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ORIGINAL RESEARCH REPORT

Personality Trait Effects on Green Household Installations

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Large, one-time investments in green energy installations effectively reduce domestic energy use and greenhouse gas emissions. Despite long-term economic benefits for households, the rate of green investments often remains moderate unless supported by financial subsidies. Beyond financial considerations, green investments may also be driven by individual psychological factors. The current study uses data from the German Socio-Economic Panel (N = 3,468) to analyse whether the household decision to invest in green energy installations is linked to the Big Five personality traits. Personality traits and domestic investments in solar and other alternative energy systems had weak indirect associations through environmental concern but not through risk preferences. Openness to Experience and Neuroticism showed a weak positive relationship with green energy installations through the environmental concern channel, whereas Extraversion had a weak negative link. Based on these findings, persuasive messaging for green investments may be more effective when it focuses on environmental concern rather than reduced risk in countries like Germany, where long-standing financial subsidies decreased the risk in green investments.

Keywords: green investment; personality trait; risk preference; environmental concern; energy use

Introduction

In Germany, households accounted for a quarter of all energy use in 2015, and most energy for residential use was generated from fossil fuels (Umwelt Bundesamt, 2017). Population growth, an increasing number of one-person households, and tendency towards bigger living spaces are expected to further increase household energy consumption. Investments in household green energy systems such as solar panels are a potent method for mitigating energy use and fossil fuel consumption. These investments are also profitable in the long term, but the uptake of green and energy-efficient household installations seems to be below of what would be optimal (Allcott & Greenstone, 2012; Hirst & Brown, 1990; Jaffe & Stavins, 1994).

A large literature explains the gap between the economic incentives of green energy installations and lack of behaviour by detailing market failures, including unpriced environmental externalities and lack of information (Allcott & Greenstone, 2012; Gerarden, Newell, & Stavins, 2015). In addition to economic forces, previous literature suggests that green decisions are also related to psychological factors that should be included in green decision-making models (Stern, Janda, et al., 2016). A number of studies found evidence that personality traits are associated with pro-environmental habits such as recycling, using public transportation and conserving energy (Brick & Lewis, 2016; Markowitz, Goldberg, Ashton, & Lee, 2012; Milfont & Sibley, 2012). Despite the importance of personality in pro-environmental behaviours, there is little evidence whether any personality traits are associated with high-cost green investments. Green investments are rare and costly, unlike pro-environmental habits. Therefore, the causes of green investments may be distinct from low-cost habits.

The article represents two main advances. First, unlike most previous work in this area, it uses large-scale, nationally representative survey data to rigorously model associations with investments in green energy. Second, we present the first study of how personality traits are linked to domestic green investments in Germany, which enacted early and large financial subsidies for generating electricity from renewable energy resources.

Individual differences

Environmentally relevant behaviour is caused not just by price signals, but also individual differences, beliefs and experiences (Stern, Sovacool, & Dietz, 2016). Frequent, low-difficulty pro-environmental behaviours are related to personality traits (Brick & Lewis, 2016), values (Stern, 2000) and political ideology in the United States (Gromet, Kunreuther, & Larrick, 2013). Whether individuals adopt expensive, single-time installations for renewable

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energy or energy efficiency is linked to heterogeneity in demographics, preferences and habits (Gerarden et al., 2015). The adoption of green installations is associated with education and age (Hamilton et al., 2014; Mills & Schleich, 2012), differences in discounting behaviour (Newell & Siikamäki, 2014) and pro-environmental habits (e.g. energy and water conservation) (Ramos, Labandeira, & Löschel, 2015). We extend these findings to green household installations by focusing on personality trait differences.

Personality traits are one possibility to differentiate between individuals since they represent "consistent patterns of thoughts, feelings, or actions that distinguish people from one another" (Johnson, 1997). They can guide life outcomes in health, relationships, social status (Caspi, Roberts, & Shiner, 2005) and economic outcomes including employment status, income and household allocation of wealth (Brown & Taylor, 2014; Fletcher, 2013; Gherzi, Egan, Stewart, Haisley, & Ayton, 2014).

A widely used taxonomy for measuring personality traits is the "Big Five", which describes five dimensions of traits: Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism (John & Srivastava, 1999). Openness to Experience is characterised by flexible, abstract thinking and an appreciation for aesthetics. Conscientiousness represents diligence, planning and a sense of duty. Extraversion is energetic engagement with a diversity of activities including social interaction. Agreeableness is valuing interpersonal harmony, and Neuroticism is the tendency to experience negative emotions such as anxiety and sadness. Openness and Conscientiousness are the Big Five personality factors that appear most associated with pro-environmental behaviour (Hirsh, 2010). However, most previous research focused on low-cost behaviours or combined low- and high-cost behaviours, and most environmental psychology research has been restricted to the United States (Gifford & Nilsson, 2014). It is unknown whether personality is related to expensive green installations, or whether those effects generalise outside of the United States.

The only study of personality traits on expensive and infrequent green investments was reported by Busic-Sontic, Czap and Fuerst (2017). They found mediating effects of the Big Five traits through risk preferences and environmental concern on domestic solar and wind energy system installations in the UK. Openness and Extraversion were positively associated with the probability of adopting the systems through risk preferences, whereas Agreeableness and Neuroticism showed a negative link. Openness and Extraversion further showed a positive correlation with green installations as mediated through environmental concern.

Cross-cultural research is necessary to build accurate models of environmental attitudes and behaviour. The current study extends previous findings from the UK (Busic-Sontic et al., 2017) to a nationally representative household sample in Germany. Germany is distinct from the UK in part due to high green energy system penetration, particularly of solar panel installations. In 1991, Germany was also the first country where the government offered fixed-unit prices for selling electricity from alternative energy resources to the grid (Bundesgesetzblatt, 1990); the UK only initiated a similar scheme in 2010 (DECC, 2015). Identifying behavioural differences in such different settings could help inform interventions (e.g. public messaging) aimed at increasing green household installations. In markets similar to Germany with a long history of policy programmes to boost green household installations, psychological factors such as personality traits might be less associated with behaviour compared to countries that introduced similar programmes later (e.g. the UK).

