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Longitudinal Predictors of Perceived Climate Change Importance and Worry among Italian Youths: A Machine Learning Approach

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Abstract: The current study aimed to investigate the longitudinal predictors of perceived importance of climate change and personal worry among Italian youths. Specifically, we used machine learning techniques to examine the predictive importance of a wide range of socio-demographic factors, political perceptions, attitudes on a national and European level (identity, attitudes, tolerance, support for democracy, authoritarianism, nationalism, political trust), efficacy beliefs, social well-being, political interest, and different forms of participation on perceived importance of climate change and personal worry. In this longitudinal study, we collected data using a questionnaire in two waves at a one-year interval—in 2016 and 2017. Participants were 1288 Italian young adults (61.3% were female; 38.7% were male) whose mean age was 19.18 (*SD* = 3.29) ranging between 15 and 30 years. Breiman's random forest algorithm performed better than Friedman's gradient boosting machines algorithm. The random forest algorithm revealed that age, tolerance toward migrants, and tolerance toward refugees were the most important predictors of perceived importance of climate change and personal worry. Other important predictors were national/European identity, political interest, internal political efficacy, nationalism, social well-being, self-efficacy, authoritarianism, anti-democratic attitudes, EU warmth, and online and civic participation.

Keywords: climate change; community; youth; beliefs; worry; machine learning algorithm

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1. Introduction

Communities around the world are increasingly facing the challenges of extreme weather events and other environmental hazards associated with climate change. Indeed, the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC; at the time of writing the IPCC is in its Sixth Assessment cycle) highlighted that the human influence on the climate system is clear, and such influence had pervasive effects on human and natural systems [1]. The literature on climate change risk perception has evidenced how the threat can be underestimated in people's subjective evaluations due to the nature of the abstract and long-term nature of changes related to climate issues [2]. Higher levels of societal awareness and support for climate action and mitigation are needed. Moreover, awareness and perceived risk are among the factors that influence individual motivation to engage in pro-environmental behavior change [3]. For instance, there is evidence that countries' carbon dioxide emissions correlate negatively with climate change risk perception [4]. However, public perceptions of global climate change are characterized by high levels of uncertainty concerning the dangers posed by climate change and whether to approve any mitigation or adaptation actions and plans [5]. While the scientific evidence concerning the dramatic impact of climate change is solid [1], climate change is still a controversial topic [6]. This is problematic because mitigation and adaptation to climate change factors require public support and engagement [7,8].

To date, most of the research examining worry and perceived importance of climate change's negative consequences for humans and the environment has focused on adults [9]. However, there are several reasons why climate change is especially relevant for young people [10]. Future generations are more likely to be affected by a failure to deal with climate change [11]. Future generations will also need to find solutions to address the predicted impact of climate change on their lives. For instance, the lives of young people will be affected by the consequences of climate change in terms of security, health, and socioeconomic conditions [9]. According to Fløttum, et al. [12] (p. 1128):

> Despite the relevance of climate change for youth, the evidence concerning the predictors of perceived importance of climate change and worry among youth is scant. To address this research gap, in the present study we focus on the predictors of perceived importance of climate change and worry among youth.

Previous studies have used a wide range of measures to assess the general public's perceptions of climate change risk, employing measures of general concern about the issue [13], perceived likelihood of impacts [14–16], perceived seriousness or importance of the issue [17–19], personal worry [20–22] or a combination of these in a single measure [23–25]. However, these aspects can be considered conceptually distinct dimensions of the perception of climate change risk [26]. For example, perceived likelihood of impacts (the cognitive component) and perceived importance of climate change (the evaluative component) may vary differently with socio-economic and attitudinal factors [19]. Personal worry, moreover, is distinguished from general concern and cognitive perceptions as it is an active emotional state more directly related to behavioral responses [26]. There is little empirical research that has considered possible differences between dimensions of climate change risk perception and has investigated which explanatory factors may be specific to each [17,27]. The present study seeks to contribute to empirical evidence by investigating explanatory factors related to two distinct dimensions of climate change risk perception—perceived importance (evaluative dimension) and personal worry about the impact (emotional dimension).

The rest of the Introduction section is structured as follows. First of all, we briefly review the literature on predictors of attitudes and concerns about climate change. Next, we focus on the predictors of climate change importance and worry within the EU context, considering some specific characteristics such as the theoretical tension between European identity and national identity. Finally, we define the main aims of the current study.

1.1. What Predicts Climate Change Importance and Worry?

The beliefs and concerns about climate change among young people tend to be associated with age [9]. There is also evidence of a strong gender divide, with young women more worried about the environment compared to young men [28]. Such gender divide is similar to ones obtained in previous studies involving adults [21,23,29,30]. In addition to gender and age, other socio-demographic variables have been linked to beliefs and concerns about climate change: level of education [21,30,31], belonging to ethnic minorities [30,32,33], socio-economic status [30,34], religiousness [30,35,36], and living in an urban vs. rural area [37].

