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DISCUSSION PAPER

// GARY CHAPMAN AND HANNA HOTTENROTT

Green Start-Ups and the Role of Founder Personality

Leibniz Association

ZEW

Green Start-ups and the Role of Founder Personality

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Abstract

Green start-ups play a vital role in the needed transition towards more environmentally sustainable economies. Yet our understanding of why some founders start green ventures and others do not remains incomplete. We build on the cognitive and decision-making perspectives on start-ups pro-environmental engagement to shed light on the role of founders' personality traits - focusing on the 'Big 5' and risk tolerance - in explaining whether founders' start new ventures with environmentally friendly products. Our analysis of a large, representative, manufacturing and service sector sample of German start-ups illustrates the important role of founder personality traits. Specifically, openness and extraversion promote environmentally friendly products while neuroticism inhibits it. We discuss the implications of these insights.

Keywords: Emission reduction, environmentally friendly products, green innovation, Big Five personality traits, sustainability

JEL codes: G24, L26, O25, O31

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1. Introduction

The visible consequences of climate change have led society to demand climate action and governments to declare climate emergencies. Transitioning to a sustainable low carbon economy has become a key solution to the environmental crisis. For this transition to work, organisations must 'go green' by offering more environmentally friendly products and solutions (Criscuolo and Menon, 2015). While prior research has focused on established organisations, attention to why founders start green ventures - typically defined as new firms providing products or services with environmental benefits - has been more limited (Demierel et al., 2019). Green start-ups have a vital role in the low carbon transition by addressing pressing environmental challenges, reducing the significant emissions attributed to smaller firms, and by helping diffuse new environmental technologies (Hall et al., 2010; Szabó, 2017; Cojianu et al., 2021). While data are sparse, it appears many founders – yet far from all – have started green(er) ventures; in our data of new firms founded between 2011 and 2016 in Germany, approximately 37% offer products with significant environmental benefits. Therefore, better understanding why some founders start green ventures, and other do not is vital.

Building on the cognitive and decision-making perspectives on start-ups' pro-environmental activities (e.g., Patzelt and Shepherd, 2011; Muñoz and Dimov, 2017; Hanohov and Baldacchino, 2017; Muñoz, 2018; Eller et al., 2020; Hernández and Muñoz, 2021), this paper examines the role of founder personality traits, which reflect founders' propensities to act in a particular way across different situations (Brandstätter, 2011). Little is known about whether and to what extent different founders' personality traits influence whether they start green ventures. The psychology literature – from which personality research originates – suggests traits play an important role in the formation of environmentally favourable attitudes and values, and in turn, affect environmental engagement and actions (Dietz et al., 2005; Hirsh and Dolderman, 2007; Hirsh, 2010; Milfont and Sibley, 2012; Busic-Sontic et al., 2017). We seek to integrate growing

psychology insights with entrepreneurship research by investigating whether founder personality traits affect whether their start-ups offer green(er) products.

We first focus on founders' 'Big Five' personality traits (openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism) (Brandstätter, 2011) as this is a dominant personality trait configuration and captures core personality elements (McCrae and John, 1992; Hurtz and Donovan, 2000). We additionally examine founders' risk tolerance as evidence suggests risk preferences are not fully captured by the 'Big Five' (Piovesan and Willadsen, 2021). We hypothesise that (a) openness, (b) agreeableness, (c) conscientiousness, and (d) extraversion, positively influence the likelihood of founders' starting new ventures with a higher degree of greeneness, while (a) neuroticism and (b) risk tolerance have a negative influence.

Our work contributes to the ongoing conversation on the cognitive perspective on start-ups pro-environmental behaviour (Patzelt and Shepherd, 2011) by shedding novel light on the role of six founder personality traits in their decisions to start green ventures that offer environmentally friendly products. We move the conversation of why start-ups go green beyond macro-level factors (Cojoianu et al., 2021) and benefit-seeking (Ambec and Lanoie, 2008) by arguing that founder personality traits shape their environmental predispositions, and in turn, impact the greenness of their start-up's products. We also empirically contribute by providing novel micro-level multi-sector evidence on the extent to which new firms are green, and the role of founders' personality traits in the greening of start-ups. Where prior work has focused mainly on 'clean' sectors (Cojoianu et al., 2021), we deploy a large, representative, manufacturing and service sector sample of German start-ups. This permits a more fine-grained identification of the green activities of new business founders within various sectors.

2. Hypotheses

As founders possess the most influence on start-up decisions, their personality traits have attracted much entrepreneurship research attention (Kerr et al., 2018). Personality traits explain a range of behaviours, such as starting businesses, creativity, problem solving, and financial success

(Frese and Gielnik, 2014; Nikolaev and Maldonado-Bautista, 2019). Specifically, entrepreneurship studies show founder 'Big Five' impacts start-up outcomes (Zhao and Seibert, 2006), and psychology research demonstrates their importance in environmental attitudes and engagement (Hirsh and Dolderman, 2007; Milfont and Sibley, 2012). Equally, risk taking plays a fundamental role in start-up activities (Chapman and Hewitt-Dundas, 2018), including 'green activities' where social returns likely outweigh the private (Hottenrott et al., 2016). Leading to our expectation that founder personality traits play an important role in the extent to which founders' start firms with greener offerings. We utilise a multi-dimensional understanding of the greenness of start-ups' offerings, capturing aspects such as reducing energy, resource use, and emissions, and improving durability and recyclability. This approach also recognises the different degrees to which founders can achieve greenness in their offerings.