Mediation of Big Five personality traits

We predict green investment decisions using an agent-based model (Busic-Sontic et al., 2017). The model describes energy efficiency and green investment outcomes from the individual point of view and tests whether each of the Big Five traits relates to the decision to invest in green energy installations directly and indirectly through risk preferences and environmental concern (see **Figure 1**).

Investing in relatively uncommon green technology such as solar panels involves uncertainty and risk. These installations cannot easily be removed, the technology can be new and unfamiliar, and the effectiveness and profitability of the installation are uncertain (Epper, Fehr-Duda, & Schubert, 2011; Linares & Labandeira, 2010; Ryan, Selmet, & Aasrud, 2012). Households might further require a loan to finance the installation, resulting in a loss of financial self-control. Higher preferences for risk should therefore facilitate the decision to adopt green energy technology.

Pro-environmental attitudes and environmental concern also facilitate pro-environmental decisions (Stern, 1999). For example, even if a green technology investment has a lower expected profitability compared to a stock purchase, pro-environmental attitudes may motivate the green investment.

Below, we summarise the existing evidence for associations of the Big Five traits with risk preferences and environmental concern, and then provide our hypotheses.

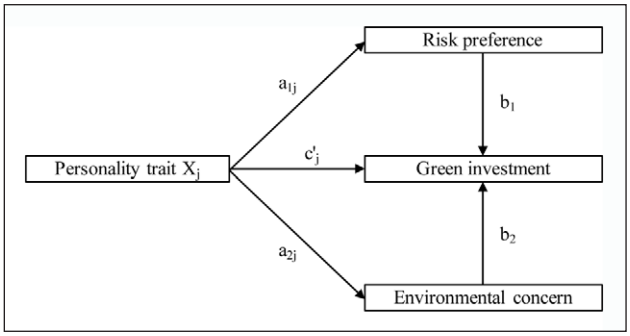

Figure 1: Big Five mediation.
Note: Model of the Big Five traits (X) mediation through risk preference and environmental concern on green investment with j = {Openness to Experience, Conscientiousness, Extraversion, Agreeableness, Neuroticism}.

Openness to Experience (O). Individuals high on O tend to be open-minded. This includes a readiness to question one's values and those of the authorities, and this requires an ability to confront uncertain situations and oppose the status quo. Open individuals also take more risks (Brown & Taylor, 2014; Lee, Deck, Reyes, & Rosen, 2008; Nicholson, Soane, Fenton-O'Creevy, Mark, & Willman, 2005). These characteristics suggest that high-O individuals may be more likely to recognise and be concerned about adverse climate change, and this is consistent with findings that O is positively associated with environmental concern (Brick & Lewis, 2016; Hilbig, Zettler, Moshagen, & Heydasch, 2013; Markowitz et al., 2012).

Conscientiousness (C). C is associated with self-discipline, striving for achievement and belief in one's competence. Conscientious individuals are less likely to take on debts (Lee et al., 2008) or take other financial risks (Nicholson et al., 2005), perhaps because of losing financial self-control. High C is positively associated with environmental concern (Hilbig et al., 2013; Hirsh, 2010; Markowitz et al., 2012). This relationship can be attributed to the tendency of conscientious people to act dutifully, including in the environmental context by striving to act consistently with pro-environmental values (Swami, Chamorro-Premuzic, Snelgar, & Furnham, 2010).

Extraversion (E). Individuals high on E tend to be assertive, energetic, optimistic and more tolerant of risk (Lee et al., 2008; Nicholson et al., 2005). E is unrelated or weakly related to environmental concern (Hirsh, 2010; Markowitz et al., 2012).

Agreeableness (A). Agreeable people are more likely to care about others and to cooperate, whereas individuals low in A are more egocentric, self-centred and are more willing to take risks. Low-A risk-taking appears related to overconfidence (Borghans, Heckman, Golsteyn, & Meijers, 2009; Lee et al., 2008; Nicholson et al., 2005).

Agreeable people consider how their behaviours affect other people, and therefore high-A individuals might also care more about environmental damage. Pro-environmental attitudes and behaviour are not only beneficial for the environment but also may improve the living conditions of others. Consistent with this view, high A is positively related to environmental concern (Hirsh, 2010; Swami et al., 2010).

Neuroticism (N). People high on N try to avoid situations where outcomes are uncertain, whereas individuals low on N are more confident, resilient, and become less anxious or upset in stressful situations. High-N individuals prefer lower risk (Borghans et al., 2009; Lee et al., 2008; Nicholson et al., 2005). The relationship between N and environmental concern is less clear: results include zero, negative and positive relationships (Brick & Lewis, 2016; Hirsh, 2010; Markowitz et al., 2012).

Based on the above evidence, we settled the following hypotheses prior to data analysis for how each trait would be associated with risk preferences, environmental concern and green household installations:

H_{1R}: Openness to Experience (O) will be positively related to green investments through a positive association between O and risk preferences.

H_{2R}: Conscientiousness (C) will be negatively related to green investments through a negative association between C and risk preferences.

H_{3R}: Extraversion (E) will be positively related to green investments through a positive association between E and risk preferences.

H_{4R}: Agreeableness (A) will be negatively related to green investments through a negative association between A and risk preferences.

H_{5R}: Neuroticism (N) will be negatively related to green investments through a negative association between N and risk preferences.

H_{1EC}: Openness to Experience (O) will be positively related to green investments through a positive association between O and environmental concern.

H_{2EC}: Conscientiousness (C) will be positively related to green investments through a positive association between C and environmental concern.

H_{3EC}: Extraversion (E) will have no association with green investments through environmental concern.