The challenges related to climate change and the related adaptation and mitigation measures risk exacerbating existing weaknesses in democratic theory and practice, especially in terms of legitimacy challenges [38,39]. Notwithstanding, democracies could offer solutions to climate change issues by fostering empowerment and participatory decision-making [40]. In addition, some researchers argue that democracy is best placed to address the challenges of climate change [40–43]. Some studies suggest that active citizens, who engage in civic participation, tend to be particularly concerned about climate change and environmental issues [44,45]. Therefore, we may expect an association between views on climate change and democracy support, empowerment, and participation.

Previous research showed that social well-being predicts pro-environmental behavior [46]. Specifically, according to the social outlook hypothesis, the experience of a positive mental state predicts a favorable view of one's community and society as well as increases the

likelihood of prosocial behavior [47]. According to Kaida and Kaida [48], there is a win-win relationship between positive psychological states and pro-environmental behaviors. Given that pro-environmental behavior can be conceptualized as a form of prosocial behavior [46], we added social well-being as a possible predictor of climate change importance beliefs and worry.

Bandura's theory of self-efficacy (and collective efficacy) has been used to understand people's reactions to climate change [49]. Specifically, the theory posits that people, groups, and communities are unlikely to address climate change effectively unless they hold a perceived sense of efficacy that their individual and collective efforts can be successful. Indeed, there is evidence that support for reducing the risks of climate change is associated with self-efficacy beliefs [50,51]. Therefore, based on Bandura's theory of self-efficacy, we may expect an association between self-efficacy and collective efficacy and climate change beliefs.

According to Bodor, et al. [52], a necessary precondition for a sufficient level of collective action is the development of trust between people. Social and institutional trust is associated with climate change beliefs and attitudes [31,53]. Therefore, we may expect that social trust could play a role in predicting climate change importance and worry.

1.2. Potential Predictors of Climate Change Importance and Worry within the EU Context

Previous research revealed that concern for the welfare of all people and nature (i.e., universalism) [54], sense of global citizenship [55], and superordinate identity [56] are important from a psychological point of view because the issue of climate change and its resolution represents a pervasive commons dilemma that requires a sense of "us" as members of a superordinate or higher-order group. In the European context, the idea of Europe can provide a superordinate identity that is potentially able to transcend traditional national identities. The emergence of a European identity is strongly interconnected with the systematic construction of national identity [57,58]. National identities and European identity become salient in relation to climate change issues [59]. The European Union (EU) could be viewed as representative of an 'Us' in relation to climate change: According to Olausson [58], "the embryo of a European identity is discursively constructed in the news reporting on climate change." The EU has indeed emerged as a leader in climate change policy in the last 20 years owing to a gradual "Europeanisation" of national climate policies, which also became an important driver for a wider integration of member states [60]. More recently, the European Council launched a comprehensive package of policies—the European Green New Deal [61]—and adopted a European Climate Law that puts the goal of climate neutral Europe by 2050 in legislation [62]. Recent forms of (neo)nationalism among western European countries reject supranational (e.g., European Union) climate policies as well as international or European Union climate treaties [61–63]. There is evidence that the adherence to policies dealing with the issue of climate change is a function of the extent to which citizens identify with the national or supernational (Europe) institutions enacting them [64]. The tension between a climate change agenda which requires a superordinate identity and a nationalist ideology that focuses on the defense of national sovereignty is relevant for climate change views. Indeed, public attitudes consistent with a nationalist ideology are linked to climate change skepticism [63]. Such nationalist ideology clashes not only with international policies to mitigate climate change but also with an increase in climate refugees [65], which is an inevitable consequence of climate change [63]. Indeed, there is evidence that opposition to immigration is associated with climate change skepticism [66]. Therefore, it is possible to hypothesize a role of national and European identification as well as attitudes towards the nation, Europe, and immigration/refugees on views about climate change.

1.3. Purpose of the Present Study

Previous research has evidenced that political attitudes and psychological variables are key factors affecting climate change perceptions, alongside or even more so than

sociodemographic characteristics [21,67,68]. Few studies have focused on assessing the predictive importance of different factors on climate change attitudes [67]. Moreover, to our knowledge, no existing studies examine the predictive importance of a wide range of socio-demographic and psychosocial factors on distinct dimensions of climate change risk perception.

In the present study, we examined the psychosocial predictors of perceived importance of climate change and personal worry among Italian youth. There is evidence that climate change risk perception and importance have different predictors [17]. The paper will explore through machine learning techniques the predictive power of socio-demographic factors, political perceptions, attitudes on a national and European level (identity, attitudes, tolerance, support for democracy, authoritarianism, nationalism, political trust), efficacy beliefs, social well-being, political interest, and different forms of participation.

2. Materials and Methods

The data were collected in two waves at a one-year interval–in 2016 and 2017, within the research project CATCH-EyoU funded by the European Union within the H2020 framework program (grant number 64538). It was approved by the Bioethics Committee of the University of Bologna. Adolescents and young adult participants filled out a self-administered questionnaire either online (64.3%) or pencil-and-paper (35.7%). To ensure anonymity and to enable data matching, participants were asked to produce an anonymous code based on instructions that were given for both surveys.

