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Title: Conceptualising the role of personality traits in making investment decisions: The case of residential energy efficiency

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Conceptualising the role of personality traits in making investment decisions: The case of residential energy efficiency

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Abstract

This paper explores whether differences in individual personality traits may explain why some households decide to undertake an energy efficiency upgrade of their property while others opt to do nothing, even in identical financial circumstances. By using the taxonomy of the Big Five personality traits, we develop a conceptual framework for how personality traits might transmit to household economic decision making in the realm of domestic energy efficiency retrofits. This model can be tested in future empirical analyses which would otherwise be prone to confounding primary (direct) and secondary (mediated) factors impacting upon the retrofit decision. Implications for environmental policy and future research are derived. The novel conception could contribute to shed light on the still highly distinctive energy-efficiency gap in residential markets.

Keywords: Energy efficiency gap, Investment decision, Residential sector, Personality economics, Risk preferences, Environmental beliefs

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Highlights

- The paper sketches the first conceptual framework that operationalises personality for energy-efficient investments in the residential sector.
- The conceptual framework posits that personality is mediated through risk preferences and environmental beliefs.
- The paper provides new perspectives on the improvement of environmental policy and marketing strategies by taking account of personality traits.

1. Introduction

Buildings consume about one third of the global final energy and are responsible for roughly the same share of total carbon emissions, and 75% of the energy consumed by buildings can be attributed to the residential sub-sector (IEA, 2013). There is a broad consensus that the residential buildings offer large potential for curbing energy usage and emissions (Bardhan et al., 2014; Evans et al., 2011). A residential study in England and Wales, for example, showed that cavity wall insulations decreased households' annual gas consumption by approximately 11% (Adan and Fuerst, 2015).

Energy-efficient technologies are an attractive option for reducing energy consumption as they deliver the same level of services in a cleaner, more efficient way without the need to cut down on the consumption of the product they deliver, for example space heating or motorised transport. However, the expected large-scale surge for energy-efficient investments in many domains, including the residential sector, has not been observed. This well-known energy-efficiency paradox or energy-efficiency gap has been studied by many scholars. The majority of explanations identifies market failures as the prime reason (see, for example, Myers, 2014; Phillips, 2012). Some of these market failures are caused by behavioural factors (Allcott and Rogers, 2014) but little research exists on how personality traits relate to energy-efficient investments.

In this paper, we argue that ignoring the impact of individual behaviour and differences in personality traits may bias the estimates of the energy-efficiency gap. The goal of this paper is twofold. First, it states the case for considering personality traits in predicting energy-efficient investments in residential buildings. Second, it provides a simple conceptual framework for understanding how personality traits affect a household's economic decision whether to adopt energy-efficient technology.

This is a novel conceptual contribution to the literature on households' energy-efficient investments. Personality traits have been rarely used in explanations of energy efficiency. The lack of theoretical models incorporating personality traits might be a reason for the observed literature gap. This paper therefore contributes to the energy-efficiency literature by presenting the first theoretical framework for the impact of personality traits on energy-efficient investments for the case of residential build-

ings. To build the conceptual framework, the paper draws on current multi-disciplinary literature on energy efficiency, economic theory and personality psychology. It integrates two robust mediation channels for personality that were found and analysed independently in previous studies: economic preferences and environmental beliefs. In doing so, it starts to fill the existing gap in terms of models that can serve as a basis for analysing the influence of personality traits on energy-efficient investments. This could open avenues for a fuller elaboration of the influence of personality on energy-efficiency measures by stimulating empirical testing in future research.

2. Why Should Personality Traits Matter?

It is well known that the perception of identical situations differs widely across individuals (Allport and Odbert, 1936; Costa and MacCrae, 1992; McCrae and Costa, 2003; Villanueva, 2010). Personality defines how an individual processes events and drives his or her corresponding characteristic behaviour and decisions. For instance, extroverted people may perceive a crowded location as enjoyable while introverts might feel less comfortable. The extroverts may appreciate the conversation and the exchange of ideas, whereas the introverts may be threatened by such surroundings and would prefer to leave. As in the case of such a common-day example, it may be true that personality drives economic decisions, such as investing in energy-efficient technology. Indeed, researchers have showed that personality traits affect investors' behaviour and several economic outcomes, including employment status and wages, households' financial asset allocation, and regional entrepreneurship rates (Gherzi et al., 2014; Fletcher, 2013; Brown and Taylor, 2014; Obschonka et al., 2015).

It might seem intuitive that personality traits can influence decisions but what are the tangible arguments for that link? More specifically, why should personality have an impact on energy-efficient investments? This paper develops three main arguments for these influences.