H_{4EC}: Agreeableness (A) will be positively related to green investments through a positive association between A and environmental concern.

H_{5EC}: Neuroticism (N) will have no association with green investments through environmental concern.

Methods

We report how we determined our sample size, all data exclusions and all measures in the study. We tested the hypotheses with the German Socio-Economic Panel study (SOEP), an annual and geographically representative survey of 12,000 German households that gathers socio-demographic, financial and other household information (SOEP, 2014; Wagner, Frick, & Schupp, 2007). All items were translated from German by the SOEP.

Solar energy and other alternative systems. The dependent variable was whether households had a solar energy or other alternative energy installation in 2013. Only homeowners were included because renters often lack the control and incentives for major building upgrades.

Personality traits. The survey measured the Big Five personality traits for the head of household and separately for their partner: Openness to Experience (O), Conscientiousness (C), Extraversion (E), Agreeableness (A) and Neuroticism (N). 465 partner households did not contain partner information and were therefore excluded prior to the analysis.

Comprehensive panel data studies as the German SOEP often face a trade-off between presenting longer and more sophisticated questionnaires and collecting lower quality information due to refusal to participate or careless responses. Brief measures of personality traits are applied due to their ease of use but they can underestimate the relationships between personality traits and behaviour compared to the longer measures (Credé, Harms, Niehorster, & Gaye-Valentine, 2012). The personality traits in this study were assessed by self-report questionnaire using a 15-item version of the Big Five Inventory (BFI-S) based on the original 44-item Big Five Inventory (Hahn, Gottschling, & Spinath, 2012). Participants rated the

statements on a 7-point Likert-type scale ranging from 1 (*does not apply to me at all*) to 7 (*applies to me perfectly*). Three items assessed each personality trait, and the internal consistency of the measures was poor (Cronbach's α = .61, .58, .66, .49, .64, for Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism, respectively).

The survey included an item measuring whether the respondent or their partner had the last word in household financial decisions. We used the trait ratings from the person with the last word, and in the case of the respondent saying both people were equally involved in decisions, we averaged the traits of the respondent and partner (last-word model). Averaging personality traits as a method to map individual-level variables to household outcomes was similarly used in previous studies (e.g. Brown & Taylor, 2014). To test the robustness of the last-word model, we ran a second analysis assuming that partners in all non-individual households have equal word in the decisions by averaging the traits of the respondent and partner for all households (collective model).

Risk preferences. Individuals were asked one question about their personal willingness to take risks: "How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?" Respondents rated their willingness on a 11-point Likert-type scale ranging from 0 (*not at all willing to take risks*) to 10 (*very willing to take risks*).

Environmental concern. Environmental concern was measured with one item: "What is your attitude toward environmental protection? Are you concerned about it?" Participants responded on a 3-point Likert-type scale of 1 (*very concerned*), 2 (*somewhat concerned*), or 3 (*not concerned at all*). We reversed the answers to create a measure with higher scores indicating greater environmental concern.

Control variables. Based on known covariates for household energy use in the green investment literature, we controlled for age, education, gender, number of children in a household and household income per member. Households with younger and more educated members are more likely to adopt energy-efficient technology (household appliances such as refrigerators and dish washers) (Mills & Schleich, 2012), possibly because of the longer return period of energy savings for younger members and better ability to predict future operational costs by more educated individuals (Di Maria, Ferreira, & Lazarova, 2010). Women report more pro-environmental behaviour than men (Zelezny, Chua, & Aldrich, 2000). The number of children in a household and income are positively associated with adopting energy efficiency measures, perhaps because of the higher energy and comfort necessities of households with children and higher costs of energy-efficient technology, respectively (Ramos et al., 2015).

We also controlled for the type of building and different solar irradiance levels across Germany by taking the annual sunshine duration for each state averaged from 1980–2013, provided by the Deutscher Wetterdienst (DWD, 2017). Buildings with multiple housing units or unfavourable roof conditions (e.g. high-rise) and shorter sunshine durations might impede green investments such as solar panel installations.

Table 1 presents the summary statistics for the last-word model. There were no meaningful differences between the last-word and collective model, mainly because 83% of partner households responded that both partners have equal say in financial decisions (see Table A.1 in Appendix A).

The Pearson correlations between the variables are presented in **Table 2**. Except for a weak negative correlation with Extraversion and Agreeableness, the coefficients did not suggest associations between green investment and the Big Five personality traits. The second column shows that building type had the strongest association with behaviour, such that buildings with more housing units reported less green investment.

Next, we ran a multiple mediator bootstrapping model according to Preacher and Hayes (2008) using Structural Equation Modelling (SEM) (see **Figure 1**). For each household, the total effect of personality trait X_j on green investment was decomposed into the direct effect c'_j and the indirect effects of X_j on green investment via the mediators of risk preference and environmental concern, with j representing Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism. The coefficients a_{1j} and a_{2j} describe the effects of personality trait X_j on the mediators, whereas paths b_1 and b_2 represent the effects of the mediators on green investment, respectively. The five personality traits were entered jointly into the equation system together with the control variables.

Because green investment is a binary outcome, the standard assumption in SEM of joint normality of the observed variables does not apply. By using maximum likelihood, the coefficients were therefore estimated conditional on the explanatory variables as given, without assuming normally distributed variables (StataCorp, 2015).

Similarly, not assuming any specific distributions of the estimated coefficients we tested for significance of the coefficients by applying bootstrapped confidence intervals with 5,000 replications (Preacher & Hayes, 2008). We used standardised values for the personality traits, risk preferences, environmental concern and the control variables to allow easier comparison of the path coefficients since the observations had different scales. The analysis scripts (Stata) are available at https://osf.io/ra9ew.

Results

The mediation effects of the Big Five personality traits on household green installations in Germany are presented in **Table 3**.

