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**How Climate-Friendly Behavior Relates to Moral Identity
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Evidence from the European Social Surveys**

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How Climate-Friendly Behavior Relates to Moral Identity and Identity-Protective Cognition: Evidence from the European Social Surveys

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Abstract:

The paper studies the role for climate-friendly behavior of individuals' moral identity, conceptualized in terms of the moral foundations identified by moral psychologists (Care, Fairness, Liberty, Loyalty, Authority, and Sanctity). Two channels of influence are distinguished: a direct influence of moral identity at given cognitions of climate change impacts and effectiveness of individual action, and an indirect influence through the effect of moral identity on these cognitions. Using data from the European Social Surveys, the paper finds that endorsement of the individual-focused (universalist) moral foundations (Care, Fairness, Liberty) and endorsement of the group-focused moral foundations (Loyalty, Authority, Sanctity) both foster climate friendly behavior through the direct channel, the former 1.5 times stronger than the latter. In addition, individual-focused moral foundations enhance climate-friendly behavior by fostering the cognition of bad impacts of climate change and of effectiveness of own action. The indirect effect amounts to up to one third of the direct effect. Results suggest that climate-friendly behavior is to a considerable extent a matter of moral factors rather than consequentialist (benefit-cost) considerations.

Keywords: climate-friendly behavior; moral identity; climate change cognition; moral foundations

JEL codes: Q54; D91; H41

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1. Introduction

Economists have traditionally explained individuals' behaviors in terms of the behaviors' expected positive and negative consequences. This applies, in particular, to the voluntary provision of public goods. It is known at least since Andreoni (1988), however, that in public-good problems which involve many actors, individuals have virtually no incentive to contribute out of consequence-related concerns even if those concerns involve altruism (that is, concern for the beneficial consequences for others). To explain voluntary contributions in such situations, it must be assumed that contributions *per se* are of value to the individual, rather than because of (or in addition to) their beneficial effects – an approach that falls into the category of deontological choice theory.¹

Mitigation of climate change is a public good to which this analysis applies: It involves many actors whose individual contributions have virtually no effect on the climate; yet individuals engage in climate-friendly behaviors, e.g. by buying energy efficient household appliances or taking actions to reduce energy consumption. To explain such behaviors, “moral satisfaction” (Kahneman and Knetsch 1992) from acting in accordance with a moral norm has been invoked that is, a feeling of “doing what is right” (Nyborg 2018).² Moral satisfaction from acting in climate-friendly ways, in turn, has been linked to the “moral foundations” identified by moral psychologists (Welsch 2020): Care, Fairness, Liberty, Loyalty, Authority, and Sanctity. These constitute a distinct set of universally available moral intuitions that people across many cultures endorse, though to different degrees (Graham et al. 2011, Haidt 2012).

Human morality, as specified in terms of the moral foundations, is conceived of by evolutionary biologists and anthropologists as an adaptive response to challenges related to the provision of public goods in groups (Tomasello 2016). In morally diverse contemporary societies, the endorsement pattern of the

¹ Deontology is usually conceived of as an approach to ethics which postulates (in the tradition of Immanuel Kant) that choices are of value *per se*, on the basis of general moral principles and independent of consequences. Consequentialist ethics (of which utilitarianism is a variety) postulates (in the tradition of John Stuart Mill) that choices are to be valued solely on the basis of their consequences. This distinction, familiar in normative theory (ethics), is paralleled in positive choice theory, where behaviors can be viewed as being determined by consequentialist considerations (as maintained in the standard economic model) or by some intrinsic value of the behaviors themselves.

² In addition to acting in accordance with a moral norm (doing what is right), pro-environmental behaviors may be based on social norms or group norms (Farrow et al. 2017, Nyborg 2018, Binder et al. 2020).

moral foundations constitutes individuals' moral identity or self-concept (Haidt 2012, Strominger and Nichols 2014). In particular, Care, Fairness and Liberty are constitutive of an individual-focused (universalist) moral identity, whereas Loyalty, Authority and Sanctity are constitutive of a group-focused moral identity.

People's identity and the associated norms and prescriptions do not only guide behaviors and choices in ways that consequentialist calculus cannot account for (Akerlof and Kranton 2000), but has been found to affect cognitions of phenomena relevant to such choices (e.g. Kahan 2013, 2017): People adjust their decision-relevant beliefs and world views to their normative matrix in order to minimize cognitive dissonance (Festinger 1957). In this way, moral identity may influence choices not only directly, based on conformity of behaviors with people's moral norms, but indirectly through moral identity's effect on choice-relevant cognitions.

Drawing on these literatures (to be discussed in more detail in the next section), the present paper studies the role of individuals' moral identity for two types of climate-friendly behavior: buying energy efficient household appliances and taking actions to reduce energy consumption. The empirical analysis tests a behavioral model that involves both consequentialist and moral concerns. Specifically, two hypotheses are considered: (1) Engaging in climate-friendly behavior depends on (a) perceptions as to the severity of climate-change impacts and effectiveness of individual action (consequence-related factors) and (b) individuals' moral identity (moral factors). (2) Perceptions of the severity of climate-change impacts and effectiveness of individual action depend on individuals' moral identity. Hypothesis (1) captures a presumed direct relationship between moral identity and behavior whereas hypothesis (2) implies a presumed indirect relationship.

Round 8 of the European Social Surveys (ESS) from 2016 provides a unique database for testing these hypotheses as it includes indicators for all relevant variables. Using ESS data from Western Europe, the paper finds that (controlling for income, the level of education, political partisanship and socio-demographic characteristics) endorsement of the individual-focused and the group-focused moral foundations both foster climate-friendly behavior through the direct channel (that is, at given behavior-

relevant cognitions), the former 1.5 times stronger than the latter. In addition, stronger (weaker) endorsement of individual-focused moral foundations enhances (lessens) climate-friendly behavior by fostering (inhibiting) the cognition of bad impacts of climate change and of effectiveness of own action. The indirect effect amounts to up to one third of the direct effect. Comparing different behaviors, moral identity is more important (through both channels) with respect to costly behavior (buying energy efficient appliances) than with respect to costless behavior (actions that reduce energy consumption). Comparing different moral foundations, the Care and Fairness foundations stand out by having the strongest (positive) influence on the perception that climate change is bad and individual action is effective, whereas the Liberty foundation strengthens the perception that climate change is bad, but weakens the perception that own action is effective. Overall, the results suggest that climate-friendly behavior is to a considerable extent a matter of moral identity rather than consequentialist considerations and that the latter are influenced by the former.