We expect four founder personality traits – openness to experience, conscientiousness, extraversion, and agreeableness – to positively influence the likelihood of starting a business with a higher degree of greenness. Openness – extent to which founders are imaginative, curious, and open to novel and unconventional ideas – and agreeableness – extent to which founders are altruistic, caring and emotionally supportive –correlate with self-transcendence (Schultz, 2000) that is linked to pro-environmental dispositions (Milfont et al., 2010). This may lead founders to value nature and societal welfare more, thus pushing them to found start-ups with more environmentally friendly offerings (Hirsh and Dolderman, 2007). Openness is also associated with stronger cognitive ability and flexibility (DeYoung et al., 2005; Hirsh, 2010), which in turn, could lead founders to start businesses with more environmentally friendly offerings by increasing their awareness and understanding of the long-term harmful ecological consequences of climate change (Patzelt and Shepherd, 2011; Hanohov and Baldacchino, 2017). Their greater openness to new experience could also increase their willingness to embrace change and focus on novel and greener offerings (Hirsh, 2014). While high agreeableness has been shown to be negatively related to competitiveness (Ross et al., 2003), agreeableness also links to greater levels of empathy,

citizenship, and compassion (Markowitz et al., 2012) potentially leading founders to place more emphasis on the wellbeing of society in their considerations, and to take more environmentally friendly actions (Schultz, 2000). Albeit in non-entrepreneurial contexts, growing literature empirically supports our intuition that agreeableness and openness aid environmental engagement (Hirsh and Dolderman, 2007).

Conscientiousness – extent to which a founder is diligent, persistent, and motivated – places greater emphasis and value on the future. Such future time perspectives have been positively linked with environmental concerns as such individuals feel more responsible for the potential longer-term consequences of their actions, and thus, are more likely to act to preserve the future (Milfont et al., 2012). The persistence, motivation, and self-discipline associated with conscientiousness also helps longer-term planning for future outcomes, which should better enable founders to plan and act for future shifts towards greener offerings (Hirsh, 2010; Milfont and Sibley, 2012).

Finally, while the link between extraversion – extent to which a founder is assertive, active, sociable, and enthusiastic – and environmental concerns and actions remains unclear (Hirsh and Dolderman, 2007; Markowitz et al., 2012), we suggest that it will be important for start-ups efforts to provide sustainable solutions. Prior work shows that greener products are often complex and rely on diverse knowledge sets increasingly spread throughout value chains (Ben Arfi et al., 2018; Chapman et al., 2018). Founders' willingness and ability to identify and exploit diverse knowledge is likely, therefore, key for starting ventures with greener offerings. The enthusiastic, active, and sociable nature of extravert founders' will likely be more effective for identifying and exploiting such diverse knowledge, than introvert's rather antisocial and reserved nature. Thus:

Hypothesis 1*: Founders who are more (a) open to experience, (b) agreeable, (c) conscientious, and (d) extravert are more likely to start a business with a higher degree of greenness.*

We expect two founder personality traits – neuroticism and risk tolerance – to negatively influence the likelihood of starting a business with a higher degree of greenness. Green products

possess highly uncertain returns, are often complex and departures from typical business practices and knowledge (Ben Arfi et al., 2018). These features likely exacerbate the fearful, anxious, and insecure natures associated with high levels of neuroticism – extent to which founders are emotionally stable (e.g., calm, anxious, fearful) and adjust well (Poškus and Žukauskienė, 2017) – resulting in highly neurotic founders leading their start-ups down more certain or traditional paths. Neuroticism also links to a fear of change that could produce a preference for the status-quo.

While risk tolerance – willingness to engage in risky behaviours and commit resources with uncertain outcomes – may be expected to help founders cope with the risk of going green (Demirel et al., 2019), higher risk tolerance may reduce the perceived importance founders attribute to going green. Prior theory suggests that risk perceptions and tolerance are important predictors of individuals' willingness to take actions to help the environment and curb climate change (O'Connor et al., 1999). This occurs through risk tolerance affecting the urgency and severity with which founders view environmental degradation and climate change, and the potential consequences (Weber, 2006; Van der Linden, 2015). Founders with high risk tolerance may have a higher threshold for the perceived risks from environmental issues before they consider them to be serious and urgent, and in turn, be less likely to found ventures offering greener products. Hence, we hypothesise:

Hypothesis 2*: Founders who are more (a) neurotic and (b) risk tolerant, are less likely to start a business with a higher degree of greenness.*

3. Data and descriptive statistics

To identify green start-ups, we use unique and detailed information from the IAB/ZEW Start-up Panel.[1] Specifically, we use information from targeted question items included in the 2018 survey wave to identify green start-ups. Founder's orientation towards greener products captures

[1] The panel has been established in 2008 and since then a representative stratified random sample (stratification according to industries and German states [*Bundesländer*]) of newly registered businesses is drawn from the Mannheim Enterprise Panel (MEP) each year and founders are interviewed via computer-aided telephone interviews (CATI). Besides newly added firms, the panel contacts firms again on a yearly-basis up to eight years after founding (see Fryges et al. 2009 for a detailed description of the survey design).

the extent to which their firms offer products that provide a positive environmental impact for their customers or end-users. This approach of identifying green start-ups allows us to understand a key dimension of greenness critical to achieving the sustainable transition, and it moves beyond identification based solely on green firms' sector affiliation, patenting activity, or product descriptions. Table 1 presents the items used to measure 'green products'. In the case of single-founder firms, the questions were addressed to the founder and in the case of several founders, to a founding team member.