In this setting, there was no evidence that Big Five traits were linked to installation behaviour mediated by risk preferences. As seen in column two of **Table 4**, this lack of effects was likely due to the absence of association between risk preferences and green investments, even though the Big Five had associations with risk preferences (see column three). However, environmental concern was positively associated with green investments. In the

environmental concern channel, high Openness and high Neuroticism households were more likely to have invested in green energy systems, whereas high Extraversion households were less likely to have invested (see **Table 3**). All three mediation effects were very small.

The control variables were all associated with installation behaviour except income (see **Table 4**). More children in a household, being male, higher education and a warmer region were positively linked to the probability of green investments, while age and building type were negatively related. Buildings with more dwelling units (e.g. high-rise) were less likely to have green installations, possibly because more parties are involved in the decision.

The robustness check of the collective model showed a comparable pattern. No significant effects were revealed through the risk preference channel (see Table A.2 in Appendix A). Regarding the environmental concern channel, the effects of Openness to Experience, Extraversion and Neuroticism were again significant and in the same respective directions.

Discussion and policy implications

The goal of this study was to investigate the relationships between personality traits and costly green investments in Germany. Overall, the analyses revealed weak associations between the Big Five personality traits and green investments through environmental concern. Compared to the considerably stronger effects of the control variables, the results suggest that personality (as measured by a brief inventory of the Big Five) is not important for who invests in high-cost green installations in Germany.

In contrast to results from UK households (Busic-Sontic et al., 2017), the current study found no mediation of the Big Five on green investments through risk preferences. The two countries' policy landscapes for renewable energy may help explain the difference. In 1991, Germany introduced the first feed-in tariff (FIT) scheme for green electricity in the world (Bundesgesetzblatt, 1990), which was later replaced and extended with a series of Renewable Energy Source Acts (Bundesgesetzblatt, 2000). The programmes, some of which guarantee FIT payments for up to 20 years, reduced the risks of green energy investments to households. This reduction in risk may have caused individual differences in risk preferences to be less associated with green energy investment decisions. The UK government, on the other hand, introduced a similar FIT scheme only in April 2010 (DECC, 2015). Because of the relatively late launch of the UK scheme compared to Germany, risk considerations in green investment decisions may be of greater importance in the UK, which could result in fewer households with low risk preferences making these investments. That is, the longer-lasting subsidy programme in Germany may have decoupled the associations between green investment and personality traits through risk preferences.

Openness and Extraversion were mediated through environmental concern, consistent with the UK results. The positive link between Openness and green investment through the environmental concern channel is supported

Table 1: Summary statistics.

	N	*M*[a]/%	*SD*[b]	Min	Max
Dependent variable					
Green investment	3,468				
Yes	639	18.43%			
No	2,829	81.57%			
Personality traits					
Openness to Experience	3,468	4.59	1.02	1	7
Conscientiousness	3,468	5.92	0.76	1.67	7
Extraversion	3,468	4.82	0.90	1	7
Agreeableness	3,468	5.37	0.82	1.33	7
Neuroticism	3,468	3.66	1.02	1	7
Mediators					
Risk preference	3,468	4.40	2.02	0	10
Environmental concern	3,468	2.11	0.55	1	3
Control variables					
Income[c]	3,468	1.62	1.31	0.12	40
Children	3,468	0.35	0.77	0	6
Age	3,468	58.34	13.66	23	97
Gender	3,468	0.50	0.30	0	1
Education[d]	3,468	4.03	1.32	2	6
Solar irradiance[e]	3,468	104.96	4.21	100	112
Building type[f]	3,468	2.78	1.24	1	7

Note: [a]Mean, [b]Standard deviation, [c]1,000 EUR/month/household member, [d]Highest education according to the ISCED-1997-classification (general elementary to higher education), [e]Annual sunshine duration averaged from 1980 to 2013 relative to the state with the lowest sunshine duration (= 100), [f]1 (*farm house*), 2 (*1–2 family house*), 3 (*1–2 family rowhouse*), 4 (*apartment in 3–4 unit building*), 5 (*apartment in 5–8 unit building*), 6 (*apartment in 9+ unit building*), 7 (*high-rise*).

Table 2: Correlation matrix.

	Green investment	O	C	E	A	N	Risk preference	Enviro. concern	Income	Children	Age	Gender	Education	Solar irradiance	Building type
Green investment	1.00														
O[a]	−.01	1.00													
C[b]	−.03	.15*	1.00												
E[c]	−.04*	.36*	.21*	1.00											
A[d]	−.04*	.13*	.34*	.09*	1.00										
N[e]	−.01	−.06*	−.11*	−.19*	−.17*	1.00									
Risk preference	.04*	.28*	.00	.19*	−.08*	−.19*	1.00								
Enviro. concern	.03	.12*	.03	−.01	.02	.12*	.01	1.00							
Income	−.01	.11*	−.05*	.02	−.02	−.11*	.08*	−.04*	1.00						
Children	.12*	−.04*	−.04*	.01	−.03	−.03	.02	.01	−.22*	1.00					
Age	−.12*	.03	.04*	−.04*	.10*	.04*	−.08*	.00	.08*	−.51*	1.00				
Gender	.08*	−.03	−.08*	−.07*	−.13*	−.16*	.17*	−.08*	.07*	.02	−.09*	1.00			
Education	.10*	.20*	−.10*	−.02	−.03	−.11*	.10*	.03	.31*	.06*	−.08*	.13*	1.00		
Solar irradiance	.10*	−.03	.03	−.05*	−.01	.02	−.04*	−.03	−.07*	−.02	.00	.00	.01	1.00	
Building type	−.20*	.05*	−.02	.01	.02	.02	.00	.04*	.04*	−.07*	−.01	−.03	.01	−.01	1.00

*$p < .05$

Note: [a]Openness to Experience, [b]Conscientiousness, [c]Extraversion, [d]Agreeableness, [e]Neuroticism.