While the methodological approach of this paper is epidemiological, involving survey data, the results obtained are consistent with experimental evidence on the role of moral or political identity for behaviors and cognitions in domains other than climate change (Strominger and Nichols 2014, Kahan 2013, Howell et al. 2019). Moreover, since the pertinent psychological research has shown that individuals' moral identity is essentially stable from the beginning of adulthood (Haidt 2012, Strominger and Nichols 2014), it seems appropriate to consider behaviors and cognitions as being influenced by moral identity rather than the other way round.

To my knowledge, the paper is the first to study the interplay between environment-friendly behavior, behavior-relevant cognitions, and moral identity. The paper most closely related to the present one (Welsch 2020) investigates the role of moral foundations for environmental concern and pro-environmental behaviors, but does not account for consequentialist determinants of those behaviors, the relevant cognitions and those cognitions' dependence on moral identity. By contrast, the present paper focuses on precisely those aspects and shows that moral identity is important for consequentialist calculus by shaping relevant cognitions.

The paper is structured as follows. Section 2 discusses the literature background and develops the general hypotheses. Section 3 describes the theoretical and empirical frameworks. Section 4 presents and discusses the results. Section 5 concludes.

2. Literature Background and Hypotheses

2.1 Moral Foundations Theory³

Moral Foundations Theory (MFT), as originally developed by Haidt and Joseph (2007), provides a conceptual organization for measuring and describing differences in moral concerns across individuals, social groups, and cultures (Graham et al. 2011). MFT was created by identifying the adaptive challenges of social life that evolutionary psychologists have described and connecting those challenges to moral values that are found in some form in many cultures around the world. The moral foundations corresponding to those adaptive challenges are labelled Care, Fairness, Liberty, Loyalty, Authority, and Sanctity (Purity). In theory, any pattern of “settings” or endorsement levels for the moral foundations is possible.

The underlying adaptive challenges, to which natural selection responded by favoring appropriate mental dispositions (morals), are caring for vulnerable children (Care), reaping the benefits of cooperation (Fairness), constraining the power of individuals to dominate and bully others (Liberty), forming coalitions to compete with other coalitions (Loyalty), forging beneficial status hierarchies (Authority), and protection against contaminants (Sanctity/Purity). Table 1 describes the moral foundations. In addition to the underlying adaptive challenges, the table shows the triggers that activate the respective mental modules.

³ This subsection draws on Welsch (2020).

Table 1: Moral Foundations Theory

	Care	Fairness	Liberty	Loyalty	Authority	Sanctity
Adaptive challenges	Caring for vulnerable children	Reaping benefits from cooperation	Constraining domination and bullying	Forming cohesive coalitions	Forging beneficial status hierarchies	Avoiding contaminants
Original triggers	Suffering, distress, neediness	Cheating, cooperation, deception	Bullies, tyrants	Threat or challenge to group	Signs of dominance and submission	Waste products, diseased people

Note: Adapted from Haidt (2012), p.146 and p. 200-211.

The social patterns or situations that trigger the various moral foundations have in common that they involve the challenge of free riding on public goods, e.g. the public goods of cooperation, defense against external threats or protection against contaminants (Haidt 2012, Tomasello 2016). Human morality as such emerged as a response to such challenges by suppressing and regulating selfishness (Graham et al. 2011). This is what makes the moral foundations potentially relevant to the study of environmental public good provision. Yet, with respect to the specific environmental good of climate change mitigation, it is useful to note that, according to factor analysis, Care, Fairness and Liberty differ from Loyalty, Authority and Sanctity, the former ones being individual-focused in the sense that they refer to individuals independent of their group membership whereas the latter ones are group-focused (Graham et al. 2011).⁴

This difference is potentially important in the case of climate change, as climate change mitigation is a *global* public good whose benefits are not restricted to particular groups such as the family, neighborhood, region or nation. Given the character of climate change mitigation as a global public good that benefits everyone, it may therefore be expected that Loyalty, Authority and Sanctity are less relevant with respect to climate-friendly behavior than they may be with respect to more local or regional and hence

⁴ The distinction between individual-focused and group-focused moral foundations is different from the ideological distinction between liberal-progressive (left-leaning) and conservative (right-leaning), though some similarities exist. While adherents to both political camps endorse Care, Fairness and Liberty in similar ways, liberal-progressives endorse Loyalty, Authority and Sanctity less than do conservatives (Haidt 2012). In the data used in this study (subsection 3.1), a more right-leaning self-placement correlates with endorsement of Fairness at $r = -0.165$ and with endorsement of Sanctity at $r = 0.127$. The correlations with the other MFs are of negligible magnitude (less than $r = 0.01$).

more group-related environmental goods. The Care and Fairness foundations, conversely, may play an important role as they respond to suffering, distress and neediness of the most vulnerable and to a need for cooperation, respectively, irrespective of membership to a group (such as family or nation). Welsch (2020) provides evidence consistent with such a view.

2.2 Moral Identity

The individual-specific endorsement pattern of the moral foundations constitutes the individual's moral matrix – her moral identity, which is a stable and characteristic feature of an individual's self (Strominger and Nichols 2014). Depending on the emphasis an individual places on Care, Fairness and Liberty on the one hand and Loyalty, Authority and Sanctity on the other, the individual's moral identity is more individual-focused or more group-focused, a distinction akin to the more group-focused nature of the Loyalty, Authority and Sanctity foundations (Haidt 2012).

Moral identity is acquired during adolescence and early adulthood and is stable thereafter. The development of moral identity involves three steps (McAdams and Pals 2006). The first step refers to a genetic predisposition that manifests itself in the personality trait of “openness to experience”: a tendency to cherishing novelty, variety, and diversity, while simultaneously being less sensitive to signs of threat. People with this trait are predisposed (but not predestined) to become individual-focused, whereas people with the opposite settings are predisposed to become group-focused. These basic dispositional traits undergo so-called characteristic adaptations during adolescence in response to the specific environments and challenges individuals happen to face. For instance, an individual scoring high on “openness to experience” may respond to strict rules in school by developing a general sense of dissatisfaction with existing arrangements which would not have happened to the same degree had she gone to a more individual-focused and less structured school (Haidt 2012).