2.1. Personality and Environmental Behaviour

First, previous theoretical constructs and empirical investigations have demonstrated a link between personality traits and environmental behaviour in general; this suggests

that specific decisions, such as energy-efficient investments, are likely to be affected as well.

According to Stern et al. (1999), personal Values, Beliefs and Norms (VBN) can be grouped as attitudinal factors that guide pro-environmental behaviour ranging from energy-saving measures to energy-efficient purchases. VBN theory explains these links through a chain of causal steps (see Figure 1). The chain starts with broad and stable personal values that influence more focused human beliefs about the environment. In turn, the latter activate personal norms to act pro-environmentally. The middle part of the chain that depict environmental attitudes or environmental concerns (beliefs) are interpreted as the mediation channel. Importantly, the model assumes personal values to be relatively stable and to exert their influence at the beginning of the causal chain.

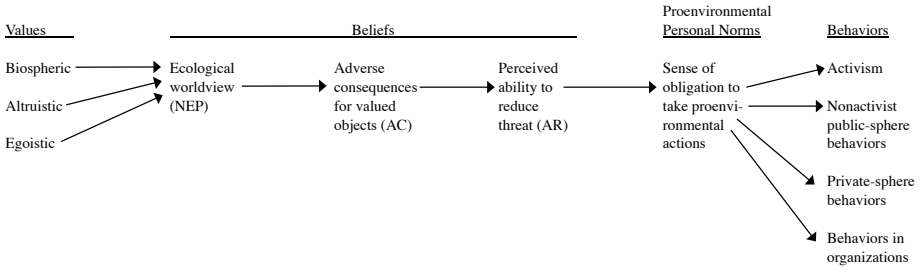

Figure 1: Causal chain of the VBN theory (Stern, 2000)

The chain structure of personal values being one step before attitudes is also proclaimed by personality trait theory (McCrae and Costa Jr, 1999). Personality traits define core personal characteristics that affect how individuals react to stimuli that they encounter. There is evidence that they stay relatively stable over an individual's life cycle (Cobb-Clark and Schurer, 2012). Attitudes, in turn, are seen as characteristic adaptions that result from a nexus of individual essential personality traits and contextual factors such as the political, social and cultural setting (McCrae and Costa Jr, 1999). Accordingly, it should follow that attitudes related to environmental concerns and subsequent environmental action or inaction can be traced back to personality traits.

2.2. Personality and Economic Theory

Second, recent economic theory on personality and economic outcomes also supports the concept that personality traits affect the choice of energy-efficient investments. Researchers are increasingly recognising connections between decision-making theory in economics and personality trait theory in psychology. Both fields address how individuals make decisions and how these lead to specific behaviour outcomes. There is general agreement among economists that they depict two closely-related concepts and that an integration of both could add significant value in explaining economic patterns (Bucciol and Zarri, 2015; Anderson et al., 2011; Ferguson et al., 2011; Borghans et al., 2008; Almlund et al., 2011). Though scholars agree on the potential value-added, clarity needs to be established on how and through which channels personality traits affect economic decisions. Becker et al. (2012) suggest that they exert a direct impact on economic outcomes complementary to economic preferences which include risk, time and social preferences. Bucciol and Zarri (2015) allude that their impact is rather translated through economic preferences. Other researchers suppose that personality traits influence individual's productivity (Borghans et al., 2008; Almlund et al., 2011). For instance, more conscientious persons may produce more income, thus, generating higher utilities compared to other individuals, holding other factors constant.

This work advocates that the integration presaged in these earlier studies should be applied to the question of energy-efficient investments. By representing an economic outcome, such investments depend on individuals' economic preferences. Although there is no agreement among economists in respect to exactly how personality traits influence decision-making processes (Bucciol and Zarri, 2015), this work suggests that, in terms of energy-efficient investments in residential buildings, personality traits are mediated both through economic preferences and environmental beliefs. The causality for the latter was elaborated in section 2.1 above. Why personality traits should impact energy-efficient investments through economic preferences is presented in the following argument.

2.3. Personality and Risk Preferences

Third, energy-efficient investments in residential buildings, as investments, depend on risk and uncertainty preferences and are consequently driven by personality traits.

This third argument is divided into two parts. The first part shows that energy-efficient investments in residential buildings depend on risk preferences, which are core economic preferences. The second part demonstrates that risk preferences are influenced by personality traits. It is concluded that energy-efficient investments in residential buildings depend on personality traits by potentially being mediated through risk preferences.

Before each of the parts can be addressed, it is important to clarify what is encompassed by the term energy-efficient investment. Here, the term defines infrequent installations that require a significant financial outlay but which lead to structural and long-term reductions in energy-usage (Karlin et al., 2014). Adoptions of energy-efficient HVAC (Heating, Ventilating, Air-Conditioning) systems and retrofits such as double-glazed windows, wall insulations, solar panel and other alternative energy installations belong to this categorisation. The returns of these investments depend on the future energy price development. As such, the adoption of energy-efficient technology clearly incorporates an investment component comparable to other financial investments such as stocks or bonds.