2.1. Procedure

Adolescents (15–19 years old) were approached in six upper secondary schools with different tracks (vocational, technical, or academic) in the Emilia-Romagna region in northern Italy. Further information on the participating schools and the data collection procedure has been previously published [57,69]. All contacted schools were public, ensuring adequate variability between tracks and municipal contexts typical of Italy (large and small cities, rural settings). We did not contact private schools because they tend to include students from families with a high socio-economic background as reported in Italian census data [70]. Convenience sampling was the sampling strategy. School's headmaster and reference teachers were contacted first. All the schools that were contacted agreed to participate. After a formal agreement, participation in the study was proposed to students. All the students agreed to take part in the study. Students completed the questionnaires on paper or online, during class and under the supervision of a researcher and/or a teacher. All students and, in the case of underage participants, parents completed participation consent forms.

Young adults (20–30 years old) were contacted by e-mail through the office of the University of Bologna (92.7%) and through youth organizations (7.3%). University students attended different courses and had origins in different parts of Italy. The choice of the University was based on convenience and because it was located in the same region as the six upper secondary schools. The students received an invitation to participate in the survey. All participants filled out consent forms before starting the online questionnaire.

2.2. The Context

Emilia-Romagna is situated in the north of Italy and is one of the regions of the country. This region comprises an area of 22,446 km^2 and about 4.4 million inhabitants. The population density is equal to 200 inhabitants per km^2 in 2019 and closely resembles the national average. Emilia-Romagna is one of the most developed and wealthiest regions in Italy and Europe. Therefore, from a socio-economic perspective, this region is similar to the most developed and wealthiest regions in Italy and Europe and cannot be compared to most other regions. Notwithstanding, the evaluation reports by the six upper secondary schools revealed that student performance in standardized tests is substantially similar to that of national benchmarks [57,69].

2.3. Sample

The sample consisted of 1288 participants (61.3% were female; 38.7% were male), after excluding incomplete responses and those missing important socio-demographic information (10%). The average age was 19.18 (*SD* = 3.29), ranging between 15 and 30 years old. Details on the representativeness of the sample are available in previous studies [70,71].

2.4. Instrument

The instrument was constructed by the CATCH-EyoU consortium. Adaptation of the questionnaire was done through two independent translations into Italian and a back translation by a third independent translator. Any differences were examined and resolved by the team. The instrument was assessed through a pilot study with 206 participants with the aim of developing a reliable, parsimonious, and valid questionnaire. The pilot study was conducted involving students from different schools but with similar backgrounds. The pilot study revealed that participants encountered no difficulty understanding the items. Moreover, changes to the questionnaire following the pilot study included the shortening of some scales and minor modifications in wording and layout. Participants were able to fill in the survey in 30 min.

2.4.1. Dependent Variables

The dependent measures were assessed at Wave 2 (W2) of the data collection in November 2017–January 2018.

To measure climate change importance, participants were asked to indicate how important they thought it was to deal with the issue of climate change on a 5-point Likert scale (1 = not important at all, 5 = extremely important).

To assess worry about climate change, participants were asked to indicate their agreement with the statement "I am worried about the impact of climate change on my country". The response scale ranged from 1 = strongly disagree to 5 = strongly agree.

2.4.2. Independent Variables

All independent variables were assessed at Wave 1 (W1) of the data collection in November 2016–January 2017. The measures were based on existing scales and previous studies in the field. Table 1 reports the description, sample items, response scales and reliabilities for all independent variable measures.

Table 1. All Independent Variable Measures.

Measure	Scale	Sample Items	Response Scale	Reliability (α)
Demographics Age Gender Religiousness National/ethnic minority Economic situation	n.a.	"Does the money your household has cover everything your family needs?"	Years old Female/Male 1 = Not at all, 4 = Very Majority/Minority 1 = Not at all, 4 = Fully	n.a.
National/European identity	The Utrecht-Management of Identity Commitments Scale (U-MICS; [72] was used to measure three dimensions of national and European identity: commitment (3 items), exploration (3 items), reconsideration (3 items).	Commitment: "I feel strong ties toward Italy/Europe" Exploration: "I often think about what it means to be Italian/European" Reconsideration: "My feelings about Italy/Europe are changing"	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	Country commitment: 0.84 Country exploration: 0.81 Country reconsideration: 0.70 EU commitment: 0.82 EU exploration: 0.84 EU reconsideration: 0.56