Given dispositional traits and characteristic adaptations, the final step in the development of moral identity is the construction of “life narratives”, that is, simplified and selective reconstructions of her past, connected to an idealized vision of the future, and saturated with morality. Life narratives provide a bridge

between an individual's developing adolescent self and her adult moral identity as individual-focused – with a taste for Care, Fairness and Liberty – or group-focused – with a taste for Loyalty, Authority and Sanctity and a heightened sense for the interests of the group.

2.3 Identity-Protective Cognition

People's moral identity not only guides their ethical decisions, but may shape their cognition of decision-relevant phenomena. The basis of identity's influence on cognitions is a desire to minimize cognitive dissonance, that is, a psychological discomfort arising from a misalignment between an individual's values and choices and the facts that characterize the choice situation. Cognitive dissonance can be resolved by changing one's identity-relevant values or by "appropriately" interpreting the facts. Given the individual's desire for a stable moral identity, the latter is a widespread strategy (Festinger 1957).

Identity-protective cognition involves individuals' differentially attending to (through selective exposure or avoidance) and/or processing (through motivated reasoning) information (e.g. Garrett et al. 2011, Kunda 1990, respectively) in a way that agrees with their world view and moral values. Identity-protective information selection and directionally motivated reasoning have been found to lead to polarized views around science and policy issues (e.g. Druckman and Bolsen 2011, Kahan 2013, Kraft et al. 2015). As shown by Kahan et al. (2017), politically polarized views on science are better explained by identity-protecting cognitive strategies than by the competing hypothesis of deficits in the public's capacity to comprehend scientific evidence.

Existing studies on identity-protecting cognition mostly refer to political partisanship as the relevant identity category. With respect to energy issues, Cacciatore et al. (2012) studied motivated processing of media information about biofuels in the U.S. and found that liberals (Democrats) and conservatives (Republicans) are affected differently by media use when forming opinions about the associated risks and benefits. Howell et al. (2019) showed how polarization of support for fracking can be understood by how risk and benefit perceptions differ between liberals and conservatives, with liberals seeing greater risk and less benefit.

More closely related to the present paper, there is ample evidence that despite scientific consensus liberal-progressive and conservative U.S. citizens hold widely different views on climate change. Specifically, liberals tend to believe that human activity is a primary cause of climate change, whereas conservatives are much less likely to hold this belief (e.g. McCright and Dunlap 2011, Brewer 2012).⁵ Similar to, but not identical with political orientation, Kahan et al. (2012) found a cultural polarization of perceived climate change risk between “hierarchical individualists” and “egalitarian communitarians”.

While there is no one-to-one relationship between ideological identity and the endorsement of different patterns of moral foundations (cf. footnote 4), this literature is suggestive of the possibility that individuals’ cognitions relevant to climate-friendly behavior may depend on their moral identity.

2.4 The Present Study and Hypotheses

Based on the notion that human morality evolved as a response to challenges related to the provision of public goods, the present paper investigates how the endorsement of alternative patterns of moral foundations relates to individuals’ engagement in climate-friendly behaviors. The paper connects the standard consequentialist explanation of such behaviors with deontological considerations, according to which behaviors have value-significance per se and are chosen on the basis of individuals’ moral identity profile. Specifically, the paper studies if and how climate-friendly behaviors relate to moral identity not only directly but indirectly, through identity’s influence on cognitions concerning the consequences of those behaviors.

Drawing on the standard consequentialist model of pro-environmental behavior on the one hand and the literature reviewed in the preceding subsections on the other, the paper explores the following general hypotheses (to be specified in more detail below):

⁵ A comprehensive review of the relationship between views on climate change and political orientation is beyond the scope of this paper. Druckman and McGrath (2019) review the literature on climate change beliefs and channels through which they relate to political orientation. They suggest that the empirical evidence is equally consistent with directional motivated reasoning and with a theory in which citizens strive to form accurate beliefs but vary in what they consider to be credible evidence.

Hypothesis 1: Engaging in climate-friendly behavior depends on (a) perceptions as to the severity of climate-change impacts and effectiveness of individual action (consequence-related factors) and (b) individuals' moral identity (moral factors).

Hypothesis 2: Perceptions of the severity of climate-change impacts and effectiveness of individual action depend on individuals' moral identity.

Hypothesis 1 captures a presumed direct relationship between moral identity and behavior whereas Hypothesis 2 implies a presumed indirect relationship.

3. Methodological Framework

3.1 Data and Sample Characteristics

The data used in the empirical analysis are taken from the European Social Survey (ESS); see www.europeansocialsurvey.org. The ESS is a cross-sectional, multi-country survey covering over 30 nations. ESS data are obtained using random (probability) samples, where the sampling strategies are designed to ensure representativeness and comparability across European countries. Following Welsch (2020), I use data from Round 8 (2016) for a set of West-European countries including Austria, Belgium, Finland, France, UK, Iceland, Ireland, Israel, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the UK. I focus on Western Europe because the pattern of the moral foundations is relatively homogeneous in Western societies but is different in other cultures (Haidt 2012).

Round 8 of the ESS is unique in that it offers proxies for all our variables of main interest, that is, climate-friendly behaviors, cognitions relevant to those behaviors, and endorsement of the six moral foundations (see Appendix I). The climate-friendly behaviors are “buying energy efficient household appliances” and “doing things to reduce energy consumption”.⁶ The behavior-relevant cognitions are

⁶ Buying energy efficient appliances and reducing energy use are frequently mentioned examples of climate-friendly behaviors (e.g. Farrow et al. 2017, Nyborg 2018). Reducing energy use yields private benefits through savings in energy bills in addition to the public benefit of contributing to climate change mitigation. If moral foundations turn out to be drivers of reducing energy use, the existence of private co-benefits makes those results more rather than less salient.

subjective assessments as to “severity of climate change impacts” and “effectiveness of own climate-friendly actions” (for their relevance, see subsection 3.2).

With respect to the moral foundations, it should be noted that the survey variables used to measure endorsement of Care, Fairness, Liberty, Loyalty, Authority, and Sanctity do not explicitly refer to moral foundations theory (Welsch 2020). Rather, the correspondence of the survey items to the moral foundations relies on the formulations used in the survey (see Appendix I). For instance, endorsement of the Fairness foundation is measured by the degree to which a respondent self-identifies as someone who “thinks it is important that every person in the world should be treated equally. She/he believes everyone should have equal opportunities in life.” Similarly, endorsement of the Loyalty foundation is measured by the degree of self-identification with the description “It is important to her/him to be loyal to her/his friends. She/he wants to devote herself/himself to people close to her/him.” It should also be noted that some of the survey questions explicitly involve a differentiation between individual-focused (universalist) and group-focused morality. This is most salient with respect to Fairness and Loyalty, the former referring to “every person in the world” whereas the latter refers to “people close”.