The first part of the argument builds on the relationship between energy-efficient investments and risk preferences. Investing in energy-efficient technology is associated with significant ambiguity and risk. The fact that markets for energy-efficient technology are immature is one of the reasons for this (Ryan et al., 2012). The lack of information, and the resulting shortfall in knowledge about the technology, effectiveness and financial profitability among consumers, create a state of ambiguity and a defensive attitude towards investments. The expected efficiency increases may also be uncertain because the technology is new and the experience from comparable energy-efficient projects is rare. Furthermore, the profitability of the investment depends on future energy use and price patterns, which are unknown (Epper et al., 2011; Linares and Labandeira, 2010). Clearly, accepting a certain amount of uncertainty is necessary if one wants to adopt energy-efficient technology in one's home.

The second part demonstrates that an important link exists between personality traits and risk preferences. A sound body of literature in psychology and economics examines the relationships between personality traits and risk-taking. Significant relationship has been found in many different areas ranging from taking part in risky sports, to health-, economic- and financial risks (Fogel and Nehmad, 2009; Magar et al., 2008; Lee et al., 2008; Becker et al., 2012; Anderson et al., 2011; Borghans et al., 2009; Tanaka et al., 2014; Obschonka et al., 2013). Undoubtedly, personality traits influence uncertainty and risk-preferences, and since these latter factors are central to the decision-making process of investing, as shown in the first part of the argument, it should follow that personality traits also show a relationship to the economic outcome of energy-efficient investments in residential buildings.

3. Energy-Efficient Investments in Residential Buildings: Towards a Framework on the Impact of Personality

The following paragraphs present a simple conceptual framework that includes and operationalises personality traits as determinants through two channels of mediation: environmental concern and risk preference. To build the framework, this paper integrates relevant multidisciplinary literature in the areas of personality traits, environmental beliefs and economic preferences. It should be emphasised that the proposed framework should not be considered as a conclusive theory: it sketches a view on how the mapping between personality traits and energy efficient-efficient investments might work. The goal is to give energy-efficiency academia a discussion base for conceptualising personality traits into energy-efficient investment models and thus to initiate further and fuller research on that link.

The conceptual framework is built in a three-step approach. In the first step, the core underlying assumptions of the framework are set. The second step incorporates the two channels for the mediation of personality traits through economic preferences and environmental beliefs. Finally, the translation of the economic preferences and environmental beliefs into a revealed outcome (i.e. whether or not to adopt energy-efficiency features) is discussed.

3.1. Underlying Assumptions and Constructs

The framework is based on the economic model for energy-efficiency developed by Allcott and Greenstone (2012). That is, it is assumed that each agent aims to maximise its own utility, as postulated by neoclassic economics. The agent chooses between an energy-efficient and a conventional technology by weighing the future expected energy savings against the additional costs of the energy-efficient investment. If the discounted value of the expected energy savings exceeds the discounted value of the incremental costs, the agent should choose the energy-efficient product:

$$PV_{Savings} \times \gamma > PV_{\Delta Costs} + O \tag{1}$$

where

- $PV_{Savings} = \frac{P \times u \times \Delta e}{r}$,
- $\gamma = \gamma(\alpha, \varphi,$ info, P-A asymmetries$)$,
- $PV_{\Delta Costs} = PV_{\Delta Costs}(\Delta I, d\%, i)$ and
- $O =$ Option to wait.

The present value of the expected savings $PV_{Savings}$ depends mainly on the price of energy, P, the energy saving intensity Δe and the risk-adjusted discount rate r. The higher the price of energy, and the higher the saving intensity of the energy-efficient investment, the better value the energy-efficient good will be (Jaffe and Stavins, 1994; Bardhan et al., 2014; Allcott and Greenstone, 2012). The risk-adjusted discount rate, r, includes the cost of capital and the opportunity costs that are forgone due to the investment in the energy-efficient project (Gerarden et al., 2015). The variable u depicts the heterogeneity of agents (Bento et al., 2012). For instance, an agent from northern latitudes is assigned a higher u because he or she has a higher preference for heating than an agent from a warmer place.