Table 3: Mediation of the Big Five personality traits.

Log-odds	R	EC	R+EC	Direct	Total
Openness to	.01	**.02***	**.03***	–.02	.01
Experience	[–.01, .04]	[.01, .03]	[.00, .06]	[–.12, .09]	[–.09, .11]
Conscientiousness	.00	.00	.00	–.02	–.02
	[–.01, .00]	[.00, .01]	[.00, .01]	[–.12, .08]	[–.11, .08]
Extraversion	.00	**–.01***	.00	–.07	–.07
	[.00, .02]	[–.02, .00]	[–.01, .01]	[–.17, .03]	[–.17, .03]
Agreeableness	–.01	.00	.00	–.03	–.04
	[–.02, .00]	[.00, .01]	[–.02, .01]	[–.13, .07]	[–.13, .07]
Neuroticism	–.01	**.02***	.01	.01	.02
	[–.02, .01]	[.00, .03]	[–.01, .03]	[–.09, .11]	[–.08, .12]

*$p < .05$.

Note: This table presents the mediation effects through risk preference (R), environmental concern (EC) and the direct and total effects in log-odds for each personality trait on solar energy and other alternative energy systems ($N = 3{,}468$). Bias-corrected 95% confidence intervals from 5,000 bootstrap samples are reported under each of the effects.

Table 4: Regressions of the mediation model for green investment.

	Green investment[a]	Risk preference	Environmental concern
Openness to Experience	–.02	.25***	.14***
Conscientiousness	–.02	–.02	.03
Extraversion	–.07	.10***	–.05**
Agreeableness	–.03	–.11***	.01
Neuroticism	.01	–.15***	.12***
Income	.00	.02	–.05***
Children	.10**	–.01	.00
Age	–.26***	–.06***	–.01
Gender	.57***	.45***	–.18***
Education	.24***	.00	.04**
Solar irradiance	.27***	–.02	–.04**
Building type	–.76***	.00	.03*
Risk preference	.05		
Environmental concern	.13***		
N	3,468	3,468	3,468

Note: [a]Log-odds, *$p < .10$, **$p < .05$, ***$p < .01$.

by previous findings that found consistent positive relationships between Openness and environmental concern (Hilbig et al., 2013; Hirsh, 2010; Markowitz et al., 2012). The negative effect of Extraversion through environmental concern was contrary to a previous finding that extraverted individuals performed more daily pro-environmental behaviours in the United States (strong direct and weak indirect effects) (Brick & Lewis, 2016). The current study has a larger and representative sample and therefore may reveal a more reliable estimate. Also, cultural differences may explain a weaker link in Germany compared to the United States in how environmental concern drives pro-environmental behaviour, because the association between pro-environmental concern and behaviours varies widely between countries and is highest in the US (Eom, Kim, Sherman, & Ishii, 2016). Another possible explanation is that introverted individuals are more receptive specifically to large-scale green investments suggested by governments because these individuals are more submissive.

In contrast to the UK data, Neuroticism was positively associated with green investment through the environmental concern channel, possibly because individuals high on Neuroticism perceive more threat from climate change (Milfont, Milojev, Greaves, & Sibley, 2015).

The effects of the Big Five traits through the environmental concern channel were smaller in Germany than in the UK. This finding may reflect a restricted association between personality and green investment because of the heavy financial subsidy programmes.

In countries at mature stages of green technology diffusion such as Germany, our results suggest that policy programmes might increase their effectiveness by engaging with individuals through the environmental concern

rather than risk preference channel. For individuals high on Neuroticism, for example, stressing the adverse impacts of climate change through environmental concern could result in more green investment than highlighting financial gains. Messaging that targets risk preferences might be only effective at the beginning of the diffusion of green technologies when risks are high. One cost-saving possibility is to reduce large financial subsidies, such as the FIT, and instead offer alternative risk reductions schemes, such as risk-sharing contracts between government and households. For example, opportunity costs due to decreasing energy prices of conventional energy resources (e.g. fossil fuels) could be shared through payments by governments to households depending on the energy price reductions. The extensive portfolio of a government allows diversification and hedging of the energy price risk so that such subsidies would cost national budgets less than predetermined fixed payments.

Individuals might also be directed towards green investments by interventions to change personality. Despite the common idea that personality traits are fixed, there is increasing evidence suggesting that personality traits can change, especially in certain periods of life (Hill, Turiano, Mroczek, & Roberts, 2012; Mõttus, Johnson, & Deary, 2012; Roberts, Walton, & Viechtbauer, 2006). Roberts et al. (2017) observed in a meta-analysis of clinical and nonclinical interventions that social skills training and cognitive–behavioural therapy, among other interventions, can cause lasting changes in some personality traits. This finding could suggest a route to change people's behaviour towards green outcomes by targeting the development of personality traits during specific life periods. To illustrate, programmes to improve cognitive functions (e.g. inductive reasoning) were found to increase Openness to Experience for older populations (Jackson, Hill, Payne, Roberts, & Stine-Morrow, 2012). Since Openness to Experience tends to decrease in old age (Roberts et al., 2006), such interventions could potentially increase the motivation for green behaviour in the elderly.

Limitations and future research

There are several design aspects that may have contributed to the small effect sizes for personality. First, the survey in this study used brief measures of personality traits and mediators. When time and resources are limited, personality researchers are often confronted with the choice between a brief or no measure of personality at all (Gosling, Rentfrow, & Swann, 2003). For example, the longest instrument of the Big Five with 240 items (Costa & MacCrae, 1992) takes approximately 45 minutes to complete and is possibly impractical for surveys with multiple focuses, such as panel studies.