The definitions and summary statistics of all main variables used in the empirical analysis are displayed in Table 2. For the moral foundations, the original coding of the data was inverted such that higher values correspond to greater importance of the respective foundations.

Table 2: Main Variables

Variable	Definition	Scale	Mean	Standard Deviation
Buy Efficient Appliances	How likely to buy most energy efficient home appliances	“Not at all likely” = 0 to “extremely likely” = 10	7.78	2.28
Reduce Energy Use	How often do things to reduce energy use	“Never” = 1 to “always” = 6	4.29	2.84
Climate Change Bad	Climate change has good or bad impact across the world	“Extremely good” = 0 to “extremely bad” = 10	6.76	2.22
Own Action Effective	How likely, limiting own energy use will reduce climate change	“Not at all likely” = 0 to “extremely likely” = 10	4.51	2.64
Care	Important to help people and care for others’ well-being	“Not important at all” = 1 to “very important” = 6	4.87	0.99
Fairness	Important that all people are treated equally and have equal opportunities	“Not important at all” = 1 to “very important” = 6	4.86	1.07
Liberty	Important to make own decisions and be free	“Not important at all” = 1 to “very important” = 6	4.82	1.11
Loyalty	Important to be loyal to friends and devote to people close	“Not important at all” = 1 to “very important” = 6	5.09	0.92
Authority	Important to do what is told and follow rules	“Not important at all” = 1 to “very important” = 6	3.70	1.41
Sanctity	Important to follow traditions and customs	“Not important at all” = 1 to “very important” = 6	4.13	1.40

Source: European Social Surveys. Data are coded such that higher values indicate greater approval or importance.

With respect to climate-friendly behavior, the mean self-rated likelihood of buying energy efficient appliances is 7.78 on the 0-10 scale (which may be interpreted as rather likely, though no verbal response

categories other than the end points of the numerical scale are offered), whereas the mean reported frequency of doing things to reduce energy use is 4.29 on the 6-point scale (which corresponds to the response category “often”). The mean assessment of how bad climate change impacts are is 6.76 on the 0-10 scale whereas the mean assessment of how effective own action is amounts to 4.51 on the 0-10 scale.

Turning to the moral foundations, Loyalty is found to be the most important (the mean score being 5.09 on the 6-point scale) and least controversial as measured by dispersion (the standard deviation being 0.92). Care, Fairness, and Liberty are of slightly lower importance (with mean scores of 4.87, 4.86 and 4.82, respectively) and show slightly more dispersion (with standard deviations between 0.99 and 1.11). The Authority and Sanctity foundations are on average considered less important (with mean scores of 3.70 and 4.13, respectively), and they are less unanimously endorsed (the standard deviation being about 1.4).⁷

3.2 Conceptual Models and Predictions

As noted above, two kinds of climate-friendly behavior will be considered in the empirical analysis: “buying energy efficient household appliances” and “doing things to reduce energy consumption” This subsection develops conceptual models of these behaviors in order to derive more specific predictions as to the role of consequentialist and moral factors claimed in Hypothesis 1. Since the first behavior is costly, but does not involve obstacles like effort, time or inconvenience, whereas the second is costless (and indeed cost-saving) but may involve such obstacles, the two behaviors are best described by two separate models. While the two models differ in their predictions as to the role of income, they agree with respect to the influence of consequentialist and moral factors.

⁷ Endorsement of the moral foundations varies by countries and socio-economic groups (Welsch 2020). Similar to the overall sample, Loyalty is the most strongly and Authority the least strongly endorsed MF in all countries. While Care, Fairness and Loyalty score fairly similarly in all countries (the range on the 6-point scale amounting to 0.7 for Care and Fairness and 0.5 for Loyalty), the dispersion is greater with respect to Authority (range of 1.2) and Sanctity (range of 1.1). Furthermore, endorsement of the MFs is firmly related to age, gender and position on the political spectrum and less so to the level of education and income. Endorsement of Care, Fairness and Liberty (individual-focused) is stronger in younger and more left-leaning individuals whereas endorsement of Authority and Sanctity (group-focused) is stronger in older and more right-leaning individuals. In addition, women are more concerned about Care, Fairness and Sanctity than are men.

Model A (buying energy efficient household appliances)

To model the purchase of energy efficient appliances, it is assumed that individual i 's utility U_i depends positively on (a) her consumption level, C_i , (b) aggregate mitigation jointly achieved by all individuals, M , and (c) her own individual mitigation effort, M_i , that is, the degree of extra efficiency the individual chooses. The utility generated by M reflects the (subjective) consequentialist value of achieving a better climate by means of mitigation. This value is to be understood as a composite parameter which reflects the individual's assessment of the severity of the (physical) impacts of climate change and the disutility the individual attaches to those impacts (through self-regarding and other-regarding concerns). By contrast, the utility generated by M_i arises independent of consequentialist considerations. It represents the deontological value of acting morally.

The utility function is specified as follows:

$$U_i = \alpha C_i^\sigma + \beta M^\sigma + \gamma M_i^\sigma, \quad (1A.i)$$

where α , β and γ are positive parameters and $0 < \sigma < 1$ ensures that the utility function is strictly concave in its arguments. The parameter β captures the consequentialist value of mitigation, which, as discussed above, involves the subjective assessment of the severity of climate change impacts, whereas the parameter γ captures the deontological (moral) value of acting in a climate-friendly manner.

The individual's conception as to how individual mitigation efforts contribute to aggregate mitigation is described as follows:

$$M = \sum_{j=1}^n e M_j, \quad (1A.ii)$$

where the parameter e measures the degree to which the individual considers individual mitigation (purchase of energy efficient appliances) to be effective.

The individual mitigation effort is costly in that it diminishes the level of consumption attainable at income Y_i according to the following budget constraint:

$$C_i = Y_i - kM_i, \quad (1A.iii)$$

where k is the marginal cost of the effort in terms of consumption foregone

As shown in Appendix II, in the framework of Model A the utility-maximizing mitigation level chosen by the individual satisfies the following

Prediction 1A: The individual's mitigation effort M_i increases in (a) income, (b) the subjective severity of climate change impacts, β , (c) the subjective assessment of mitigation effectiveness, e , and (d) the moral value of acting in a climate-friendly manner, γ .