--- Table 1 about here ---

Figure 1 shows the response patterns for the different environmental actions in the final sample containing 11,496 observations from 3,053 unique firms founded between 2011 and 2016.[2] Energy and resource saving product features (which includes CO_2 reduction) are more common (40.6 and 31.8 per cent, respectively) than attributes where the private benefits to the firm are less clear such as reducing water, soil and air emissions or improved recycling (28.2 and 20.5 per cent, respectively). This aligns with earlier research on the Porter Hypothesis that shows companies adopt environmentally friendly actions in areas where there are also private returns to such behaviour (Rammer and Rexhäuser 2014).

Figure 2 illustrates the shares of green start-ups for eleven sectors ranging from cutting edge manufacturing to software and services. While expecting sectoral differences due to regulatory differences and varying technological opportunities, we see that the overall patterns are quite consistent across sectors and all sectors show some green efforts. Manufacturing sectors show more activities with benefits focused on durability and improved recycling, potentially due to regulatory efforts and customers demanding more durable and recyclable offerings. Service sectors are more engaged in resource or energy saving efforts.

--- Figures 1 and 2 about here ---

[2] Since these questions refer to any activities since the year of founding, we construct the final data set by using the information obtained in 2018 for all years in which the firms were interviewed.

Since the responses to the individual items (types of environmental effects) are correlated, we conduct principal component analyses (PCA) and find the five items to map into a single factor which we label 'green products' (Appendix Table A.3, Panel A). Panel A in Table 2 shows descriptive statistics for all items and the predicted factor score. The 'Big five' traits are measured using a 15-item survey instrument based on the five-dimensional OCEAN construct (openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism). Since recent research suggests risk preferences are not sufficiently captured in OCEAN (Piovesan and Willadsen, 2021), we capture entrepreneurial risk-tolerance using a two-item scale (Appendix Table A.1 for details on the item scales). Panel B of Table 2 summarizes the main personality trait variables. We conduct a confirmatory PCA on the 15 items as well as on the 2 items for risk tolerance. The results support the underlying theoretical factor structures (Appendix Table A.3, Panels C and D for detailed results of the PCA). We use the predicted factor scores for each trait as the main explanatory variables in the analysis.

--- Table 2 about here ---

We hypothesized that founders' personality traits influence the extent to which their start-ups offer greener products. Figure 3 illustrates the differences in the ROCEAN dimensions for founders of green companies compared to others. For this illustration, we classified a start-up as green if the predicted factor score (as shown in Table 1) is above the mean. The graphical illustration shows that there are indeed striking differences in baseline personality traits. Green founders have higher scores in all dimensions except agreeableness and neuroticism with the smallest difference in levels of conscientiousness between the two groups.

--- Figure 3 about here ---

4. Method and Results

To examine the relationship between personality traits and green start-ups while accounting for other founder and firm characteristics, we include a set of controls that capture whether the firm

was founded by a single founder or team of founders (*Team*), the gender composition (*Female founder)*, the average age of the founding team (*Founder age*), their *industry experience*, their experience as a founder (*Serial entrepreneur, failure experience*), whether founders have an *academic* background, and the legal form (*Limited liability*). We also control for the sector, R&D efforts (*R&D*), number of employees (*Employees*), the financial situation (*Profit*), the main motive of the founders to start the business (*Opportunity*), and the market reach (*Export*). Finally, we include information on the age of the firm at the time of the survey wave, its location in West or East Germany and its industry affiliation[3]. Table A.4 in the Appendix describes the construction and definition of the control measures in more detail and Table A.5 presents descriptive statistics for these variables.

In our main analysis, we employ the compound factor score for green products as the dependent variable in multivariate regression models estimated by Ordinarily Least Squares (OLS). In addition, we estimate a simultaneous 5-equation ordered probit model using conditional mixed process estimation (CMP) where we employ the item scores as dependent variables and the joint estimation accounts for the correlation across different green product qualities. Table 3 shows the main results. In the first specification, we include only the personality traits. In the second, we add further founder and firm characteristics. The test of joint significance of the personality traits shows that overall personality matters for starting ventures with greener products. The F-test remains statistically significant even after including founder and firm characteristics. In line with H1, we find that openness to experience and extraversion are positively and significantly linked to green products. Higher degrees of neuroticism, however, translate into lower degrees of greenness (supporting H2). Risk tolerance is positively linked to green products, contrary to our hypothesis, but is only significant at the 10% confidence level. Note that the overall model is statistically significant already in columns (1) without further controls (with F = 19.5***). However, the R^2

[3] 30 plus years since Germany re-unification, substantial structural differences remain between the former GDR states and the west of Germany (Lichter et al. 2021). Table A.6 shows the distribution of companies by sector.

values are generally low and increase when other variables are included. This suggests that besides the factors accounted for here, further unobserved drivers may play a role such as regulation, ownership patterns, and further founder-specific attributes not yet captured by the model. Model (3) presents the results from the simultaneous equation model. The correlation of errors between equations (ρ) is positive and significant for all possible combinations confirming that joint estimation is preferable. Like in model (2), we find openness and extraversion to positively affect any type of green product; for the latter trait with the exception of improved recycling. On the other hand, agreeableness turns out to be positively and significantly related to 'improved recycling', but not to any other type. Thus, for this trait, we find H1 partially confirmed. The previously identified negative link between neuroticism and green products is mainly driven by the types 'Energy reduction', Resource reduction' and 'Increased durability'. In line with this finding, the disaggregate model further reveals that higher tolerance mainly drives products with 'emissions reduction'. Regarding other founder and venture characteristics, we find – besides the sector in which the start-up is active – founder age and experiences as well as higher R&D efforts to also play an important role.