The brief 15-item version of the Big Five Inventory in this study revealed a low reliability of the personality trait dimensions as assessed by Cronbach's alphas. Because low score reliabilities may obscure true relationships (Credé et al., 2012), the short personality inventory might be a reason for the weak link found between personality traits and green investments. Futures studies could use more items per trait to assess whether the weak associations are indeed related to reliability and validity issues of the personality measures, or instead to the presumption that historically large subsidies for green installations in Germany (particularly solar panels) may have obscured more subtle associations with personality.

Similarly, the validity of the single-item measures of risk preference and environmental concern could be improved by the use of multiple items, which could reduce measurement error and therefore increase the validity of the variables (Credé et al., 2012). This would also allow to test for internal consistency of reliability of these measures which cannot be computed with single-item scales.

Second, inferring longitudinal processes from this cross-sectional survey data should be done with caution. The cross-sectional design of the mediation analysis fails to account for causation that may occur throughout time and prior measures of time-varying variables may well have an impact in later periods (Maxwell, Cole, & Mitchell, 2011). The effects of mediators such as risk preference and environmental concern may not unfold immediately on green investments. Because the cross-sectional mediation estimates do not account for time-dependent impacts, they may be biased estimates of longitudinal parameters and should not be taken as indicators for longitudinal mediation (Maxwell & Cole, 2007; Maxwell et al., 2011). Future work might assess whether a longitudinal mediation model is feasible with a binary outcome that is generally not reversed, such as solar panel installation.

Finally, personality traits are only one way to test for individual differences. Other factors excluded from this report such as personal values and norms may also be linked to green investments (Jansson, Marell, & Nordlund, 2010; Mirosa, Lawson, & Gnoth, 2013).

Conclusion

This work furthers the understanding of how personality traits relate to green household installations by using a nationally representative sample in Germany and measuring one-time, difficult actions that reduce environmental impact. Expensive household installations likely have different causes than the recurring, low-cost pro-environmental behaviours that are typically studied. The results suggest a weak positive mediation of Openness to Experience and Neuroticism and a weak negative mediation of Extraversion on green investment, both meditated through environmental concern. Given the small magnitude of the observed mediation effects and Germany's historically large subsidies for green installations, future studies might investigate the sensitivity of personality trait effects to financial subsidies throughout time, and include other beliefs, preferences, or motivations that may drive green household investments.

Data Accessibility Statement

Due to legal restrictions, access to the data can be only provided to registered users with the Deutsches Institut für Wirtschaftsforschung (DWI) Berlin, who signed a data distribution contract for the German Socio-Economic

Panel study (SOEP). The scientific use of the data is free of charge and can be requested at http://www.diw.de/en/diw_02.c.238238.en/conditions.html. All the participant data can be found in the SOEP data version soep.v30 (https://doi.org/10.5684/soep.v30). The analysis scripts are available at https://osf.io/ra9ew.

Additional File

The additional file for this article can be found as follows:

- **Appendix A.** Collective model. DOI: https://doi.org/10.1525/collabra.120.s1

Competing Interests

The authors have no competing interests to declare.

Author Contributions

- Contributed to conception and design: AB-S
- Contributed to acquisition and analysis of data: AB-S
- Contributed to interpretation of results: AB-S, CB
- Drafted and/or revised the article: AB-S, CB
- Approved the submitted version for publication: AB-S, CB

References

Allcott, H., & **Greenstone, M.** (2012). Is there an energy efficiency gap? *The Journal of Economic Perspectives*, *26*(1), 3–28. DOI: https://doi.org/10.1257/jep.26.1.3

Borghans, L., Heckman, J. J., Golsteyn, B. H. H., & **Meijers, H.** (2009). Gender differences in risk aversion and ambiguity aversion. *Journal of the European Economic Association*, *7*(2–3), 649–658. DOI: https://doi.org/10.1162/JEEA.2009.7.2-3.649

Brick, C., & **Lewis, G. J.** (2016). Unearthing the "green" personality: Core traits predict environmentally friendly behavior. *Environment and Behavior*, *48*(5), 635–658. DOI: https://doi.org/10.1177/0013916514554695

Brown, S., & **Taylor, K.** (2014). Household finances and the 'Big Five' personality traits. *Journal of Economic Psychology*, *45*, 197–212. DOI: https://doi.org/10.1016/j.joep.2014.10.006

Bundesgesetzblatt. (1990). *Gesetz über die Einspeisung von Strom aus erneuerbaren Energien in das öffentliche Netz (Stromeinspeisungsgesetz)* (S. 2633). Bonn: Bundesgesetzblatt.

Bundesgesetzblatt. (2000). *Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz – EEG) sowie zur Änderung des Energiewirtschaftsgesetzes und des Mineralölsteuergesetzes* (Teil I Nr. 13 S. 305). Bonn: Bundesgesetzblatt.

Busic-Sontic, A., Czap, N. V., & **Fuerst, F.** (2017). The role of personality traits in green decision-making. *Journal of Economic Psychology*. DOI: https://doi.org/10.1016/j.joep.2017.06.012

Caspi, A., Roberts, B. W., & **Shiner, R. L.** (2005). Personality development: Stability and change. *Annual Review of Psychology*, *56*(1), 453–484. DOI: https://doi.org/10.1146/annurev.psych.55.090902.141913

Costa, P. T., & **MacCrae, R. R.** (1992). *Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEO FFI): Professional manual*. Odessa, FL: Psychological Assessment Resources.

Credé, M., Harms, P., Niehorster, S., & **Gaye-Valentine, A.** (2012). An evaluation of the consequences of using short measures of the Big Five personality traits. *Journal of Personality and Social Psychology*, *102*(4), 874–888. DOI: https://doi.org/10.1037/a0027403

DECC. (2015). *Review of the Feed-in Tariffs Scheme*. Department of Energy and Climate Change. Retrieved from: http://www.cibse.org/getmedia/4dc06683-9be1-44bb-b00c-7621fe7e4745/FITs_Review_Government_response.pdf.aspx.