The factors (b) and (c) refer to the consequentialist drivers of the individual's mitigation effort whereas (d) refers to the deontological (moral) driver.

Model B (doing things to reduce energy consumption)

In order to model energy saving as recurrent behavior (rather than a one-time investment) we need to disaggregate consumption into consumption of energy, E , and non-energy, N . In contrast to Model A, where mitigation yields utility, it is now assumed that *more* consumption of energy yields *disutility* through negatively affecting the climate (consequentialist channel) and through contradicting the individual's climate friendly morality (deontological channel). Apart from these channels, the consumption of E yields utility (through heating, cooling, lighting etc.) as does the consumption of N . Model B takes the following form:

$$U_i = \alpha_N N_i^\sigma + \alpha_E E_i^\sigma - \beta Q^\sigma - \gamma E_i^\sigma, \quad (1B.i)$$

$$Q = \sum_{j=1}^n eE_j, \quad (1B.ii)$$

$$N_i = Y_i - pE_i, \quad (1B.iii)$$

where all parameters are positive and $0 < \sigma < 1$. In the utility function (1B.i), Q denotes a characteristic of the global climate (e.g. greenhouse gas concentration) which negatively affects the individual's utility (for self-regarding or other-regarding reasons), where the strength of the effect, β , (again) incorporates the degree to which the individual thinks that climate change is bad. (1B.ii) is the individual's subjective model of how energy consumption or, likewise, energy saving affects the climate, where e is the subjective effectiveness parameter. (1B.iii) is the budget constraint according to which the consumption of non-energy equals income minus the consumption of energy times the price of energy, p (in units of non-energy).

The parameter β captures the consequentialist value of energy saving, which (as noted above) involves the subjective assessment of the severity of climate change impacts, whereas the parameter γ captures the deontological (moral) value of saving energy (moral disapproval of energy consumption).

As Appendix II shows, in the framework of Model B the utility-maximizing level of energy saving chosen by the individual satisfies the following

Prediction 1B: The individual's level of energy saving (a) decreases in income, (b) increases in the subjective severity of climate change impacts, β , (c) increases in the subjective assessment of mitigation effectiveness, e , and (d) increases in the moral value of acting in a climate-friendly manner, γ .

The main difference from Model A is that energy saving is decreasing in income whereas the costly mitigation effort is increasing in income. Similar to Model A, the factors (b) and (c) represent the consequentialist drivers of energy saving whereas (d) represents the deontological (moral) driver.

As seen in the Appendix, in both models the consequentialist drivers become less effective as the number of individuals, n , increases whereas the effectiveness of the moral driver is unaffected by the number of individuals. The former reflects an incentive to free-ride on others' efforts in public-good problems

involving many individuals – where containment of this incentive is precisely the basis of the evolutionary advantage afforded by morality (Tomasello 2016).

The empirical analysis tests the Predictions 1A and 1B together with the hypothesis that not only individuals' climate-friendly behaviors but their assessment of the severity of climate change impacts and their assessment of the effectiveness of their behaviors depend on the moral foundations they endorse.

3.3 Empirical Strategy

By denoting the variables *Care*, *Fairness*, *Liberty*, *Loyalty*, *Authority*, and *Sanctity* jointly by *Morals*, the estimating equations for the climate-friendly behaviors can be stated as follows (where the index *i* refers to the individuals):

$$BuyEfficientAppliances_i = const_{11} + a_{11}ClimateChangeBad_i + b_{11}OwnActionEffective_i + c_{11}Morals_i + d_{11}Controls_i + error_{11,i} \quad (1.1)$$

$$ReduceEnergyUse_i = const_{12} + a_{12}ClimateChangeBad_i + b_{12}OwnActionEffective_i + c_{12}Morals_i + d_{12}Controls_i + error_{12,i} \quad (1.2)$$

In these formulations, *Controls* denotes the set of socio-demographic variables usually considered in the literature on pro-environmental behavior (e.g. Welsch and Kühling 2009): household income, level of education, position on the left-right scale, poor health, household size, being female, age, living with partner, being unemployed, urban-rural scale. In addition, the regressions include country fixed effects.

According to the *Predictions 1A* and *1B* in subsection 3.2, the coefficients a_{11} , a_{12} , b_{11} and b_{12} are expected to be positive.

The estimating equations for the behavior-relevant cognitions read as follows (with the same set of controls as above):

$$ClimateChangeBad_i = const_{21} + c_{21}Morals_i + d_{21}Controls_i + error_{21,i} \quad (2.1)$$

$$OwnActionEffective_i = const_{22} + c_{22}Morals_i + d_{22}Controls_i + error_{22,i} \quad (2.2)$$

Following best practice (e.g. Gatignon 2014, Chapter 11) the estimating equations will be estimated as a (recursive) system of seemingly unrelated regressions to accommodate the possibility of cross-equation correlation of errors (due to omitted common factors).⁸

4. Results and Discussion

4.1 Climate-Friendly Behaviors

Table 3 presents results of regressions of climate-friendly behaviors on individuals' cognitions of the severity of climate impacts and the effectiveness of individual action (consequentialist factors) and on individuals' moral foundations as well as regressions of the cognitions on moral foundations. All regressions control for socio-demographic factors, in particular the levels of income and education.

Regression 1 is a benchmark regression of “how likely buy energy efficient appliances” on the consequentialist factors and the controls (which corresponds to the standard consequentialist model). The stated likelihood of buying energy efficient appliances is significantly positively related to the degrees of considering climate change to be bad and individual action to be effective as well as to income. These results are consistent with Prediction 1A. The coefficient of determination (R^2) is 0.065; it is about 60 percent larger than in a regression on the controls only ($R^2 = 0.040$; results not shown), which suggests that cognitions as to climate change impacts and the effectiveness of own action contribute considerably to explaining the likelihood of buying energy efficient appliances.⁹

⁸ The system is recursive in that the cognitions are supposed to affect the behaviors but not the other way round. In recursive systems, the matrix of coefficients of the endogenous variables is triangular, implying that its determinant is 1. More sophisticated system estimators are thus not required (Davidson and McKinnon 1993, 644-645).

⁹ Coefficients of determination are typically low in models of pro-environmental attitudes and behaviors. For instance, Gelissen (2007) reports $R^2 = 0.035$ for “support of environmental protection” and Binder et al. (2019) report $R^2 = 0.053$ for a composite index of pro-environmental behavior.