We next explore whether some traits reinforce or offset each other. While most personality entrepreneurship research has focused on the effects of individual traits, individuals possess different traits to varying extents simultaneously. Different traits likely interact with one and other, potentially reinforcing or offsetting each other's effects (Merz and Roesch, 2011; Brick and Lewis, 2016; Breu and Yasseri, 2022). For example, high extraversion may be aided by high openness as a key factor inhibiting the exploitation of diverse external knowledge is a lack of openness to external knowledge (Chapman and Hewitt-Dundas, 2018). The curiosity and openness to novel and unconventional ideas in high openness likely overcomes this barrier and thus, strengthens extraversion's environmental effects, while the closed approach in low openness likely reinforces this barrier and thus, weakens extraversion's effects. The positive characteristics (e.g., sociability)

associated with higher values of openness and extraversion may equally be able to cancel out or attenuate the negative characteristics (e.g., anxiety) associated with higher neuroticism.

To examine the potential for trait interactions, we estimate the joint effect of trait-pairs in separate regression models (otherwise specified as in Model 2 in Table 3) and report the coefficient and standard errors of the respective interaction term in Table 4. Note that the main effects do not switch signs in any of the cases and remain significant at previously reported levels. We find conscientiousness turns positive and significant at higher values of openness and extraversion. This refines our insights by suggesting that these traits interact, but that it is not conscientiousness alone that initiatives greenness. Moreover, extraversion and risk tolerance, extraversion and agreeableness, and openness and agreeableness turn out to be substitutive. Interestingly, being more extravert can almost offset neuroticism's negative impact.

--- Table 3 and 4 about here ---

We test the sensitivity of our findings to alternative empirical analyses. First, we compare the findings for green products to those for 'green innovations' (see Table A.2 for the survey question related to these attributes and Table A.3, Panel B for details on the PCA for these items)[4]. Green innovations reflect efforts to change firms' internal processes and means of production by implementing innovations with environmental benefits within the firm, and thus, may capture a different element of starting a green venture. We repeat the models presented in Table 3 and the results show a similar picture for *innovations* with environmental impact about extraversion and openness (Table A.8). Yet here consciousness and agreeableness are also positively and significantly linked to green innovation efforts, except for the case of 'increased durability' (Table A.8). Next, we estimate the equations for green products and innovations jointly since the two types of green activities are likely related within firms. We find indeed support for a correlation across

[4] Figure A.1 shows response patterns for the innovation items and Table A.7 presents descriptive statistics. Figure A.2 shows green innovation activities by sector and Figure A.3 presents the density distributions for the predicted scores for products and innovations.

the two equations, but the main results regarding ROCEAN traits as discussed above hold. Detailed results in Table A.9 in the Appendix.

5. Conclusion and Discussion

Understanding why founders start green ventures is important for economies in their transition to more sustainable production and consumption. We extend the cognitive and decision-making approaches to entrepreneurs' pro-environmental behaviour (Patzelt and Shepherd, 2011; Hanohov and Baldacchino, 2017) by theorizing founder personality plays an important role in predisposing them to have a 'taste' for greenness. Using detailed, multi-sector information on founders and their companies, we show that founders who are more open and extravert (e.g., open to new ideas, outgoing) are more favourable to starting green ventures. Their personality helps to stimulate a focus on green offerings when founders' start a new venture. We also find that higher degrees of neuroticism translate into a more unfavourable disposition toward starting a green venture, which we suggest is due to the mismatch between the characteristics associated with high neuroticism (e.g., anxiety, resistance to change) and the demands of starting green ventures (e.g., embracing complexity, departing from traditional business practices). We also provide first exploratory insights into the interactive effects of founders' different personality traits, suggesting that different traits can reinforce (e.g., conscientiousness and extraversion) or offset (e.g., neuroticism and extraversion) each other's effects. Finally, we document that personality matters for both green products as well as green process innovations with conscientiousness and agreeableness playing a stronger role for green activities were the benefits are closer to the founder, i.e. affecting the environmental impact within their firms. These insights advance our understanding of the antecedents of founders' environmental engagement by adding a personality dimension that better explains why founders start green ventures.

While personality traits have long been considered fixed early in life, increasing evidence suggests personality traits can evolve and be influenced (McCrae and Costa, 1990; Borghans et al., 2008; Bieidorn et al., 2019). Given the important role we identify of founder openness,

extraversion, and neuroticism, this suggests that policymakers may seek to directly target and influence these traits to enhance founders' propensity to start green ventures. One route may be through education and training programmes (Camuffo et al., 2020) that can provide experiences to enhance the openness, curiosity, and sociability associated with openness and extraversion, and negate the anxiety, fear, and change aversion associated with neuroticism. Another route may be through large-scale education programmes that target founders' sustainability attitudes and behaviours; Hopwood et al. (2021a; 2021b) suggest that as people learn more about climate change's consequences, it can influence their personality.