Table 1. *Cont.*

Measure	Scale	Sample Items	Response Scale	Reliability (α)
Attitudes toward the country/EU	Five items measured the competence (2 items) and warmth (3 items) dimensions of the Stereotype Content Model [73] with reference to the country and the EU.	"How would you describe Italy/the European Union? Competent/Incompetent; Efficient/Inefficient; Warm/Cold; Friendly/Unfriendly; Welcoming/Unwelcoming"	5-point semantic differential: 1 = Competent, 5 = Incompetent	Country Competence: 0.72 Country Warmth: 0.81 EU Competence: 0.58 EU Warmth: 0.69
Tolerance toward migrants	Three items adapted from previous studies [74] measured tolerance toward migrants' rights.	"Migrants should have the right to maintain their traditions and cultural heritage."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.70
Tolerance toward refugees	Three items adapted from previous studies (ref) measured tolerance toward refugees' rights.	"I feel that our government does not do enough to help refugees."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.72
Antidemocratic attitudes	Three items adapted from Finkel, et al. [75] measured support for democracy, freedom of speech and expression.	"Instead of needing 'civil rights and freedoms' our country needs one thing only: law and order."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.65
Authoritarianism	Three items adapted from Funke [76], measured support for the control of civil liberties.	"Instead of needing 'civil rights and freedoms' our country needs one thing only: law and order. "	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.64
Nationalism	Following previous research [77] three items measured nationalist attitudes.	"Generally speaking, Italy is a better country than most other countries."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.73
Institutional and social trust	Three items derived from previous studies [78] measured trust in the European Union, the national government and in most people.	"I trust the European Union."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.58
Self-efficacy	Five items from the Generalized Self-Efficacy Scale [79] were used to measure the belief that one can perform novel or difficult tasks, or cope with adversity.	"I can always solve difficult problems if I try hard enough."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.81
Political efficacy	The following dimensions of political efficacy were measured: competence self-concept (2 items, [74,80], the belief about one's own political competence and awareness; collective efficacy (2 items, [74]), the belief that one's group can have political influence; internal political efficacy (3 items; [81]), the belief in being able competently to participate in political action.	Self-concept: "I feel that I have a pretty good understanding of important societal issues." Collective efficacy: "I think that by working together, young people can change things for the better." Internal political efficacy: "If I really tried, I could manage to actively work in organizations trying to solve problems in society."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	Political self-concept: $r = 0.61$ Collective political efficacy: $r = 0.57$ Internal political efficacy: 0.82
Political alienation	Four items adapted from Fischer and Kohr [82] measured sense of political powerlessness related to Italy and the EU	"People like me do not have opportunities to influence the decisions of the European Union/national parliament."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.84

Table 1. *Cont.*

Measure	Scale	Sample Items	Response Scale	Reliability (α)
Personal empowerment	Two items adapted from previous studies [80,83], measured personal capacity to act politically.	"I am able to look for people, institutions and services that can help me to find solutions to my problems."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	r = 0.44
Social well-being	Four items from the Mental Health Continuum—Short Form [84,85] assessed perceived social wellbeing.	"During the past month, how often did you feel that . . . Our society is becoming a better place."	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.68
Political interest	Four items, adapted from previous studies [78,86], measured interest in politics, in societal issues, in European-related topics and in national politics.	"How interested are you in politics?"	5-point Likert scale: 1 = strongly disagree, 5 = strongly agree	0.89
Civic and political participation	Civic and Political Participation Scale [87,88] was used, measuring four forms of participation: Political; Civic; Online; and Protest. Participants were asked to report their activities in the last 12 months.	Political participation: "Contacted a politician or public official (for example via e-mail)"; Civic participation: "Volunteered or worked for a social cause"; Online participation: "Discussed social or political issues on the internet" Protest participation: "Taken part in an occupation of a building or a public space".	5-point Likert scale: 1 = No, 5 = Very often	Political participation: 0.80 Civic participation: 0.70 Online participation: 0.84 Protest participation: 0.66
Participation at EU level	18 items adapted from the Civic and Political Participation Scale [85] measured participation related to the EU.	"Were any of the activities related to the EU? If yes, then please tick them."	Yes/No	0.80
EU voting intentions	Ad hoc item measured the intention to vote in the next EU elections.	"Will you vote in the next European parliament elections?"	Yes/No/I don't know	n.a.

2.5. Design

Analyses were conducted using JASP Version 16.3 [89] and the R-package gbm and random Forest. In the analyses, we used two machine learning algorithms—Breiman's random forest algorithm and Friedman's gradient boosting machines (GBM) algorithm —because they (1) can analyze predictor variables of different data levels, such as categorical, ordinal, or continuous data and (2) provide variable importance measures that can be employed to rank predictors according to their predictive power. For both the GBM algorithm and the random forest algorithm, we scaled the variables. We conducted different sensitivity to determine the optimal selection of the hyperparameters. Regarding the random forest algorithm, we optimized the error of prediction using a validation data set using a maximum of 5000 possible decision trees to be considered, and we set as 50 the percentage of training data that is used to train each individual tree. As data split preferences, we used 20% of the data as holdout test data and 20% for the purposes of training. Concerning the GBM algorithm, we tested 100 to 5000 trees to fit using shrinkage rates that ranged between 0.01 and 0.001. We chose a shrinkage rate below 0.001 with a maximum of 5000 trees to improve predictive performance. We randomly chose 20% of the data as holdout test data. The accuracy of the model was tested by twenty-fold cross-validation. We evaluated the performance of each model using the Mean Square Error (MSE), the root-mean-square error (RMSE), and the coefficient of determination (R^2). The best model from each algorithm

was determined based on the lowest RMSE and, in case of a tie, the highest R^2. Missing data analysis revealed minimal missing data (i.e., 4.35%). Following recommendations for dealing with missing data [90], given that missing data was minimal (less than 5%), we decided not to impute data.

