained 87% of the current use of the Earth's resources): the first-order autoregressive statistical model was supported by empirical data.
- Differences between countries disappeared, since the previous use of the Earth's resources was taken into account (i.e., the effects of variables that were not considered in the estimation were captured by  $EF_{t-1}$ ).

Note that I assumed that the concave Kuznets curve could be represented by a logarithmic function to minimize the number of parameters to be estimated, since few variables were used. Moreover, the causality of the highlighted relationships was supported by the Granger test and the stationarity of the dependent variable was confirmed by the Levin–Lin–Chu test (see Supplementary Materials SIII). Finally, I assumed that Pope Francis and Patriarch Bartholomew could affect the intercept of the Kuznets curve rather than its slope, since they potentially affect environmental behaviours (in the short-run) rather than environmental technology (in the long-run).

### 3.4. Absolute Reliability (i.e., Significant Negative Impacts on $EF$ )

This subsection addresses the following research question: regardless of the differences in the pursued social goals, did Pope Francis significantly reduce  $EF$  to a greater extent than Patriarch Bartholomew? The answer is yes.

Indeed, I will show that the gross negative impact on  $EF$  by Pope Francis (i.e.,  $-0.942$ ) is larger than the gross negative impact on  $EF$  by Patriarch Bartholomew (i.e.,  $-0.304$ ). I will also show that the net positive impact on  $EF$  by Pope Francis for Catholic believers (i.e.,  $0.003 = -0.942 + 0.945$ ) is smaller than the net positive impact on  $EF$  by Patriarch Bartholomew for Orthodox believers (i.e.,  $0.198 = -0.304 + 0.502$ ).

I will test my hypothesis about the absolute reliability of Pope Francis and Patriarch Bartholomew specified in Section 2.5 (i.e., many broad instruments by Pope Francis and

few targeted instruments by Patriarch Bartholomew) by estimating the random-effect linear regression using the same panel data used for Equation (1) based on the following equation:

$$EF_t = CON + \ln INC_t + INE_t + Cat_t + Ort_t + PF_t + PB_t + \zeta \quad (5)$$

where the variables have the same meanings and depict the same phenomena as in Equation (4) and  $\zeta$  represents the residual error term, but the environmental status in the previous year  $EF_{t-1}$  is excluded so that  $EF_t$  includes the possibility of pursuing other goals with environmental consequences. Note that  $CON$  measures the average  $EF$  across 199 countries in the world, after excluding Catholic and Orthodox countries, but is not weighted for populations.

Table 4 presents the results of this analysis for *absolute* reliability (i.e., Equation (5)).

**Table 4.** The absolute impacts of Pope Francis (PF) and Patriarch Bartholomew (PB) on the environmental status based on the random-effect linear regression (Equation (2)).  $CON$  = the constant term;  $EF_t$  = the per capita ecological footprint at time  $t$ ;  $\ln INC_t$  = logarithm of the per capita  $GDP$  (purchasing power parity) at time  $t$ ;  $INE_t$  = the Gini inequality index at time  $t$ ;  $Cat_t$  and  $Ort_t$  = the percentages of Catholic and Orthodox believers at time  $t$ , respectively;  $PF_t$  and  $PB_t$  = the percentages of Catholic and Orthodox believers from 2015 and 1997, respectively. Number of observations = 4525; number of countries = 199; number of years = 25 (1995–2019).  $R^2 = 0.373$ ;  $\chi^2(6) = 94.95$ ,  $p < 0.001$ ,  $\sigma_u = 1.8382704$ ,  $\sigma_e = 0.70562474$ ,  $\rho = 0.87157912$ .