Where prior work has adopted a sectoral or regional level approach to studying green start-ups (Demierel et al., 2019), we offer a more fine-grained individual-level perspective. We document substantial variation in venture-level engagement in green products (and process innovations), and that founder heterogeneity, namely founder personality traits, drive differences in greenness. Additionally, where prior work has often focused mainly on 'clean' sectors (e.g., Cojoianu et al., 2021), we deploy a broad multi-sector sample of manufacturing and service firms. This is important as to achieve a low carbon economy all areas of production must participate, and thus, it is key to identify antecedents across multiple sectors. We also extend the broader entrepreneurial personality literature (Kerr et al., 2018) by showing that in addition to founder personality shaping private start-up outcomes, it also influences start-ups ecological contribution via their green products and processes.

Our work has limitations that point to opportunities for future work. We focused on the 'Big Five' and risk tolerance given our entrepreneurial context. But a broad range of personality traits, such as narcissism, altruism, cooperativeness, and trust, have been identified and may warrant consideration. Second, we draw data from a single advanced western country – Germany. As we need to combat climate change globally, and institutions differ across countries, we encourage examination of other countries and contexts.

Tables & Figures

Table 1: Measurement of Green Offerings

Question:	***Does your company offer products or services that have the following environmental impacts on customers or end users?***	
	Item:	***Label:***
a)	Reduction of energy consumption or the total CO^2 balance at the customer's site	Energy reduction
b)	Reduction of material and resource consumption, e.g., water, at the customer's site	Resource reduction
c)	Reduction of further emissions into the air, water, soil or noise at the customer's site	Emission reduction
d)	Improvement of the recyclability of customer's products	Better recycling
e)	Increase the durability of customer's products	Better durability

Notes: The answering options were 0: no impact, 1: Yes, some impact, 2: Yes, strong impact.

Figure 1: Green start-up activities by type of greenness (item responses)