3. Results

Table 2 shows the correlation coefficients (Pearson's r) between W1 variables and W2 perceived importance and worry. Only a portion of the W1 variables of interest reported a correlation greater than 0.10—a standard definition of a small effect [91]. Age, Participation at EU level, EU voting intentions, online participation, civic participation, European commitment, European exploration, national exploration, country-competence, political interest, self-concept (political efficacy), collective efficacy (political efficacy), internal political efficacy, tolerance-refugees, and tolerance-immigrants were positively related to both climate change importance and climate change worry. Antidemocratic attitudes, authoritarianism, nationalism, and place of living (countryside) correlated negatively with both climate change importance and climate change worry. While the relationship between gender (male) and climate change importance was not significant, the relationship between gender (male) and climate change worry was significant and negative.

Table 2. Correlation Coefficients (Pearson's r) between W1 Correlates and W2 Climate Change Importance and Climate Change Worry.

W1 Correlates	Climate Change Importance (W2)	Climate Change Worry (W2)
Age	0.310 **	0.286 **
Gender (male)	−0.042	−0.132 **
Religiousness	−0.043	0.005
National/ethnic minority	−0.027	−0.043
Place of living (countryside)	−0.100 **	−0.104 **
Household income level (higher income)	−0.076 **	−0.043
Participation at EU level	0.111 **	0.105 **
EU voting intentions	0.211 **	0.246 **
Online participation	0.253 **	0.256 **
Political participation	0.091 **	0.099 **
Civic participation	0.182 **	0.212 **
Protest participation	0.028	0.027
European commitment	0.135 **	0.118 **
National commitment	−0.004	−0.034
European exploration	0.264 **	0.231 **
National exploration	0.214 **	0.192 **
European reconsideration	0.060 *	0.037
National reconsideration	0.029	0.025
EU—competence	−0.058 *	−0.078 **
EU—warmth	0.071 *	0.052
Country—warmth	−0.038	−0.022
Country—competence	0.136 **	0.107 **
Tolerance—refugees	0.285 **	0.266 **
Tolerance—immigrants	0.275 **	0.261 **
Antidemocratic attitudes	−0.182 **	−0.183 **
Authoritarianism	−0.182 **	−0.183 **
Nationalism	−0.144 **	−0.158 **
Political alienation	−0.052	−0.043
Self-efficacy	0.085 **	0.084 **
Personal empowerment	0.072 **	0.075 **
Political interest	0.264 **	0.227 **
Institutional and social trust	0.106 **	0.080 **
Social well-being	0.053	0.010

Table 2. *Cont.*

W1 Correlates	Climate Change Importance (W2)	Climate Change Worry (W2)
Self-concept (political efficacy)	0.180 **	0.160 **
Collective efficacy (political efficacy)	0.225 **	0.179 **
Internal political efficacy	0.233 **	0.208 **

Note. ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

The predictions derived from machine learning algorithms are reported in Table 3. The random forest algorithm reported the lowest RMSE. In addition, the random forest algorithm had the lowest MSE. Finally, the coefficient of determination (R^2) was similar across the machine algorithms when predicting climate change importance (about 15% of explained variance), while R^2 of the random forest regression model predicting climate change worry was higher (19% of explained variance) compared to the gradient boosting model (6% of explained variance). Therefore, we chose the random forest algorithm, and we calculated the variables importance for each random forest model.

Table 3. Comparison of Machine Learning Algorithms Predicting Climate Change Importance and Climate Change Worry.

		Validation MSE	Test MSE	RMSE	R2
Climate change importance	Gradient boosting	0.809	0.986	0.993	0.153
	Random forest	0.769	0.864	0.930	0.148
Climate change worry	Gradient boosting	0.837	0.940	0.970	0.059
	Random forest	0.916	0.831	0.912	0.194

Note. MSE = mean squared error; RMSE = root-mean-square error.

Table 4 displays the total increase in node purity of variables of the established random forest models. A higher increase in node purity meant greater importance of a variable and more contribution of a variable to the variation of the outcome. Age, tolerance toward migrants, and tolerance toward refugees had the highest node purity increase values for both climate change importance and climate change worry.

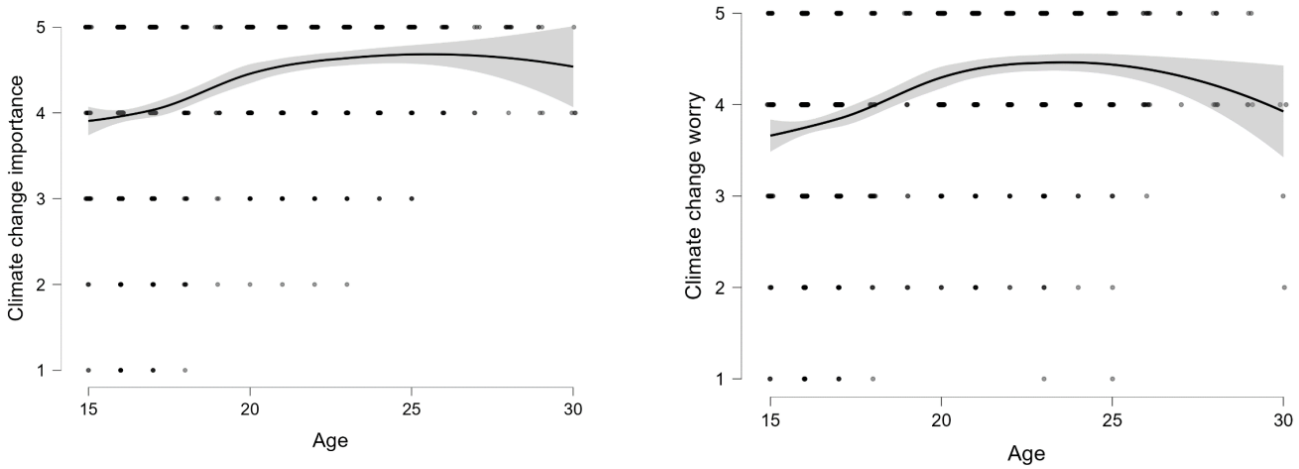
Table 4. Importance Rank of Variables (i.e., Total Increase in Node Purity) in Random Forest Model.