Table 3: Estimation Results

	Buy Efficient Appliances		Reduce Energy Use		Climate Change Bad	Own Action Effective
	(1)	(2)	(3)	(4)	(5)	(6)
Climate Change Bad	0.08*** (12.75)	0.07*** (11.07)	0.05*** (7.50)	0.05*** (6.97)		
Own Action Effective	0.10*** (20.23)	0.10*** (18.55)	0.03*** (4.62)	0.02*** (4.47)		
Care		0.08*** (4.64)		0.05*** (2.86)	0.02 (0.96)	0.19*** (9.17)
Fairness		0.10*** (7.10)		0.04*** (2.88)	0.22*** (15.57)	0.16*** (9.30)
Liberty		0.08*** (5.74)		-0.01 (0.15)	0.05*** (3.54)	-0.07*** (4.11)
Loyalty		0.05*** (2.59)		0.06*** (2.99)	0.15*** (8.41)	-0.10*** (4.75)
Authority		0.01 (1.46)		-0.01 (0.02)	-0.08*** (7.79)	0.06*** (4.64)
Sanctity		0.08*** (7.90)		0.03** (2.34)	-0.07*** (6.56)	0.12*** (9.50)
Household Income	0.01** (2.55)	0.02*** (3.60)	-0.03*** (4.08)	-0.02*** (3.44)	0.04*** (7.55)	0.03*** (4.03)
Education Level	0.01*** (6.13)	0.01*** (5.91)	0.01 (1.60)	0.01 (1.68)	0.01*** (6.47)	-0.01 (0.22)
Left-Right Scale	-0.02** (2.51)	-0.01* (1.95)	-0.03*** (4.25)	-0.02*** (3.51)	-0.12*** (18.31)	-0.05*** (6.16)
Poor Health	-0.06*** (3.73)	-0.05*** (2.92)	0.01 (0.22)	0.01 (0.74)	0.10*** (6.08)	0.12*** (6.07)
Household size	0.02 (1.44)	0.01 (0.27)	-0.03** (2.18)	-0.03*** (2.63)	0.04*** (3.16)	0.03** (2.37)
Female	0.23*** (8.39)	0.16*** (5.99)	0.12*** (3.39)	0.09*** (3.13)	0.05** (1.99)	0.15*** (4.44)
Age	0.02*** (22.45)	0.02*** (20.97)	0.01*** (12.25)	0.01*** (11.85)	-0.01*** (9.02)	-0.01*** (2.85)
Living with partner	0.41*** (12.65)	0.42*** (13.01)	0.03 (0.99)	0.03 (0.86)	0.01 (0.19)	0.05 (1.24)
Unemployed	0.01 (0.03)	0.05 (0.69)	0.25*** (3.39)	0.27*** (3.65)	0.03 (0.41)	0.06 (0.76)
Urban-rural scale	0.03*** (2.68)	0.03** (2.42)	0.01 (1.12)	0.01 (1.05)	0.05*** (4.11)	-0.02 (1.11)
Constant	6.76	7.71	3.90	4.27	7.93	5.77
Observations	24632	24262	24731	24348	24551	24721
Adj. R ²	0.065	0.078	0.016	0.019	0.060	0.024
Adj. R ² controls only	0.040		0.013		0.037	0.008

Regressions based on ESS Round 8. The t-statistics in parantheses are based on standard errors clustered at the country level. * $p < 0.1$. ** $p < 0.05$, *** $p < 0.01$. Main variables are defined in Table 2. Household Income: deciles. Education Level: primary education not completed = 0 to doctoral degree = 8. Left-Right Scale: left = 0 to 10 = right. Poor Health: very good =1 to very bad = 5. Urban-Rural Scale: big city =1 to countryside = 5.

Regression 2 adds the endorsement of the six moral foundations. This leaves the results from regression 1 intact but raises R^2 from 0.065 to 0.078, that is, by 20 percent. Together, including the consequentialist and moral factors implies that R^2 almost doubles relative to the controls-only model. All moral foundations except Authority attract significantly positive coefficients. Of the significant foundations, Fairness displays the largest (0.10) and Loyalty the smallest coefficient (0.05). Adding coefficients across the individual-focused foundations (Care, Fairness and Liberty) and across the significant group-focused foundations (Loyalty and Sanctity) shows that the influence of the former is about twice as strong as that of the latter (0.26 and 0.13, respectively). Thus, while both types of moral foundations contribute to mitigation behavior, the individual-focused foundation is a stronger contributor than the group-focused foundation.

With respect to the controls, the likelihood of buying energy efficient appliances is significantly positively related to age, the level of education, being female, living with a partner, and living in a more rural area and significantly negatively related to a more right-leaning political orientation and poor health according to both regressions 1 and 2.

Regression 3 is the benchmark regression for “doing things to save energy”, which omits the moral foundations. The stated likelihood of engaging in energy saving activities is significantly positively related to the subjective severity of climate change and the subjective effectiveness of individual action and significantly negatively related to income, consistent with Prediction 1B. The coefficient of determination is 0.016, which is much smaller than in the case of household appliances, but almost 25 percent larger than in a regression on the controls only ($R^2 = 0.013$; results not shown).

Regression 4 adds the endorsement of the six moral foundations. This leaves the results from regression 3 intact but raises R^2 to 0.019, that is, by 19 percent. Together, including the consequentialist and moral factors leads to an increase of R^2 relative to the controls-only model by 46 percent. All moral foundations except Liberty and Authority attract significantly positive coefficients. Different from the case

of household appliances, adding coefficients across the significant individual-focused foundations (Care and Fairness) and across the significant group-focused foundations (Loyalty and Sanctity) shows no appreciable difference between the two types of moral foundations (the sum being 0.09 in both cases).

Considering both behaviors jointly and adding the significant coefficients across the individual-focused and group-focused moral foundations, respectively, gives 0.35 with respect to the former and 0.22 with respect to the latter. Climate-friendly behavior thus positively depends on both types of moral foundations, but about 1.5 times more strongly so on the individual-focused than the group-focused ones.

With respect to the controls, the likelihood of engaging in energy saving activities is significantly positively related to age, being female and being unemployed and significantly negatively related to a more right-leaning political orientation and the size of the household according to both regressions 3 and 4. A major difference to the case of household appliances is that unemployed people (at fixed income) are more likely to engage in saving energy, possibly because of less opportunity cost (in terms of time) of doing so.