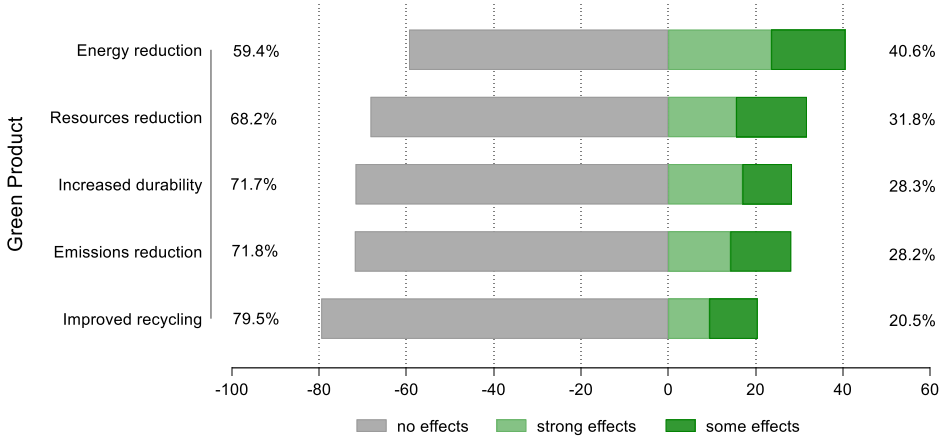

Figure 2: Green products by sector

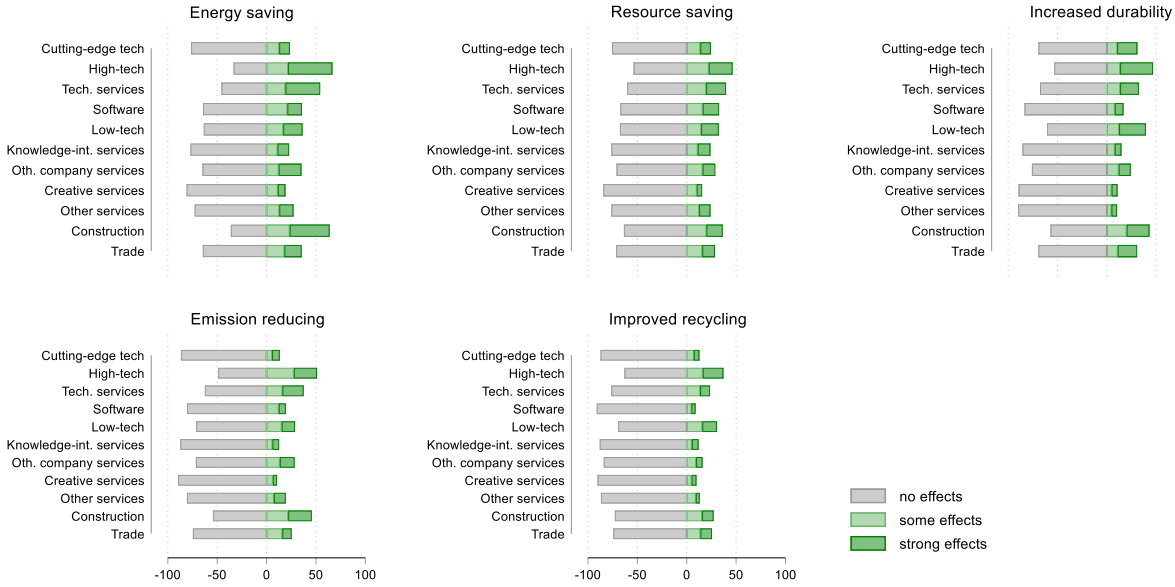

Table 2: Descriptive Statistics for the main variables

	Mean	Std. Dev.	Min	Max
Panel A:				
Green Products				
Energy reduction	0.642	0.838	0	2
Resource reduction	0.473	0.749	0	2
Increased durability	0.454	0.767	0	2
Emissions reduction	0.424	0.727	0	2
Improved recycling	0.299	0.631	0	2
Predicted factor score:				
Green products	0.000	1.000	-0.791	2.842
Panel B:				
Personality traits				
Risk tolerance	2.686	1.156	1	5

Openness	3.723	0.743	1	5
Conscientiousness	4.259	0.616	1	5
Extraversion	3.848	0.730	1	5
Agreeableness	4.027	0.665	1	5
Neuroticism	2.370	0.751	1	5
Predicted factor scores:				
Risk tolerance	0.000	1.000	-1.452	2.029
Openness	0.000	1.000	-4.425	2.277
Conscientiousness	0.000	1.000	-5.863	1.819
Extraversion	0.000	1.000	-4.184	1.984
Agreeableness	0.000	1.000	-2.345	3.665
Neuroticism	0.000	1.000	-4.641	2.117

Notes: N = 11,496. The values for the personality traits are the average item scores over the three sub-items per trait (two in the case of risk tolerance).