Outcome: Climate Change Importance		Outcome: Climate Change Worry	
Age	17.263	Age	16.775
Tolerance toward refugees	15.990	Tolerance toward migrants	15.187
Tolerance toward migrants	15.912	Tolerance toward refugees	13.925
Online participation	15.716	Political interest	12.832
European exploration	14.044	Internal political efficacy	12.600
Political interest	13.442	Online participation	12.258
European reconsideration	12.467	European exploration	11.763
National exploration	11.665	National exploration	11.31
Internal political efficacy	11.105	Political alienation	11.187
European commitment	10.242	European commitment	11.077
Nationalism	10.222	Civic participation	10.655
Political alienation	9.894	European reconsideration	10.067
National commitment	9.436	Nationalism	9.638
EU warmth	9.426	Self-efficacy	9.574
Civic participation	9.352	National commitment	9.455
Social well-being	9.185	EU warmth	9.364
Self-efficacy	9.038	Social well-being	9.126
National reconsideration	9.011	Authoritarianism	9.043
Collective efficacy (political efficacy)	8.963	Anti-democratic attitudes	8.995
Authoritarianism	8.582	National reconsideration	8.855
Anti-democratic attitudes	8.480	Country competent	8.475

Table 4. *Cont.*

Outcome: Climate Change Importance		Outcome: Climate Change Worry	
Education of mother/carer	8.414	Country warmth	8.369
Self-concept (political efficacy)	8.361	EU competent	8.281
Place of living	8.334	Personal empowerment	8.118
EU competent	8.046	Self-concept (political efficacy)	7.997
Country competent	7.985	Institutional and social trust	7.722
Education of father/carer	7.631	EU voting intentions	7.504
Country warmth	7.504	Place of living	7.216
Institutional and social trust	7.271	Collective efficacy (political efficacy)	7.160
Personal empowerment	6.637	Education of father/carer	6.959
Having a partner	5.274	Education of mother/carer	6.361
Religiousness	4.800	Having a partner	5.191
EU voting intentions	3.876	Protest participation	4.597
Political participation	3.841	Religiousness	4.359
Protest participation	3.682	Mother's occupation status	4.235
Mother's occupation status	3.615	Household income level	3.684
Household income level	3.353	Political participation	2.867
Father's occupation status	3.068	Gender	2.671
Gender	2.054	Father's occupation status	2.426
Living with one or both parents/carers	2.033	Participation at EU level	2.132
Having the citizenship	1.717	Having the citizenship	2.129
Participation at EU level	1.651	Living with one or both parents/carers	1.751
Living with friends/roommates	1.567	National/ethnic majority or minority	1.477
National/ethnic majority or minority	0.948	Living with friends/roommates	1.196
Other living arrangements	0.387	Living alone	0.411
Living with partner/spouse	0.222	Other living arrangements	0.240
Living alone	0.221	Living with partner/spouse	0.158

The relationships between age and both climate change importance and climate change worry are depicted in Figure 1. Climate change importance and climate change worry linearly increase from the age of 15 years to about 23–25 years. At the age of 23–25 years, a plateau is reached. Thereafter, a small decrease in climate change importance and climate change worry was observed.



(**a**) (**b**)

Figure 1. Scatterplot depicting the correlation between age and the dependent variables using a loess line as the fit function: (**a**) Correlation between age and climate change importance; (**b**) Correlation between age and climate change worry.

The second group of variables with high node purity increase values included national/European identity (commitment, exploration and reconsideration dimensions), political interest, internal political efficacy, nationalism, social well-being, self-efficacy, authoritarianism, anti-democratic attitudes, EU warmth, and online and civic participation (Table 4). With the exception of age, the importance of the other socio-demographic variables (e.g., gender, parents' status, income, citizenship, living arrangements) was lower. In addition, the importance of attitudes toward the country/EU (except for Country warmth), personal empowerment, self-concept (political efficacy), institutional and social trust, EU voting intentions, collective efficacy (political efficacy), protest participation, religiousness, political participation, and participation at EU level was lower. The importance of collective efficacy (political efficacy) was higher in the model predicting climate change importance compared to the model predicting climate change worry, while the importance of internal political efficacy and self-efficacy was slightly higher in the model predicting climate change worry compared to the model predicting climate change importance.