Di Maria, C., Ferreira, S., & **Lazarova, E.** (2010). Shedding Light on the Light Bulb Puzzle: The Role of Attitudes and Perceptions in the Adoption of Energy Efficient Light Bulbs. *Scottish Journal of Political Economy*, *57*(1), 48–67. DOI: https://doi.org/10.1111/j.1467-9485.2009.00506.x

DWD. (2017). DWD Climate Data Center. Retrieved 4 February 2017 from: http://www.dwd.de/DE/leistungen/cdcftp/cdcftp.html.

Eom, K., Kim, H. S., Sherman, D. K., & **Ishii, K.** (2016). Cultural variability in the link between environmental concern and support for environmental action. *Psychological Science*, *27*(10), 1331–1339. DOI: https://doi.org/10.1177/0956797616660078

Epper, T., Fehr-Duda, H., & **Schubert, R.** (2011). *Energy-using durables: The role of time discounting in investment decisions* (Report No. 290417). Swiss Federal Office of Energy.

Fletcher, J. M. (2013). The effects of personality traits on adult labor market outcomes: Evidence from siblings. *Journal of Economic Behavior & Organization*, *89*, 122–135. DOI: https://doi.org/10.1016/j.jebo.2013.02.004

Gerarden, T. D., Newell, R. G., & **Stavins, R. N.** (2015). *Assessing the energy-efficiency gap* (NBER Working Paper No. 20904). National Bureau of Economic Research. Retrieved from: http://www.nber.org/papers/w20904.pdf.

Gherzi, S., Egan, D., Stewart, N., Haisley, E., & **Ayton, P.** (2014). The meerkat effect: Personality and market returns affect investors' portfolio monitoring behaviour. *Journal of Economic Behavior & Organization*, *107(Part B),* 512–526. DOI: https://doi.org/10.1016/j.jebo.2014.07.013

Gifford, R., & **Nilsson, A.** (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology*, *49*(3), 141–157. DOI: https://doi.org/10.1002/ijop.12034

Gosling, S. D., Rentfrow, P. J., & **Swann, W. B.** (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality*, *37*(6), 504–528. DOI: https://doi.org/10.1016/S0092-6566(03)00046-1

Gromet, D. M., Kunreuther, H., & **Larrick, R. P.** (2013). Political ideology affects energy-efficiency attitudes and choices. *Proceedings of the National Academy of Sciences*. DOI: https://doi.org/10.1073/pnas.1218453110

Hahn, E., Gottschling, J., & **Spinath, F. M.** (2012). Short measurements of personality – Validity and reliability of the GSOEP Big Five Inventory (BFI-S). *Journal of Research in Personality*, *46*(3), 355–359. DOI: https://doi.org/10.1016/j.jrp.2012.03.008

Hamilton, I. G., Shipworth, D., Summerfield, A. J., Steadman, P., Oreszczyn, T., & **Lowe, R.** (2014). Uptake of energy efficiency interventions in English dwellings. *Building Research & Information*, *42*(3), 255–275. DOI: https://doi.org/10.1080/09613218.2014.867643

Hilbig, B. E., Zettler, I., Moshagen, M., & **Heydasch, T.** (2013). Tracing the path from personality — via cooperativeness — to conservation. *European Journal of Personality*, *27*(4), 319–327. DOI: https://doi.org/10.1002/per.1856

Hill, P. L., Turiano, N. A., Mroczek, D. K., & **Roberts, B. W.** (2012). Examining Concurrent and Longitudinal Relations Between Personality Traits and Social Well-being in Adulthood. *Social Psychological and Personality Science*, *3*(6), 698–705. DOI: https://doi.org/10.1177/1948550611433888

Hirsh, J. B. (2010). Personality and environmental concern. *Journal of Environmental Psychology*, *30*(2), 245–248. DOI: https://doi.org/10.1016/j.jenvp.2010.01.004

Hirst, E., & **Brown, M.** (1990). Closing the efficiency gap: Barriers to the efficient use of energy. *Resources, Conservation and Recycling*, *3*(4), 267–281. DOI: https://doi.org/10.1016/0921-3449(90)90023-W

Jackson, J. J., Hill, P. L., Payne, B. R., Roberts, B. W., & **Stine-Morrow, E. A. L.** (2012). Can an old dog learn (and want to experience) new tricks? Cognitive training increases openness to experience in older adults. *Psychology and Aging*, *27*(2), 286–292. DOI: https://doi.org/10.1037/a0025918

Jaffe, A. B., & **Stavins, R. N.** (1994). The energy paradox and the diffusion of conservation technology. *Resource and Energy Economics*, *16*(2), 91–122. DOI: https://doi.org/10.1016/0928-7655(94)90001-9

Jansson, J., Marell, A., & **Nordlund, A.** (2010). Green consumer behavior: determinants of curtailment and eco-innovation adoption. *The Journal of Consumer Marketing*, *27*(4), 358–370. DOI: https://doi.org/10.1108/07363761011052396

John, O., & **Srivastava, S.** (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In: Pervin, L., & John, O. (Eds.), *Handbook of Personality: Theory and Research,* 102–138. Guilford Press.

Johnson, J. A. (1997). Chapter 3 – Units of Analysis for the Description and Explanation of Personality. In: *Handbook of Personality Psychology,* 73–93. San Diego: Academic Press. Retrieved from: http://www.sciencedirect.com/science/article/pii/B9780121346454500044.

Lee, J., Deck, C., Reyes, J., & **Rosen, C.** (2008). *Measuring risk attitudes controlling for personality traits* (Working paper No. 0801). Florida International University, Department of Economics.