γ captures the behavioural aspects of energy efficiency. Energy inefficiencies are usually reflected by setting $\gamma < 1$, evoked by several reasons. First, since in the neoclassical framework, agents are usually risk averse, the uncertainty of the future benefits of the energy-efficient investments might impede their adoption (Bardhan et al.,

2014; Fischbacher et al., 2015). A lower α indicates lower risk-/uncertainty taking. Second, the agent may not internalise the environmental costs associated with the energy use because they are not captured in the price of energy (Gerarden et al., 2015; Ramos et al., 2014). Adding φ accounts for these externalities. This means that in the case of $\varphi = 0$ the agent tends to under-invest in energy efficiency. Third, the agent may under-invest because he or she lacks the information (info) about energy-efficient measures (Allcott and Rogers, 2014; Costa and Kahn, 2013). Finally, a significant amount of energy-efficiency may be lost due to principal-agent (P-A) asymmetries (Myers, 2014; Bird and Hernández, 2012). In the residential markets, for example, landlords omit or tend to buy energy-efficient components at the lowest possible costs because they are not paying fo the energy bills.

An investment in energy-efficiency consists of an upfront cost and possible future interest payments caused by debt. The discounted present value $PV_{\Delta Costs}$ depends on the additional capital needed, ΔI, the percentage that is financed by debt ($d\%$) and its interest rate, i (Knittel et al., 2014).

Finally, the volatility of energy prices and uncertainty about future technology changes provide the consumer with an option to wait. Delaying the energy-efficient product might be valuable because energy prices and the costs for the energy-efficient technology might decline, which can lower the present incentive to invest in energy efficiency (Ansar and Sparks, 2009; van Soest and Bulte, 2001).

To introduce the essence of personality traits, it is assumed that preferences and beliefs are not universal or given a priori. Based on the previous literature regarding environmental behaviour and economic and personality theory (see section 2), the model is extended by allowing personality traits to have an impact on the agent's risk preference and environmental belief, which are captured with risk-taking α and the externalities φ. The levels of these factors are implicitly a function of the agent's personality Ψ, so that $\gamma = \gamma(\alpha(\Psi), \varphi(\Psi), \text{info}, \text{P-A asymmetries})$. Thus, risk preference ($\alpha(\Psi)$) and environmental belief ($\varphi(\Psi)$) drive agent's decision-making through γ, which in turn shapes the expected energy savings of energy-efficient investments ($PV_{Savings} \times \gamma$).

Before the details of the mediation of the personality traits through risk preferences and environmental beliefs are sketched under step two, a clear definition of

personality traits is necessary. One of the most established and recognised frameworks for measuring personality traits is the model of the Big Five. The origins of this model can be traced back to the work Allport and Odbert (1936), who created a huge collection of adjectives as characteristics for describing individuals. Later studies identified strong correlations between specific characteristics and defined clusters accordingly. Costa and MacCrae (1992) and Goldberg (1992) conceptualised these personality clusters in a taxonomy of five main dimensions: openness to experience, conscientiousness, extraversion, agreeableness and neuroticism. Further cross-cultural investigations showed the robustness and comparability of the concept across different regions in the world (Schmitt et al., 2007). Although there is agreement on the applicability of the five traits for expressing personality, a variety of definitions have been offered. The definitions for this research are taken from Costa and MacCrae (1992), who were also among the main contributors to work on expanding the application of the traits on a cross-cultural level. The specifications of each trait can be found in Appendix A.

3.2. The Two Channels of Mediation: Risk Preferences and Environmental Concerns

Standard economic theory includes risk as a core parameter in its utility function that is maximised. Risk-taking belongs to economic relevant preferences, which drive decisions correspondingly. As elaborated in section 2.3, for the question of energy-efficient investments, risk and uncertainty preferences are central to the decision-making process. This is the first channel of personality traits mediation in the model.

Due to the unique characteristic that energy-efficient investments contain an environmental-related part, an additional consideration is necessary. As illustrated in section 2.1, personality traits depict a similar concept to personal values. Both concepts may be linked to environmental beliefs as measured by an individual's environmental concern or attitude (Czap and Czap, 2010; Crosbie and Baker, 2010; Brick and Lewis, 2014; Mirosa et al., 2013). Environmental concerns therefore constitute the second channel of personality traits mediation in this model. In sum, personality traits enter the decision question as to whether or not to invest in energy-efficiency through risk preferences (economic preferences) and environmental concerns (environmental beliefs).

In the following paragraphs, each of the Big Five personality traits, either relevant to risk- and uncertainty-taking or to environmental concern, is introduced. Next, a causal impact of personality traits on risk preferences and environmental concern is presented based on the existing risk and environmental attitudes literature. The relationships are summarised in the left-hand box labelled "The Mechanism" in Figure 2. The figure zooms out the detailed mechanism of how personality traits may affect the final decision outcome of energy-efficient investments through the agent's behavioural factors $\gamma(\alpha(\Psi))$ and $\gamma(\varphi(\Psi))$.