4. Discussion

The aim of the current study was to investigate the longitudinal predictors of climate change importance and worry in a sample of Italian youth. The use of machine learning techniques allowed us to handle a large number of potential predictors without variable deletion. More important, the use of traditional techniques like ordinary least squares (OLS) approaches satisfactorily explain the outcomes in an initial sample but may fail to accurately predict the same outcome in other samples. Indeed, without preventing overfitting, it is difficult to estimate if and how the model can generalize to new samples even if the goodness of fit or the effect size indicates a good performance of the model. Machine learning techniques provide predictive accuracy for out-of-sample data and "an increased focus on prediction, rather than explanation, can ultimately lead us to greater understanding of behavior" [92].

The findings of the present study revealed that age is one of the most important variables predicting climate change importance and worry. Specifically, climate change importance and worry increased from the age of 15 years to the age of 30 years. Previous research demonstrated that although the levels of knowledge regarding different aspects of climate change are positively related to age among youth, the levels of belief and concern regarding climate change tend to decline from 14 to 18 years [9]. Such "adolescent dip" in belief and concern regarding climate change has been found in several studies [93–97]. Different reasons have been put forward to explain such "adolescent dip": disruptions in the development of prosocial moral reasoning [98], greater adherence to hedonistic values among late adolescents [96], higher feelings of powerlessness to exert change among adolescents [22,99], higher adherence to worldview and cultural values among adolescents [28,100], and higher opportunities to make choices and greater awareness of the costs associated with pro-environmental behaviors and policies [9]. The findings of the present study do not offer support for these assumptions. Age positively predicted climate change importance and worry. We believe that adolescence and young adulthood (i.e., emerging adulthood) is a key developmental stage for climate change importance and worry for three main reasons. First, the development of abstract thinking and complex abstract thinking is particularly important in taking in new information and understanding the complexity and seriousness of climate change as well as complex global problems and risks. Second, among adolescents and young adults, understanding the larger world and its problems represents an important developmental challenge [101,102] Indeed, preparing students for sustainable development goals and active citizenship is gaining more importance to the point that they have been formalized as compulsory learning subjects of civic education, which was introduced as mandatory into the Italian education system in 2019 [87,103]. Third, different psychological and social changes mark adolescence such as emotional separation from parents and social autonomy, development of identity and strong peer relationships, challenging the authority and the social structure of society [104].

For instance, there is evidence that peers play an important role in developing knowledge and beliefs concerning climate change [105,106] and that there are complex interactions, divergent points of view, and conflicts between parents and late adolescents concerning environmental issues [106,107]. Given the complex interaction among these factors, we believe that the relationship between age and climate change importance and worry is multi-directional and contextually bound. Therefore, the phenomenon of adolescent dip might be true for some individuals, contexts, and cultures, but not for all. Indeed, there is evidence that pro-environmental behavior among adolescents is inversely associated with age only in an individualistic culture but not in a collectivistic culture [108]. In terms of the individualism/collectivism dimension, Italy falls between Western countries and Asian countries [109]. Given the role of age, an implication for policymakers is to plan, develop, and provide a range of curriculum-based educational opportunities to early adolescents to help them explore and discuss the issues of climate change in an engaging way.

The perception of the seriousness of climate change is positively correlated with a leftist position on the left–right scale [29,110]. While political orientation has been found to be an important predictor of climate change perceptions, especially in the US and in Western and Northern Europe, in Southern and Eastern European countries, like Italy, the left-right political divide tends to be smaller regarding climate change [20,21]. The meaning of the "left" and "right" labels can vary in different political contexts. A deeper investigation of conservative orientations on social justice and immigration-related issues is needed to gain better insight into what determines individuals' perceptions about climate change. By including a wide range of political attitudes related to nationalist vs. European and democratic vs. authoritarian orientations, our study provides a more comprehensive look at the political positions that influence climate change perceptions. The findings suggest that among Italian youth immigration-related attitudes are particularly relevant in predicting perceived importance of climate change and personal worry about its impact. We believe that climate-related and immigration-related attitudes are a part of a larger network of ideologies or ideological climates that also include nationalism, authoritarianism, and hostility to the EU [65,66,111–113]. According to this network of ideologies, the primary targets of hostility are typically refugees and immigrants, but also environmentalists and climate scientists, as well as the EU as a supranational institution that is directing climate change [111]. The findings of the present study suggest that tolerance toward refugees and migrants are particularly relevant when predicting climate change importance and worry and that young people frame the issue of climate change as an issue of justice, being probably aware that the consequences of climate change disproportionately affect communities in the Global South and that environmental migration is already a reality [114]. It is interesting to note that climate change skepticism and denial predicted by immigration-related attitudes may contribute to one of the effects of climate change: A growth in migration flows [115,116]. In the prediction of climate change importance and worry, authoritarianism, anti-democratic attitudes, nationalism, as well as EU identity and attitudes, seem less important than immigration-related attitudes. Nevertheless, nationalism and national/European identity and attitudes formed the group of most important variables after age, immigration-related attitudes, online participation, and political interest. We may speculate that climate-related attitudes and concerns are associated with different ways of adopting and questioning national and European identity. Both national and European identity exploration were related to the outcome variables, but commitment only to a European identity was associated with climate change importance and worry. Questioning the meaning of European identity concerning climate change may refer to young people's awareness of the need for a global approach to the issue. Still, it does not mean failing to recognize Europe's weight in environmental issues: the correlational data also show that the perception of a competent Europe is associated with a reduction in concern about climate issues. Even the data on the European vote, strongly related to climate worry, seems consistent with this understanding, in which Europe is given the mandate to play its part. The national identity dimension seems to work the opposite as

nationalist policies do not put climate change at the center of the political agenda; only exploration of this identification in our young sample is related to climate change attitudes.