$EF_t$	Coef.	Robust Std. Err.	$z$	$p >  z $	[95% Conf. Interval]	
$\ln INC_t$	0.4936057	0.0634119	7.78	0.000	0.3693206	0.6178908
$INE_t$	−0.0664816	0.017645	−3.77	0.000	−0.1010651	−0.0318981
$Cat_t$	0.9459123	0.3749366	2.52	0.012	0.2110501	1.680775
$Ort_t$	0.5020042	0.707159	0.71	0.478	−0.884002	1.88801
$PF_t$	−0.9425761	0.3687476	−2.56	0.011	−1.665308	−0.2198441
$PB_t$	−0.3045687	0.1256148	−2.42	0.015	−0.5507691	−0.0583683
$CON$	4.194425	0.7427576	5.65	0.000	2.738647	5.650203

Thus, the main insights can be summarized as follows:

- The existence of a Kuznets curve was confirmed again.
- A larger inequality still significantly ( $p < 0.001$ ) worsened the environmental status.
- Catholic and Orthodox believers were significantly ( $p = 0.012$ ) and non-significantly ( $p = 0.478$ ) above other religions and cultures in terms of their use of the Earth's resources, respectively.
- Both  $PF$  and  $PB$  had a significant ( $p = 0.011$  and  $p = 0.015$ , respectively) and beneficial (negative coefficients) impact on the use of the Earth's resources, although Pope Francis promoted a large reduction in the use of resources (i.e.,  $-0.942$  individually and  $-0.141 = -0.942 \times 0.15$ , with 0.15 representing the world proportion of Catholic believers), whereas Patriarch Bartholomew promoted a small reduction in the use of resources (i.e.,  $-0.304$  individually and  $-0.012 = -0.304 \times 0.03$ , with 0.03 representing the world proportion of Orthodox believers).
- The unweighted use of the Earth's resources by cultures and religions other than Catholicism and Orthodoxy (i.e., 4.19 ha) was consistent with the average weighted use of the Earth's resources (i.e., 2.75 ha), since believers in Catholic and Orthodox countries were fewer and richer than people living in other countries.
- Differences between countries were crucial since the use of the Earth's resources in the previous year was not taken into account ( $\rho = 0.87$ ).

Note that these estimations refer to the absolute reduction of  $EF$ , since all policies characterizing each country (e.g., health, education, and population policies) are neglected if we disregard  $EF_{t-1}$ . Moreover, Pope Francis and Patriarch Bartholomew did not affect the percentage changes in  $EF$  (see Supplementary Materials SIII). Finally, these estimations suggest that Pope Francis and Patriarch Bartholomew together reduced the per capita use

of the Earth's resources by 5% per year:  $(0.942 \times 0.15 + 0.304 \times 0.04)/2.75 = 0.05$ , with 2.75 representing the global average per capita  $EF$ .

### 3.5. Insights Attained

Sections 3.1 and 3.2 confirmed that Pope Francis is absolutely and relatively unfeasible, whereas Sections 3.3 and 3.4 lead to the following insights:

- Pope Francis was more successful than Patriarch Bartholomew in absolute reliability, although some bishops in some countries may have trumped their leaders by influencing climate change beliefs [25]. In other words, Pope Francis was more effective than Patriarch Bartholomew since he mixed many different behavioral rules.
- Pope Francis was less successful than Patriarch Bartholomew in relative reliability, since Catholic countries also pursued (absolutely unfeasible) social goals [64]. In other words, Pope Francis was less effective than Patriarch Bartholomew since he mixed many incompatible ethical values.

Note that I used few variables (i.e.,  $EF$ ,  $GDP$ ,  $INE$ ) to highlight the impacts of Pope Francis and Patriarch Bartholomew, where  $INE$  depicts poverty reduction, by introducing the lagged  $EF_{t-1}$ . Indeed,  $EF_{t-1}$  represents the social achievements characterizing a country (i.e., personal fulfilment as a preliminary goal), including education (here, depicted by  $ESS$ ) and health (here, depicted by  $LEB$ ), whereas the per capita variables (i.e.,  $EF$ ,  $INC$ ) depict the population policies (i.e., population growth as an essential constraint).

In summary, pursuing many incompatible goals based on different ethical values is detrimental for relative reliability, whereas applying many different instruments based on various behavioral rules is beneficial for absolute reliability.

## 4. Discussion

The following statements by scientists have been adapted by Pope Francis: the climate is a common good (§23); we need to slow down and look at reality in a different way, to appropriate the positive sustainable progress which has been made, but also to recover the values and the great goals swept away by our unrestrained delusions of grandeur (§114); the environment is one of those goods that cannot be adequately safeguarded or promoted by market forces (§190); the desire to create and contemplate beauty manages to overcome reductionism through a kind of salvation which occurs in beauty (§112).