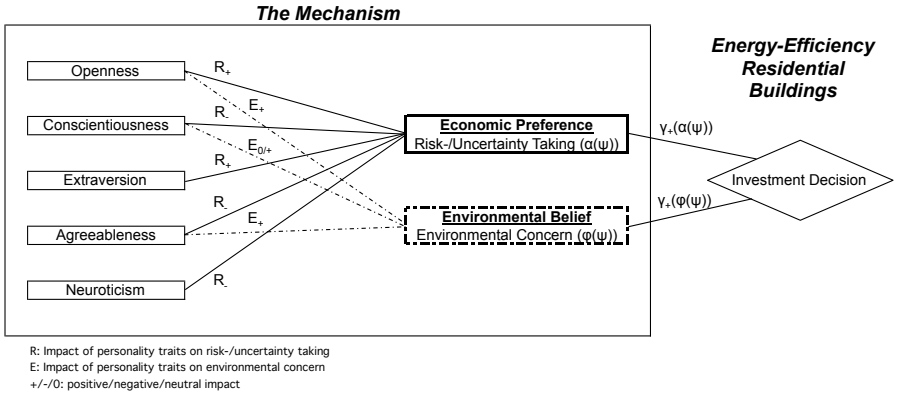

Figure 2: Personality traits mediation on the energy-efficiency of residential buildings

Openness. The first personality trait assessed is Openness to Experience (O). O is associated with higher openness to undertake new actions, which very often involves a degree of uncertainty. It also means a higher readiness to question ones values and those of the authorities, which requires an ability to confront uncertain situations since the status quo is abandoned. Previous work has demonstrated strong evidence for a positive relationship between O and risk preferences. Lee et al. (2008) and Nicholson et al. (2005) both revealed a positive correlation between O and financial risk-taking in lottery questions and real-world practices respectively. Other studies confirmed the same link in respect to household asset allocations and entrepreneurship rates (Brown and Taylor, 2014; Obschonka et al., 2013).

There is also strong support for a link between O and environmental beliefs. As

stated by Brick and Lewis (2014), flexible and abstract thinking, two main facets of *O*, are required among others to anticipate long-term environmental consequences. In addition, the readiness of individuals with high *O* to question their own values and the status quo goes in line with scrutinising the current situation of adverse climate change. Support for this assumed causality is given by empirical research that evidences a positive correlation between *O* and environmental concern, as measured by the New Environment Paradigm (NEP) (Dunlap and Van Liere, 1978), for example (Brick and Lewis, 2014; Hilbig et al., 2013; Markowitz et al., 2012; Hirsh and Dolderman, 2007).

Conscientiousness. The second personality trait, Conscientiousness (*C*), means having strong beliefs in one's own competence, being self-disciplined and striving for achievement. People with a high degree of *C* tend to be responsible and hardworking. Such achievement, however, is not aimed at random environments, such as gambling, for example. Rather, goals are strived for under controlled conditions. This aversion to uncontrolled or uncertain environments is evident in the analysis conducted by Brown and Taylor (2014), who found that households with a high *C* level have a lower willingness to acquire debts. Taking on debt depicts a step towards loosing financial self-control (compared to equity) which is not desirable for *C* people (Lee et al., 2008). The significant negative impact of *C* on general financial risk-taking is evidenced by Nicholson et al. (2005), who also propose an inverted link between *C* and risk-taking. In other words, *C* people are less prone to take risks.

Causality discussions on the link between *C* and environmental concern bring out arguments both in favour of and against pro-environmental engagement (see, for example, Markowitz et al., 2012). Results from empirical studies evidence a consistent positive relationship, though some show very small influences and minor inconsistencies (Milfont and Sibley, 2012; Hirsh, 2010; Markowitz et al., 2012; Hilbig et al., 2013). Swami et al. (2010) justify the causality for the positive impact of *C* on environmental concern with the need for achievement in pro-environmental values. Thus, the facets that work in favour of pro-environmental attitudes such as self-discipline, responsibility and carefulness seem to outweigh the opposing impacts. Based on the consistent

positive correlations in the existing studies and the possibility of opposing facets, it is concluded that a positive or neutral influence of C on environmental concern can be expected.

Extraversion. Extraversion (E) directs people's interest towards the outer world. Individuals who score highly in E values are assertive, ambitious, energetic and optimistic. These attributes provide a strong basis to deal with uncertain decisions. Indeed, similar to O, E was found to be a typical characteristics of entrepreneurship-prone individuals who face a significant amount of uncertainty (Zhao et al., 2010; Caliendo et al., 2014). A positive association between E and risk and uncertainty-taking, respectively, has also been revealed in other studies (Lee et al., 2008; Nicholson et al., 2005; Becker et al., 2012; Brown and Taylor, 2014).