Figure 3: Founder personality traits and green products

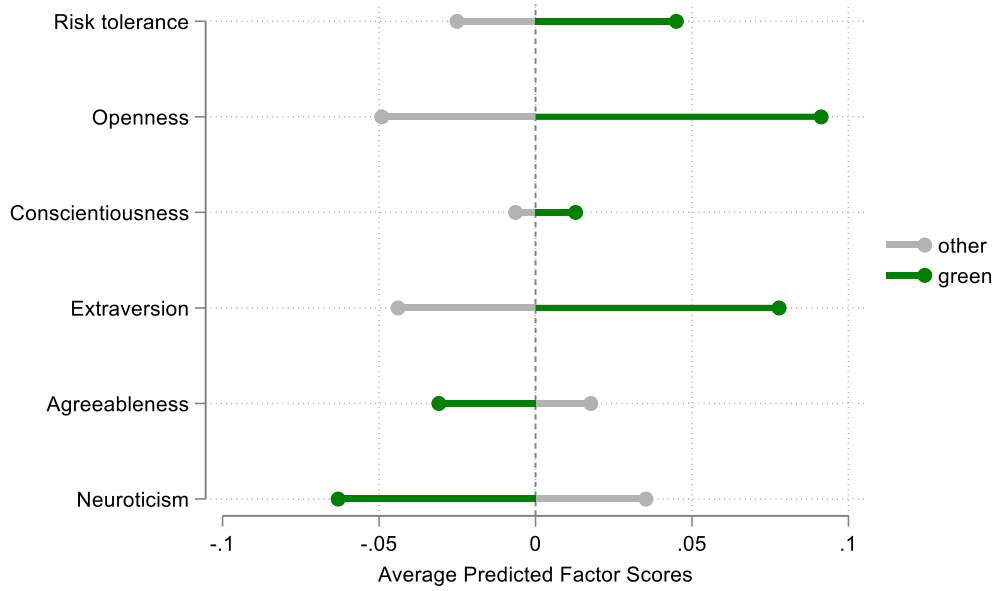

Table 3: Personality and Green Products

	(1)	(2)	(3)				
	Green product	Green product	Energy reduction	Resource reduction	Increased durability	Emissions reduction	Improved recycling
Risk tolerance	**0.013**	**0.020***	**0.009**	**0.014**	**0.025***	**0.038*****	**0.013**
	(0.010)	**(0.010)**	**(0.012)**	**(0.013)**	**(0.013)**	**(0.013)**	**(0.014)**
Openness	**0.072*****	**0.070*****	**0.038*****	**0.042*****	**0.096*****	**0.023***	**0.121*****
	(0.010)	**(0.010)**	**(0.013)**	**(0.013)**	**(0.014)**	**(0.013)**	**(0.015)**
Conscientiousness	**0.014**	**0.005**	**0.016**	**-0.002**	**0.009**	**-0.006**	**-0.003**
	(0.010)	**(0.010)**	**(0.012)**	**(0.013)**	**(0.013)**	**(0.013)**	**(0.014)**
Extraversion	**0.028*****	**0.038*****	**0.041*****	**0.053*****	**0.026***	**0.070*****	**0.016**
	(0.010)	**(0.009)**	**(0.013)**	**(0.013)**	**(0.014)**	**(0.013)**	**(0.015)**
Agreeableness	**-0.016***	**-0.010**	**-0.005**	**-0.006**	**-0.005**	**0.005**	**0.028****
	(0.010)	**(0.009)**	**(0.012)**	**(0.012)**	**(0.013)**	**(0.012)**	**(0.013)**
Neuroticism	**-0.055*****	**-0.031*****	**-0.063*****	**-0.037*****	**-0.031****	**-0.018**	**-0.017**
	(0.010)	**(0.010)**	**(0.012)**	**(0.012)**	**(0.013)**	**(0.013)**	**(0.014)**
Profit		0.035*	0.030	0.033	0.048	0.030	0.034
		(0.021)	(0.027)	(0.028)	(0.029)	(0.029)	(0.031)
Industry experience		0.002**	0.003*	0.002	0.006***	0.000	0.001
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
ln(R&D)		0.026***	0.026***	0.032***	0.024***	0.024***	0.025***
		(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Failure experience		0.012	-0.037	0.063	-0.006	0.079	-0.057
		(0.056)	(0.070)	(0.070)	(0.075)	(0.072)	(0.078)
Serial entrepreneur		-0.028	0.002	0.002	-0.055*	-0.034	-0.025
		(0.020)	(0.026)	(0.027)	(0.029)	(0.028)	(0.030)
ln(employees)		0.065***	0.042**	0.054***	0.083***	0.019	0.112***
		(0.016)	(0.019)	(0.020)	(0.021)	(0.020)	(0.022)
Female Founder		-0.106***	-0.287***	-0.057*	-0.150***	-0.238***	0.093**
		(0.023)	(0.034)	(0.034)	(0.037)	(0.036)	(0.037)
Opportunity driven		0.074***	0.080**	0.143***	0.060*	0.023	0.036
		(0.024)	(0.031)	(0.032)	(0.033)	(0.032)	(0.035)
University degree		-0.084***	-0.061**	-0.107***	-0.180***	-0.093***	-0.134***
		(0.021)	(0.028)	(0.029)	(0.030)	(0.029)	(0.032)
Founder age		0.006***	0.003**	0.005***	0.001	0.010***	0.008***
		(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Team		-0.070***	0.036	-0.055*	-0.031	0.003	-0.229***
		(0.023)	(0.030)	(0.031)	(0.033)	(0.032)	(0.035)

Exporter		0.039	0.012	0.103***	0.095***	-0.007	0.017
		(0.024)	(0.030)	(0.031)	(0.032)	(0.032)	(0.034)
East Germany		-0.053**	-0.093***	-0.065*	-0.022	-0.049	0.031
		(0.025)	(0.033)	(0.034)	(0.035)	(0.034)	(0.036)
Firm age		-0.019***	-0.013*	-0.014*	-0.031***	-0.014*	-0.031***
		(0.006)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Limited liability		-0.054**	-0.033	-0.032	-0.132***	-0.011	-0.111***
		(0.022)	(0.029)	(0.029)	(0.031)	(0.030)	(0.032)
Observations	11,496	11,496			11,496		
Joint sign. Pers. (F-Test)	19.50***	20.28***			200.42***		
Joint sign. of sectors (F-Test)	-	102.63***			1794.76***		
R^2	0.010	0.121			-		
Log likelihood	-	-			-36,821.23		
Correlations between equations (ρ)	-	-	$\rho_{1_2} = 0.770^{***}$	$\rho_{1_3} = 1.120^{***}$	$\rho_{1_4} = 0.599^{***}$	$\rho_{1_5} = 0.529^{***}$	$\rho_{2_3} = 0.854^{***}$
	-	-	$\rho_{2_4} = 0.786^{***}$	$\rho_{2_5} = 0.662^{***}$	$\rho_{3_4} = 0.708^{***}$	$\rho_{3_5} = 0.610^{***}$	$\rho_{4_5} = 0.888^{***}$

Note: The columns for models 1 and 2 show OLS regression results and the column for model 3 presents CMP regression result (ordered probit for individual items).
All models contain a constant and industry dummies. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Personality traits combined (OLS regression results)

	Risk tolerance	Openness	Conscientious-ness	Extraversion	Agreeableness
Openness	-0.006				
	0.009				
Conscientiousness	-0.014	**0.020*****			
	(0.009)	**(0.008)**			
Extraversion	**-0.026*****	0.011	**0.041*****		
	(0.009)	(0.008)	**(0.008)**		
Agreeableness	-0.002	**-0.038*****	0.001	**-0.037*****	
	(0.009)	**(0.009)**	(0.009)	**(0.009)**	
Neuroticism	-0.005	0.003	0.009	**0.023*****	-0.003
	(0.009)	(0.008)	(0.008)	**(0.008)**	(0.009)

Note: The table shows the estimated coefficient and standard error of the interaction term of the two traits, respectively, based on 15 regression models with one interaction terms included per model. The model specification is otherwise identical to Model 2 in table 3.

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Appendix Tables and Figures

Table A1: Measurement of personality traits

Question		Trait
1	In order to achieve corporate goals even in uncertain situations, my company proceeds… a) … rather cautiously, in a wait and see approach in order to avoid wrong decisions. b) …rather bravely and aggressively so as not to miss any business opportunities.	Risk tolerance
2	My company has a strong inclination for projects with a) … low risk and thus normal but secure returns. b) … high risk and thus opportunities for very high returns.	
1	I am someone who is original and who brings up new ideas. I am someone who values artistic experiences. I am someone who has vivid fantasies and a good imagination.	Openness to Experience
2	I am someone who works thoroughly. I am someone who is rather lazy.* I am someone who gets things done effectively and efficiently.	Conscientiousness
3	I am someone who is communicative and talkative. I am someone who can get out and be sociable. I am someone who is reserved.*	Extraversion
4	I am someone who is at times a little rude to others.* I am someone who can forgive. I am someone who is considerate and kind to others.	Agreeableness
5	I am someone who worries often. I am someone who gets nervous easily. I am someone who is relaxed and can handle stress well.*	Neuroticism

Notes: Answers to these questions were self-ratings on a Likert scale from 1 to 5. For the risk tolerance questions answering options were 1: completely a), 2: rather a), 3: undecided, 4: rather b), 5: completely b). For the baseline personality traits the answering options range from 1: does not apply to me at all to 5: fully applied to me. *These items were reversely coded before the factor analysis.