4.2 Climate-Related Cognitions

Regressions 5 and 6 in Table 3 estimate the dependence of climate-related cognitions on moral foundations and the controls. As seen in regression 5, a perception of greater severity of climate change impacts is significantly positively related to Fairness, Liberty and Loyalty and negatively related to Authority and Sanctity. While the R^2 is only 0.060, it is much larger than in a corresponding regression on the controls only ($R^2 = 0.037$; results not shown)). Moral foundations thus contribute markedly to explaining assessments of climate change impacts over and above the controls.

According to regression 6, an assessment of greater effectiveness of individual action is significantly positively related to Care, Fairness, Authority and Sanctity, and significantly negatively related to Liberty and Loyalty. The R^2 (0.024) is smaller than in the case of perceived climate change impacts, but much higher than in a corresponding regression on the controls only ($R^2 = 0.008$; results not shown), indicating again an important role of moral foundations for behavior-relevant cognitions.

Considering both cognitions jointly and adding the significant coefficients across the individual-focused and group-focused moral foundations, respectively, gives 0.55 with respect to the former and 0.08 with respect to the latter. Cognitions that enhance climate-friendly behavior thus positively depend on both types of moral foundations, but almost seven times more strongly so on the individual-focused than the group-focused ones.

With respect to the controls, both cognitions are significantly positively related to poor health, being female, the size of the household, and income and significantly negatively related to right-leaning political orientation and age. The view that climate change is bad is significantly positively related to a higher level of education and significantly negatively related to living in a more rural area whereas the view that individual action is effective is not significantly related to both of these factors.

Overall, as hypothesized, moral foundations are related to climate-friendly behaviors as well as to cognitions relevant to those behaviors, thus influencing the behaviors both directly, at given cognitions, and indirectly by influencing those cognitions.

4.3 Direct and Indirect Effects of Moral Foundations

Table 4 shows the magnitudes of the moral foundations' direct and indirect effects on the two climate-friendly behaviors, using the significant coefficients from Table 3. Indirect effects are "coefficient of regression of behavior on cognition" times "coefficient of regression of cognition on moral foundation". With respect to appliances, the Care and Fairness foundations stand out by not only strongly fostering behavior directly but by also having a strong indirect effect on it. In the case of Care, the indirect effect amounts to about one quarter of the direct effect ($0.019/0.08$); in the case of Fairness the indirect effect contributes almost one third of the direct effect ($((0.015+0.016)/0.10)$). With respect to actions to reduce energy consumption, the indirect effect of Care amounts to one twelfth of the direct effect ($0.004/0.05$) whereas the indirect effect of Fairness is about one third of the direct effect ($((0.011+0.003)/0.04)$).

Table 4: Direct and Indirect Effects of Moral Foundations on Climate-Friendly Behaviors

	Buy Efficient Appliances			Reduce Energy Use		
	Direct	Through “Climate Change Bad”	Through ”Own Action Effective”	Direct	Through “Climate Change Bad”	Through ”Own Action Effective”
Care	0.08	n.s.	0.019	0.05	n.s.	0.004
Fairness	0.10	0.015	0.016	0.04	0.011	0.003
Liberty	0.08	0.004	-0.007	n.s.	0.003	-0.001
Loyalty	0.05	0.001	-0.010	0.06	0.008	-0.002
Authority	n.s.	-0.006	0.006	n.s.	-0.004	0.001
Sanctity	0.08	-0.005	0.012	0.03	-0.004	0.002

Based on estimates from Table 3. Indirect effects are “coefficient of regression of behavior on cognition” times “coefficient of regression of cognition on moral foundation”. N.s. = not significant.

In contrast to the Care and Fairness foundations, the Liberty foundation and the group-focused moral foundations (Loyalty, Authority and Sanctity) have mixed indirect effects on the climate-friendly behaviors. In particular, strong endorsements of Liberty and Loyalty affect both behaviors negatively through the indirect channel in that these moral foundations are negatively associated with considering individual action to be effective. Endorsements of the Authority and Sanctity foundations affect the behaviors negatively through the indirect channel in that Authority and Sanctity are negatively associated with considering climate change to be bad.

4.4 Summary and Discussion

The empirical results are consistent with the idea that engaging in climate-friendly behaviors is directly related to individuals’ moral identity in terms of the six universally available moral intuitions identified by Moral Foundations Theory. In addition, the results are consistent with the idea that cognitions which consequentialist calculus suggests to be behavior-relevant are also related to moral identity, which provides an indirect channel through which climate-friendly behavior is linked to moral identity.

In more detail, it was found that the explanatory power of regressions of the behaviors and cognitions is substantially improved by including endorsement of the moral foundations. Differentiating

between individual-focused (universalist) moral foundations (Care, Fairness, Liberty) and group-focused moral foundations (Loyalty, Authority, Sanctity), it was found that the former foster climate friendly behavior through the direct channel much more strongly than the latter. In addition, endorsement of the individual-focused moral foundations enhances climate-friendly behavior by fostering the cognition of bad impacts of climate change and of effectiveness of own action, whereas those cognitions are not unambiguously related to stronger endorsement of a group-focused morality. Comparing different individual-focused moral foundations, the Care and Fairness foundations stand out by having the strongest (positive) effect on the perception that climate change is bad and individual action is effective, whereas the Liberty foundation strengthens the perception that climate change is bad, but weakens the perception that own action is effective.

In interpreting these results it should be recalled that all regressions control for political partisanship, that is, individuals' self-placement on the left-right scale. The finding that, through both the direct and indirect channels, endorsement of individual-focused moral foundations is more important for climate-friendly behavior than is endorsement of group-focused moral foundations thus should not be confused with the often-found evidence that liberal-progressives (left) display more environmental concern and/or environment-friendly behavior than do conservatives (right).

With respect to the relative importance of individual-focused and group-focused moral foundations, it was noted by Welsch (2020) that it is the character of climate change mitigation as a *global* public good which makes a universalist (individual-focused) morality potentially more relevant to climate-friendly behavior than is a group-focused morality. When this specific feature of climate change mitigation is disregarded, however, the explicitly group-focused Loyalty foundation becomes an important driver of behavior in addition to Care and Fairness (Welsch 2020). The results concerning individual-focused and group-focused morality are thus intuitive in the light of the nature of the climate problem.