Previous analyses have found no, or only a very small influence of E on pro-environmental attitudes and therefore, no relationship is derived between E and environmental beliefs (Nisbet et al., 2009; Milfont and Sibley, 2012; Markowitz et al., 2012).

Agreeableness. People with a high degree of Agreeableness (A) believe in the sincerity and good intentions of others. They tend to be cooperative and more group- than self-oriented. On the other hand, individuals with low A tend to be antisocial and egocentric. Self-centred individuals are often inclined towards over-confidence by overestimating their own abilities and knowledge. This can lead to a higher propensity for risk (Chui et al., 2010; Mihet, 2013). Thus, an inverse relationship between A and risk-taking should apply. The assumed relationship is supported by empirical studies in various risk-taking domains (Lee et al., 2008; Nicholson et al., 2005; Borghans et al., 2009; Bucciol and Zarri, 2015).

Related to environmental beliefs, previous work indicates a positive link between A and environmental concern. Several analyses report a robust and positive impact of A on biospheric concern and pro-environmental goals (Hirsh and Dolderman, 2007; Milfont and Sibley, 2012; Passafaro et al., 2015; Swami et al., 2010; Czap and Czap, 2010). People who score high in A have a higher concern for the welfare of others. This means that they will consider the consequences of their actions for other people. For

example, if a household installs energy-efficient heating for its house, carbon emissions can be reduced and climate warming can be slowed down. This not only adds value for the household that installed the heating but it also improves the living conditions of fellow men and later generations. Individuals high in *A* are therefore more prone to make pro-environmental decisions since they also help to improve others' living conditions.

Neuroticism. Finally, Neuroticism (*N*) should have a negative influence on risk-taking. Neurotic people have a tendency for a high degree of anxiety and susceptibility to stress. They try to avoid situations where outcomes are uncertain. Individuals who score low for *N*, meanwhile, are more confident, resilient, and are able to face stressful situations without becoming anxious or upset. These are attributes that are required in risky or uncertain situations. The literature reports a strong and consistently negative link between *N* and risk-taking (Nicholson et al., 2005; Lee et al., 2008; Anderson et al., 2011; Borghans et al., 2009; Becker et al., 2012; Zhao et al., 2010).

On the other hand, results on the link between *N* and environmental beliefs were mixed, ranging between no, negative and positive correlations (Wiseman and Bogner, 2003; Hirsh, 2010; Brick and Lewis, 2014; Markowitz et al., 2012). Hence, no clear associations can be derived between *N* and environmental beliefs.

3.3. Translation of Economic Preferences and Environmental Beliefs into Investment Decisions

After the impact of personality traits on risk preference and environmental concern has been addressed, the influence of the two latter factors on the final economic outcome, energy-efficient investments in residential buildings, needs to be analysed (translation). The connections between the final investment decision and economic preference and environmental belief, respectively, are illustrated in the right-hand side of Figure 2.

As elaborated in section 2.3, investing in energy-efficiency involves uncertainty and risk. In addition to the risk factors that are also commonly present in other types of investments (for example, prices), specifically for energy-efficient investments, the

new technology represents an additional source of uncertainty. From the economic perspective, therefore, higher preferences for risk can facilitate the decision to undertake an energy-efficiency project. The box Economic Preference in Figure 2 depicts this first mediation process of personality traits through risk preferences.

Energy-efficient investments consist of an environmental component. As shown in section 2.1, environmental beliefs drive environmental behaviour. Pro-environmental attitudes and environmental concern facilitate pro-environmental decisions. This also includes the decision of a household to adopt energy-efficient technology. Even if an energy-efficient investment has a lower expected profitability compared to a stock purchase, for example, pro-environmental attitudes might still compensate the corresponding loss in household's utility and lead the decision towards energy-efficiency. The box Environmental Belief in Figure 2 illustrates this second mediation process of personality traits through environmental concern.

The final impact of personality traits on energy-efficient investments can be analysed by synthesising the translation of the mediators with the correlations between the personality traits and mediators from section 3.2. O and E should show a positive impact because they are expected to relate positively to either both or one of the mediators. In the case of C and A, the mediators work in opposite directions and therefore, the final influence on energy-efficient investments depends on the magnitude of each of the specific mediator impacts. N is expected to have a negative influence because of its negative link to risk-taking.