Online participation and political interest emerged as important factors in predicting climate change importance and worry. Although scholars, policymakers, and practitioners have all called attention to the issue of online misinformation about climate change [117], we believe that the Internet may also provide spaces for ordinary citizens' engagement in everyday discussions and deliberation about climate change [118–121]. There is evidence that European young people are less skeptical regarding the possibility of contrasting climate change and that social media platforms have played a pivotal role in supporting young activists in promoting environmental awareness and mobilizing collective action [122]. The findings of this study confirm the important role played by the Internet in youth's political lives [123]. To foster participation in climate discourse online, the provision of information on climate change from social media and interpersonal conversations about climate change topics have been found useful [124]. We believe there may be an interplay between political interest and online participation: Political interest may stimulate the use of the Internet to get information and to participate in issues related to climate change and vice versa.

Efficacy beliefs and civic participation played a role in the prediction of climate change importance and worry. The finding that prior experience with civic engagement as well as the beliefs that one is capable of performing an action predict engagement with climate change is in line with the theoretical social-cognitive model of political activism for climate change mitigation [125]. The political dimensions of efficacy beliefs are stronger predictors of climate change importance and worry than personal ones, and they also have a stronger association with climate change importance than with worry: we can speculate that having the sense that one can act as a collective works as a coping strategy, reducing the emotional burden of climate change, without undermining its perceived seriousness.

The low importance of social and institutional trust in predicting climate change importance and worry is in line with the findings of previous research [52,126]. There is evidence that the effect size of the relationship between general, or non-domain specific, trust and engagement with climate change is negligible, while trusting scientists and environmental groups strongly correlates with public climate-friendly behaviors [127]. Therefore, future studies may employ different and more relevant trust measures. General trust may not capture the expectations of reciprocity that are key to addressing climate change as a collective action problem. In addition, the findings of the present study confirm the significant, albeit modest, role of social well-being in predicting climate change importance and worry as a form of prosocial behavior [46].

Previous research revealed a strong gender divide, with greater worry about climate change among young women compared to young men [28]. This gender divide was found not only in studies involving young people but also adults [21,23,29,30]. In the present study, gender played a very small or negligible role in predicting climate change importance and worry. We contend that such gender differences tend to disappear when including more proximal variables in the model. Therefore, although gender differences may exist, such as in civic and political engagement and participation [128], their role is modest and may be explained by different mediators. Also, the greater accessibility of the Internet and social media could contribute to closing the gender gap in political participation that, in turn, may contribute to making women's voices more influential in contrasting climate change: there is evidence that when women are more influential in politics, policies address climate change issues more seriously [129].

We found some differences in the most important predictors between the two outcomes. Collective efficacy (political efficacy) had higher importance in the model predicting climate change importance compared to the model predicting climate change worry. In addition, internal political efficacy and self-efficacy showed a higher importance in the model predicting climate change worry compared to the model predicting climate change importance. This pattern of findings seems to suggest that worry about climate change has more to do with personal beliefs about one's own capability, while climate change

importance is more strongly connected to the capability of members of a community. Therefore, worry about climate change is more individual-oriented, whereas climate change importance is more community-oriented. Despite these small differences, it is interesting to note that the model predicting climate change importance differed slightly from the model predicting climate change worry.

It is important for these findings to be replicated and extended to other European countries to see if equivalent findings emerge. This research has some limitations that need to be acknowledged. First, the sample cannot be considered representative of the population of Italian youth because convenience sampling was used. Although we did not use a representative sample in our study, we do not believe that our findings are biased. Specifically, we examined theoretical relationships between constructs that we believe are not affected by our sampling techniques. Moreover, in our models, we controlled for the effect of many factors, including several socio-demographic variables. Second, the longitudinal design of the research cannot support any causal claims. Third, we acknowledge that we used paper and pencil as well as online surveys. We cannot rule out the hypothesis that a difference in the delivery of a research questionnaire (e.g., method, time, setting) had the potential to influence the answers. Finally, the use of self-report measures may be subject to biases such as recall bias, single-responder bias, and social desirability bias.

5. Conclusions

To our knowledge, this is the first longitudinal study examining the predictive importance of a wide range of socio-demographic and psychosocial factors on perceived importance of climate change and personal worry about its impact among youth. Among Italian adolescents and young adults, age is the most important predictor, and the levels of climate change importance and worry grew from the age of 15 years to the age of 30 years. In addition to age, the findings of the present study highlighted the role of immigration-related attitudes in predicting perceived climate change importance and worry. Although there is no straightforward logical connection between climate change skepticism (or denial) and negative attitudes towards refugees and migrants, we believe that such seemingly unrelated perceptions, attitudes, and beliefs are part of a larger network of ideologies or ideological climates surrounding global issues.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data that support the findings of this study will be made openly available upon publication in a public data repository that can mint a persistent digital identifier (i.e., a digital object identifier).

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