In particular, de-growth by Kallis [65] (i.e., an ecological-economic perspective based on a socially sustainable and equitable reduction, and eventually stabilization, of materials and energy that a society extracts, processes, transports, distributes, consumes, and returns back to the environment as waste), deep ecology by Leopold [66] and Naess [67] (i.e., a challenge of the mechanical worldview, by suggesting the transformation of materialism and instrumental rationality into reverence and respect for nature, and the dualism between human beings and nature into an eco-centric and bio-centric egalitarianism, respectively), and a-growth by Van Den Bergh [68] (i.e., an ecological-economic strategy focused on indifference or neutrality about economic level and growth as a non-robust and unreliable indicator of social welfare and progress, due to the many unpriced environmental effects and the many neglected non-market transactions such as informal activities and relationships) theoretically support the §114, §112 and §190 statements, respectively.

Note that the strong sustainability paradigm [69] supports inter-generational equity in access to the same amount of natural resources and the same status of the environment.

In summary, if the focus is on the overall scientific model of Pope Francis, one should consider the following anthropocentric sustainability paradigms:

- *Laudato Si'* is close to deep ecology, and it is more environmentally concerned than an ecosystem services approach: ecosystems have an intrinsic value independent of their usefulness (§140).
- *Laudato Si'* accepts a-growth, and it is more environmentally concerned than weak sustainability: the economic market is inadequate to solve environmental problems (§190).

- *Laudato Si'* accepts strong sustainability: inter- and intra-generational solidarity in resource distribution (§159 and §162).
- *Laudato Si'* is close to de-growth: we need to slow down and look at reality in a different way (§114).

Thus, *Laudato Si'* can be summarized as a happy de-growth paradigm, in which happiness is based on religiosity. Note that despite these similarities to the scientific paradigms, *Laudato Si'* differs from strong sustainability, since the latter uses equity rather than solidarity, and it differs from deep ecology, since the latter advocates a reduction in population. In other words, *Laudato Si'* could rely on the intrinsic value of nature, based on respect for creation and on strong law enforcement, as in the case of all religious ethics as opposed to secular ethics [70]. However, despite the roots of *Laudato Si'* in the Catholic tradition, with an anthropocentric perspective that humans are above all other creatures, and without an immanent God so that no things are intrinsically bad, *Laudato Si'* does not suggest reliable ethics. Indeed, universal communion does not imply happy sobriety [71,72].

In contrast, Patriarch Bartholomew is close to strong sustainability paradigm, where the moral standing of nature is based on an immanent God rather than on a duty to future generations. In particular, frugality is supported by the sanctity of nature combined with pantheism (i.e., the belief that God is greater than the universe and God both includes and is part of it) [73,74].

## 5. Conclusions

The purposes of this paper was to apply a scientific approach to compare Pope Francis and Patriarch Bartholomew as representatives of Catholic and Orthodox Churches about environmental issues in terms of absolute and relative feasibility as well as in terms of absolute and relative reliability. Indeed, since incentives for individual cooperation to achieve global sustainability cannot be fostered by global institutions (e.g., global markets, global agreements), where any (secular or religious) institution defines (ethical) values and (behavioral) rules, in order to solve global sustainability as an urgent and practical ethical problem (i.e., urgency requires religious rather than secular ethics, practice requires feasibility and reliability of religious values and rules), religions can be seen as existent institutions characterized by (behavioral) rules and (ethical) values, not necessarily shared by all religions, which can help achieve global sustainability. Note that we focused on Catholic and Orthodox Churches since Pope Francis and Patriarch Bartholomew have been particularly active on environmental issues in recent decades (e.g., “Pope Francis”, “environmental ethics”, news and press as keywords identify 91,500 and 19,400 items in Google, respectively; “Patriarch Bartholomew” and the same keywords identify 2990 and 2970 items in Google, respectively).