4. Discussion

In this paper, ideas from recent economic theory on personality traits are integrated with tools from personality psychology into environmental behaviour theory. By combining these existing strands of knowledge, a new framework for the effects of personality traits on energy-efficient investments in residential buildings has been sketched. The approach enables to suggest a mechanism for how individuals might mediate personality traits through their economic preferences and environmental beliefs that in turn lead to the observable outcomes of energy-efficient investments. In

contrast to previous research, this paper has incorporated the potential effect of personality through dual channels of mediation: economic preferences and environmental beliefs, as opposed to just one. Addressing either one of the channels in isolation could lead to inconsistent conclusions and the framework proposed in this paper could therefore serve to add clarity in respect to observed behaviour. To illustrate, if it is true that agreeableness is inversely related to risk preferences and positively related to environmental concern (see Figure 2), agreeableness would exhibit opposing effects on the final outcome of energy-efficient investments. It might be implausible to observe an individual of a household who scores extremely highly in respect to agreeableness with no energy-efficient measure affiliation. High agreeableness, however, might neutralise the pro-environmental inclination through the channel of risk preferences, which works against the adoption of energy-efficient technology. Further, the inclusion of all five personality traits into one framework may clarify how personality traits with a negative impact on energy-efficient investments may offset those with a positive effect.

Due to its significant potential to curb energy usage, having a fuller understanding of the functionality of energy-efficient investments is vital not only for academia but also for stakeholders in practice. Policy organisations promoting pro-environmental behaviour, for example, should have a comprehensive appreciation of the core drivers of energy-efficient investments. Understanding the impact of personality traits can help in elaborating the limitations of education or monetary incentives in respect to influencing households' willingness to invest in energy-efficient technology. If personality traits affect energy-efficient investments, programmes that target changing people's way of thinking might be ineffective because personality traits are stable constructs. This might explain why eco-labelling schemes can fall short of their promises (Abrahamse et al., 2005). The heterogeneity of personality profiles may shed light on why providing information may not be enough to improve energy efficiency. For instance, simply informing people about environmental issues might not increase their willingness to invest in energy efficiency because low levels of openness could constrain it. Also, financial subsidies might fail to foster energy-efficient investments because people's personality profiles can limit their willingness to take the risks inherent in energy-efficient projects.

Policy-makers, pro-environmental organisations and providers of financing for energy-efficient technology might do well to take account of stable psychological characteristics (personality traits) in their strategies. By using information about personality traits, they can tailor-fit their strategies to different target audiences. For example, if facets of openness drive pro-environmental decisions, policy-makers should present pro-environmental actions as new and cutting-edge (Markowitz et al., 2012). Moreover, policies could be applied on a regional large-scale base. Recent studies have found geographical manifestations of personality traits which show that specific traits are more prevalent in some regions than in others (Obschonka et al., 2015, 2010; Rentfrow et al., 2013). Such findings can be used to tailor polices to specific groups of personalities. For instance, regions with low levels of openness should be confronted with proposals that require only marginal changes in behaviour because they prefer the status quo. Similarly, if stimulating and restraining personality traits for energy-efficient investments are known, pro-environmental organisations can design their programmes in a way that engages with these traits. People with low agreeableness levels tend to care less about the environment but at the same time they like to show their achievements. Pro-environmental organisations can engage with this facet by illustrating that going "green" increases social status (social achievement), for example. Likewise, producers of energy-efficient technologies may benefit by tailoring their marketing strategies to the relevant traits. For instance, the effects of eco-labels could be improved. Again, if openness is a crucial factor in deciding to pursue energy-efficiency, labels could be designed with visual effects that engage with the typical openness facets of inner feelings and emotions. Instead of using alphabetical letters or figures of carbon emissions, the levels of energy-efficiency could be visualised with pictures ranging from polluted cities (low energy-efficiency) to green landscapes (high energy-efficiency). Such visualisations might be more effective for openness-prone people than just highlighting the financial value of energy savings.

Another way of taking account of personality traits for successful energy-efficient investments is by diversifying financing products. Energy-efficient projects do not offer investors as much choice between different levels of risk as is available for other investments (stocks, bonds, structured financial products, etc.). This means that a person

with a risk-averse personality profile, for example, may be reluctant to invest because of the high perceived risk in an energy-efficient project. A wider variety of risk levels could be introduced by increasing the range of mortgage products for energy-efficient measures that are currently offered by some liquidity providers. Such mortgages could be tailored specifically to mitigate the risk inherent in energy-efficient projects, for example by the use of floating rate loans that link interest rate payments to energy prices. In such a scenario, the interest rate is adjusted downwards/upwards on a regular basis in line with fluctuations in energy prices. As such, losses in energy-efficient projects caused by energy price declines are compensated with lower interest rate payments. Another solution may be risk-sharing energy policies. For example, future losses or gains in energy-efficient projects could be shared between government and households. The extensive portfolio of a government allows a better allocation and diversification of risk than does an average household's portfolio. Risk-mitigation can also be achieved via Energy Performance Contracting (EPC). An EPC constitutes a partnership between a client and an Energy Service Company (ESCO), under which the ESCO implements an energy-efficient project and either guarantees a certain level of energy savings to the client or shares cost savings with him/her. The implementation costs are repaid through the cost savings arising from the project. As such, risks are transferred partly to the ESCO and funding is provided through the income streams of cost savings. The level of guarantees for energy saving or risk-sharing could be tailored in EPCs according to the clients' personal attitudes to risk.