Linares, P., & **Labandeira, X.** (2010). Energy efficiency: Economics and policy. *Journal of Economic Surveys*, *24*(3), 573–592. DOI: https://doi.org/10.1111/j.1467-6419.2009.00609.x

Markowitz, E. M., Goldberg, L. R., Ashton, M. C., & **Lee, K.** (2012). Profiling the "pro-environmental individual": A personality perspective. *Journal of Personality*, *80*(1), 81–111. DOI: https://doi.org/10.1111/j.1467-6494.2011.00721.x

Maxwell, S. E., & **Cole, D. A.** (2007). Bias in cross-sectional analyses of longitudinal mediation. *Psychological Methods*, *12*(1), 23–44. DOI: https://doi.org/10.1037/1082-989X.12.1.23

Maxwell, S. E., Cole, D. A., & **Mitchell, M. A.** (2011). Bias in Cross-Sectional Analyses of Longitudinal Mediation: Partial and Complete Mediation Under an Autoregressive Model. *Multivariate Behavioral Research*, *46*(5), 816–841. DOI: https://doi.org/10.1080/00273171.2011.606716

Milfont, T. L., Milojev, P., Greaves, L. M., & **Sibley, C. G.** (2015). Socio-structural and psychological foundations of climate change beliefs. *New Zealand Journal of Psychology*, *44*(1).

Milfont, T. L., & **Sibley, C. G.** (2012). The big five personality traits and environmental engagement: Associations at the individual and societal level. *Journal of Environmental Psychology*, *32*(2), 187–195. DOI: https://doi.org/10.1016/j.jenvp.2011.12.006

Mills, B., & **Schleich, J.** (2012). Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries. *Energy Policy*, *49*, 616–628. DOI: https://doi.org/10.1016/j.enpol.2012.07.008

Mirosa, M., Lawson, R., & **Gnoth, D.** (2013). Linking personal values to energy-efficient behaviors in the home. *Environment and Behavior*, *45*(4), 455–475. DOI: https://doi.org/10.1177/0013916511432332

Mõttus, R., Johnson, W., & **Deary, I. J.** (2012). Personality traits in old age: measurement and rank-order stability and some mean-level change. *Psychology and Aging*, *27*(1), 243–249. DOI: https://doi.org/10.1037/a0023690

Newell, R. G., & **Siikamäki, J.** (2014). Nudging energy efficiency behavior: The role of information labels. *Journal of the Association of Environmental and Resource Economists*, *1*(4), 555–598. DOI: https://doi.org/10.1086/679281

Nicholson, N., Soane, E., Fenton-O'Creevy, M., & **Willman, P.** (2005). Personality and domain-specific risk taking. *Journal of Risk Research*, *8*(2), 157–176. DOI: https://doi.org/10.1080/1366987032000123856

Preacher, K. J., & **Hayes, A. F.** (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879–891. DOI: https://doi.org/10.3758/BRM.40.3.879

Ramos, A., Labandeira, X., & **Löschel, A.** (2015). Pro-environmental households and energy efficiency

in Spain. *Environmental and Resource Economics*, *63*(2), 367–393. DOI: https://doi.org/10.1007/s10640-015-9899-8

Roberts, B. W., Luo, J., Briley, D. A., Chow, P. I., Su, R., & **Hill, P. L.** (2017). A systematic review of personality trait change through intervention. *Psychological Bulletin*, *143*(2), 117–141. DOI: https://doi.org/10.1037/bul0000088

Roberts, B. W., Walton, K. E., & **Viechtbauer, W.** (2006). Patterns of mean-level change in personality traits across the life course: a meta-analysis of longitudinal studies. *Psychological Bulletin*, *132*(1), 1–25. DOI: https://doi.org/10.1037/0033-2909.132.1.1

Ryan, L., Selmet, N., & **Aasrud, A.** (2012). Plugging the energy efficiency gap with climate finance. In *International Energy Agency Insights Series 2012*. Paris: OECD, IEA.

SOEP. (2014). *Data for years 1984–2013* (version 30). Socio-Economic Panel (SOEP). DOI: https://doi.org/10.5684/soep.v30

StataCorp. (2015). *STATA structural equation modeling reference manual. Release 14*. Texas: StataCorp.

Stern, P. C. (1999). Information, incentives, and proenvironmental consumer behavior. *Journal of Consumer Policy*, *22*(4), 461–478. DOI: https://doi.org/10.1023/A:1006211709570

Stern, P. C. (2000). New environmental theories: Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, *56*(3), 407–424. DOI: https://doi.org/10.1111/0022-4537.00175

Stern, P. C., Janda, K. B., Brown, M. A., Steg, L., Vine, E. L., & **Lutzenhiser, L.** (2016). Opportunities and insights for reducing fossil fuel consumption by households and organizations. *Nature Energy*, *1*, 16043. DOI: https://doi.org/10.1038/nenergy.2016.43

Stern, P. C., Sovacool, B. K., & **Dietz, T.** (2016). Towards a science of climate and energy choices. *Nature Climate Change*, *6*(6), 547–555. DOI: https://doi.org/10.1038/nclimate3027

Swami, V., Chamorro-Premuzic, T., Snelgar, R., & **Furnham, A.** (2010). Egoistic, altruistic, and biospheric environmental concerns: A path analytic investigation of their determinants. *Scandinavian Journal of Psychology*, *51*(2), 139–145. DOI: https://doi.org/10.1111/j.1467-9450.2009.00760.x

Umwelt Bundesamt. (2017). Energieverbrauch privater Haushalte. Retrieved 2 April 2017 from: http://www.umweltbundesamt.de/daten/private-haushalte-konsum/energieverbrauch-privater-haushalte.

Wagner, G. G., Frick, J. R., & **Schupp, J.** (2007). The German Socio-Economic Panel study (SOEP): Scope, Evolution and Enhancements. *Schmollers Jahrbuch*, *127*(1), 139–169. DOI: https://doi.org/10.2139/ssrn.1028709

Zelezny, L. C., Chua, P.-P., & **Aldrich, C.** (2000). Elaborating on gender differences in environmentalism. *Journal of Social Issues*, *56*(3), 443–457. DOI: https://doi.org/10.1111/0022-4537.00177

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