Section 2 showed that Patriarch Bartholomew provides a specific religious perspective, whereas Pope Francis in *Laudato Si'* suggests a generic religious perspective, both in terms of values and rules. In particular, Pope Francis is too general in supporting an inter-religions dialogue for the sake of protecting nature (e.g., in §201: The majority of people living on our planet profess to be believers. This should spur religions to dialogue among themselves for the sake of protecting nature, defending the poor, and building networks of respect and fraternity. See also §92). In other words, sustainability achievements should not rely on impossible (in the short-run) and implausible (in the long-run) compromises between religions to cope with an urgent issue. However, this does not imply that the suggested inter-religion dialogue cannot be applied to specific aspects (e.g., community involvement, decreased consumerism) by avoiding the extension of religious ethical principles to other communities or the extension of precepts and proscriptions of one religion to other religions.

Section 4 showed that Patriarch Bartholomew evokes a theoretically consistent scientific model, whereas the scientific model by Pope Francis in *Laudato Si'* is theoretically inconsistent with some scientific disciplines related to sustainability science because it retains concepts from sacred texts on intergenerational solidarity and the value of a single

organism. In other words, *Laudato Si'* shows that it not always possible to perform an interdisciplinary scientific analysis if we simultaneously try to commit to theological concepts. However, this does not imply that adopting an interdisciplinary approach cannot help us deal with the various aspects of the sustainability crisis (e.g., in §138: Fragmentation of knowledge and the isolation of bits of information can actually become a form of ignorance, unless they are integrated into a broader vision of reality. See also §197). In particular, whether ethics is above science (i.e., it specifies limits for science) or whether ethics is at the same level as science (i.e., they mutually identify goals and instruments), a holistic approach lets us rely on a larger set of instruments to achieve a complex objective, whenever there is no cost-free solution in terms of a lack of achieved goals and met constraints or in terms of a lack of supported ethics.

Section 3 showed that Patriarch Bartholomew was more relatively effective, but Pope Francis was more absolutely effective. In particular, although Pope Francis pursued many incompatible goals based on unclear and inconsistent values, whereas Patriarch Bartholomew pursued few goals based on clear and consistent values (i.e., Patriarch Bartholomew > Pope Francis in terms of absolute and relative feasibility), Pope Francis suggested many and broad rules, whereas Patriarch Bartholomew suggested few and focused rules. In other words, Pope Francis influenced many people from different cultures (i.e., Pope Francis > Patriarch Bartholomew in terms of absolute reliability), by pursuing many incompatible goals (i.e., Patriarch Bartholomew > Pope Francis in terms of relative reliability), where the larger absolute reliability reached by Pope Francis seems to be due to his smaller relative feasibility.

In summary, although based on different values and rules, Pope Francis and Patriarch Bartholomew together significantly favored the achievement of global sustainability, by reducing the per capita use of Earth resources by 5% per year.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su151813789/s1>.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data used in this study are available on request from the corresponding author.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**Table A1.** List of acronyms and variables.

	Definition	Unit
EF	Per capita Ecological Footprint	Ha
$\Delta EF$	Change in per capita Ecological Footprint	The same unit as EF
LEB	Life Expectancy at Birth	Years
ESS	Enrolment at Secondary Schools	%
POP	Population	Million
CON	Constant in linear or logarithmic regressions	The same as the dependent variable
U	Per capita welfare	Unspecified since unused
INC	Per capita income	Gross Domestic Product GDP, PPP (US \$)
E	Per capita use of environmental resources	Ha
E*	Per capita long-run sustainable E at the world level	Ha
INE	Inequality	Gini index in [0–100]
$\alpha$	Consumption preferences	[0, 1] with realistic values in [0, 0.7]
$\beta$	Environmental concerns	[0, 1] with realistic values in [0, 0.2]



Table A1. Cont.

	Definition	Unit
$\Delta\beta$	Change in environmental concerns	The same unit as $\beta$
$\gamma$	Inequality concerns	[0, 1] with realistic values in [0, 0.1]
<i>Cat</i>	Catholic believers	% at a country level
<i>Ort</i>	Orthodox believers	% at a country level
<i>PF</i>	Pope Francis	Catholic believers from 2015 (% at a country level)
<i>PB</i>	Patriarch Bartholomew	Orthodox believers from 1997 (% at a country level)

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