The consideration of personality traits in policy interventions is justified if the impact is reasonable. Hence, future research may ask to which extent personality traits matter? Neoclassic economics assumes homogeneous agents that invest if an expected financial value is positive. If confronted with an energy-efficient project and under conditions of frictionless markets (no financing restrictions, no transaction costs, etc.) the theory suggests that agents make the same decisions. Heterogeneous personality profiles, however, may produce different expected values for the same energy-efficient projects and lead to different decisions. If the influence of personality traits is high enough, an energy-efficient investment that should be accepted under the neoclassic economic model might still be rejected in the extended model with personality traits.

A very defensive energy-efficient personality profile, for instance, may reduce the value of a highly profitable energy-efficient investment with a low payback period to an extent that would result in a negative expected value (over the same period) and extend the payback period significantly. On the other hand, a project with an expected loss and a very long payback period might still be accepted by an agent with an energy-efficient-prone personality profile because it may increase the value of the project sufficiently to generate a gain. Quantifying this value increase or decrease would specify the extent to which personality traits matter. Future research could try to determine the value in experiments of hypothetical energy-efficient projects by calculating and comparing individuals' expected profits in the neoclassic model and the extended model including personality traits. The illustrated framework for residential buildings might also serve as a basis for the research of personality traits in other domains with similar characteristics (for example, energy-efficient vehicles), which further emphasises the need to test the suggested relationships empirically.

The difficulties inherent in capturing less tangible assets such as personality traits, or the complexity of the mechanisms by which these might be mediated are real but are not reasons for avoiding the challenge. It might be true that personality trait as an explanatory variable is a more subjective factor than directly observable attributes such as price or income. Nonetheless, sound frameworks exist in the field of personality psychology that are able to measure personality with a high degree of objectivity. Energy-efficiency scholars should recognise their potential value for their research as other research disciplines have done already, since they could significantly enrich the understanding of factors for energy-efficient investments which in turn could contribute to narrow the observed energy-efficiency gap.

Appendix A. Specifications of the Big Five Personality Traits

The Big Five personality traits' specifications, according to Costa and MacCrae (1992), are as follows:

- **Openness to Experience**: the active seeking and appreciation of experiences for their own sake.

  - *Fantasy*: receptivity to the inner world of imagination
  - *Aesthetics*: appreciation of art and beauty
  - *Feelings*: openness to inner feelings and emotions
  - *Actions*: openness to new experiences on a practical level
  - *Ideas*: intellectual curiosity
  - *Values*: readiness to re-examine own values and those of authority figures

- **Conscientiousness**: degree of organisation, persistence, control and motivation in goal directed behaviour.
  - *Competence*: belief in own self efficacy
  - *Order*: personal organisation
  - *Dutifulness*: emphasis placed on importance of fulfilling moral obligations
  - *Achievement Striving*: need for personal achievement and sense of direction
  - *Self-Discipline*: capacity to begin tasks and follow through to completion despite boredom or distractions
  - *Deliberation*: tendency to think things through before acting or speaking

- **Extraversion**: quantity and intensity of energy directed outwards into the social world.
  - *Warmth*: interest in and friendliness towards others
  - *Gregariousness*: preference for the company of others
  - *Assertiveness*: social ascendancy and forcefulness of expression
  - *Activity*: pace of living
  - *Excitement Seeking*: need for environmental stimulation
  - *Positive Emotions*: tendency to experience positive emotions

- **Agreeableness**: the kinds of interactions an individual prefers from compassion to tough mindedness.

  - *Trust*: belief in the sincerity and good intentions of others
  - *Straightforwardness*: frankness in expression
  - *Altruism*: active concern for the welfare of others
  - *Compliance*: response to interpersonal conflict
  - *Modesty*: tendency to play down own achievements and be humble.
  - *Tender-Mindedness*: attitude of sympathy for others

- **Neuroticism**: identifies individuals who are prone to psychological distress.
  - *Anxiety*: level of free floating anxiety
  - *Angry Hostility*: tendency to experience anger and related states such as frustration and bitterness
  - *Depression*: tendency to experience feelings of guilt, sadness, despondency and loneliness
  - *Self-Consciousness*: shyness or social anxiety
  - *Impulsiveness*: tendency to act on cravings and urges rather than reining them in and delaying gratification
  - *Vulnerability*: general susceptibility to stress

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