The contribution of this study relative to literature that focused on the left-right dichotomy refers not just to the (direct) relationship between moral identity and climate-friendly behavior, but to the relationship between morality and climate-related cognitions. As was seen in the literature review

(subsection 3.3), previous studies on identity-protective cognition focused on identity in terms of the left-right dichotomy, not on morality profiles. While the present paper is consistent with this literature, by finding perceptions of the severity of climate change impacts and the effectiveness of own action to be positively related to a more left-leaning ideological orientation, it finds, on top of this, a positive relationship of those perceptions to individual-focused morality but not to group-focused morality.

With respect to the finding of morality-dependence of cognitions, a word of caution may be in order: The finding bears no implications as to whether cognitions fostered by stronger endorsement of an individual-focused morality are correct or biased. The result just states that people with different moral identities hold different beliefs. If there is a bias (for instance with respect to effectiveness of own action), it is a bias that strengthens the power of individual-focused morality in counter-veiling the free-rider incentives involved in the public good of climate change mitigation — consistent with the role assigned to human morality by evolutionary theory.

5. Conclusion

Evolutionary biologists and cultural anthropologists have come to view human morality as a means to mitigate free-rider problems in the provision of public goods, and moral psychologists have identified a distinct set of universally available moral intuitions, referred to as moral foundations, whose individual-specific endorsement pattern constitutes an individual's moral identity. In addition to influencing behaviors directly, this paper has found moral identity to influence individuals' cognitions, such as to minimize cognitive dissonance between morals and cognitions. To the extent that cognitions are behavior-relevant, this constitutes an indirect channel through which moral identity and behaviors may be related.

This paper has explored how voluntary contributions to the public good of climate change mitigation relate to individuals' moral identity both directly and indirectly, through moral identity's influence on behavior-relevant cognitions. It was found that universalist (individual-focused) moral foundations (Care, Fairness, Liberty) influence climate friendly behavior more strongly than do group-focused moral foundations (Loyalty, Authority, Sanctity). While individual-focused moral foundations

foster the cognitions that climate change impacts are bad and own action is effective in reducing climate change, the influence of the group-focused moral foundations is more ambiguous. Indeed, the cognition that climate change is bad was found to be *negatively* related to endorsement of the Authority and Sanctity foundations. The stronger influence of individual-focused as opposed to group-focused morality is consistent with the character of climate change mitigation as a *global* public good, that is, one whose benefits are not restricted to a specific group (such as family, neighborhood, region or nation).

Given that individuals' moral identity is largely fixed from the beginning of adulthood, the finding of identity-dependence of climate change cognitions may explain the persistent cognitive divide typically found in public debates concerning the issue even in the face of mounting scientific evidence on the causes and impacts of climate change.

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APPENDIX I: Key Questions from ESS Round 8

Climate-friendly behavior:

Buy Efficient Appliances: “If you were to buy a large electrical appliance for your home, how likely is it that you would buy one of the most energy efficient ones? 0 Not at all likely; ...; 10 Extremely likely.”

Reduce Energy Use: “There are some things that can be done to reduce energy use, such as switching off appliances that are not being used, walking for short journeys, or only using the heating or air conditioning when really needed. In your daily life, how often do you do things to reduce your energy use? 1 Never; ...; 6 Always.”

Behavior-relevant cognitions:

Climate Change Bad: “How good or bad do you think the impact of climate change will be on people across the world? 0 Extremely bad; ...; 10 Extremely good.” (Reverted for empirical analysis.)

Own Action Effective: “How likely do you think it is that limiting your own energy use would help reduce climate change? 0 Not at all likely; ...; 10 Extremely Likely:”

Moral foundations:

“Now I will briefly describe some people. Please tell me how much each person is or is not like you: 1 Very much like me; ...; 6 Not at all like me.” (Reverted for empirical analysis.)

Care: “It is very important to her/him to help the people around her/him. She/he wants to care for their wellbeing.”

Fairness: “She/he thinks it is important that every person in the world should be treated equally. She/he believes everyone should have equal opportunities in life.”

Liberty: “It is important to her/him to make her/his own decisions about what she/he does. She/he likes to be free and not depend on others.”

Loyalty: “It is important to her/him to be loyal to her/his friends. She/he wants to devote herself/himself to people close to her/him.”

Authority: “She/he believes that people should do what they’re told. She/he thinks that people should follow rules at all times, even when no-one is watching.”

Sanctity: “Tradition is important to her/him. She/he tries to follow the customs handed down by her/his religion or her/his family.”

APPENDIX II: Proof of Predictions 1A and 1B

Substituting equations (1A.ii) and (1A.iii) into (1A.i), setting the derivative with respect to M_i equal to zero (first-order condition), invoking symmetry ($\sum_j M_j = nM_i$) and rearranging yields the utility-maximizing ratio of mitigation and consumption:

$$\frac{M_i}{C_i} = \left(\frac{\beta e^\sigma}{\alpha k} \right)^{\frac{1}{1-\sigma}} =: A$$

The partial derivatives with respect to β , e and γ are positive whereas the derivatives with respect to n and k are negative. Moreover, the derivatives with respect to β and e are decreasing in n whereas the derivative with respect to γ is independent of n .

Writing $M_i = A \cdot C_i = A(Y_i - kM_i) = \left(\frac{A}{1+kA} \right) Y_i$ shows that M_i is increasing in Y_i . Moreover, invoking the quotient rule shows that the signs of the derivatives of A with respect to β , e , γ , n and k apply to the respective derivatives of M_i . This establishes Prediction 1A.

Following the same steps as in Model A, the utility maximizing ratio of energy to non-energy consumption is given by:

$$\frac{E_i}{N_i} = \left(\frac{\alpha_E \beta e^\sigma}{\alpha_N p} \right)^{\frac{1}{1-\sigma}} =: B$$

The partial derivatives with respect to β , e , γ and p are negative whereas the derivative with respect to n is positive. Moreover, the derivatives with respect to β and e are decreasing in n whereas the derivative with respect to γ is independent of n .

Writing $E_i = B \cdot N_i = B(Y_i - pE_i) = \left(\frac{B}{1+pA} \right) Y_i$ shows that energy consumption, E_i , is increasing in Y_i . Moreover, invoking the quotient rule shows that the signs of the derivatives of B with respect to β , e , γ ,

n and p apply to the respective derivatives of E_i . Observing that energy saving is the negative of energy consumption establishes Prediction 1B.

Zuletzt erschienen /previous publications:

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