Table A2: Measurement of green innovations

Question:	*Since its foundation, has your company introduced innovations that have had the following environmental effects for your company?*	
	Item:	***Label:***
a)	Reduction of energy consumption or the total CO^2 balance in your company	Innovation: Energy reduction
c)	Reduction of material and resource consumption, e.g. water, in your company	Innovation: Resource reduction
b)	Reduction of further emissions into the air, water, soil or noise in your company	Innovation: Emission reduction
d)	Improving methods and tools of recycling within the company or own products	Innovation: Better recycling
e)	Increase the shelf life of your company's products	Innovation: Better durability

Notes: The answering options were 0: no effects, 1: Yes, some effects, 2: Yes, strong effects.

Table A.3: PCA for Green Offerings

Panel A: Products with environmental benefits				
Component	Eigenvalue	Difference	Proportion	Cumulative
1	**2.832**	**2.017**	**0.566**	**0.566**
2	0.815	0.303	0.163	0.729
3	0.512	0.021	0.103	0.832
4	0.491	0.142	0.098	0.930
5	0.350	.	0.069	1.000
Likelihood ratio test independent vs. Saturated: $chi^2(10)$ = 2.8e+04 Prob. > chi^2 = 0.000				

Panel B: Innovations with environmental benefits				
1	**2.679**	**1.829**	**0.536**	**0.536**
2	0.850	0.270	0.170	0.706
3	0.581	0.120	0.116	0.822
4	0.461	0.031	0.092	0.914
5	0.430	.	0.086	1.000
Likelihood ratio test independent vs. Saturated: $chi^2(10)$ = 2.3e+04 Prob. > chi^2 = 0.000				

Panel C: Big 5 personality traits				
1	**2.795**	**1.118**	**0.186**	**0.186**
2	**1.678**	**0.034**	**0.112**	**0.298**
3	**1.644**	**0.209**	**0.110**	**0.408**
4	**1.435**	**0.230**	**0.096**	**0.504**
5	**1.135**	**0.257**	**0.076**	**0.579**
6	0.878	0.057	0.059	0.638
7	0.821	0.105	0.055	0.692
8	0.716	0.055	0.048	0.740
9	0.662	0.026	0.044	0.784
10	0.636	0.028	0.042	0.827
11	0.608	0.066	0.041	0.867
12	0.542	0.027	0.036	0.903
13	0.515	0.016	0.034	0.938
14	0.499	0.064	0.033	0.971
15	0.435	.	0.029	1.000
Likelihood ratio test independent vs. Saturated: $chi^2(105)$ = 2.6e+04 Prob. > chi^2 = 0.000				

Panel D: Risk tolerance				
1	**1.404**	**0.808**	**0.702**	**0.702**
2	0.596	.	0.298	1.000
Likelihood ratio test independent vs. Saturated: $chi^2(1)$ = 2051.09 Prob. > chi^2 = 0.000				

Table A.4: Description of variables

Name	Unit of Measurement	Description
Industry Experience	Years	Number of years founder has worked in the same industry as the startup
Failure experience	Binary (yes/no)	Takes the value one if founder had a previous firm that closed due to liquidation or bankruptcy
Founder age	Years	Average founder age in the firm
Serial Entrepreneur	Binary (yes/no)	Takes the value one if founder had previously founded a firm
Female Founder	Binary (yes/no)	Takes the value one if at least one person in the founding team is female
Opportunity driven	Binary (yes/no)	Takes the value one if the founder indicated to have founded the firm to pursue a specific business idea, to exploit opportunity of higher earnings, or to pursue the opportunity to work independently and self-determined.
Academic	Binary (yes/no)	Takes the value one if at least one of the founders has a university degree
Profit	Binary (yes/no)	Takes the value one if the firm is at least at break even or makes profits in the reference year. Zero in case of a financial loss.
Exporting	Binary (yes/no)	Takes the value one if the firm has sales outside of Germany
Team founder	Binary (yes/no)	Takes the value one if the firm was founded by more than one person
ln(employees)	Head count	Total number of employees (excluding members of the founding team)
ln(R&D expenditures)	Euros	Amount spent on R&D in the reference year
East Germany	Binary (yes/no)	Takes the value one if the firm's location is in one of the five eastern German states
Cohort (firm age)	Years	Years since founding year, i.e., first year of business activity after registration
Limited liability	Binary (yes/no)	Takes the value one if the firm is a limited liability company
Industry indicators	Binary (yes/no)	Distinguishes between 11 different sectors of activity. See Table A.6 for details on the sample distribution across sectors.

Table A.5: Descriptive statistics of control variables

Variable	mean	sd	min	max
Industry experience	17.98	10.34	1	58
Failure experience	0.031	0.173	0	1
Founder age	44.95	10.24	17	99
Serial entrepreneur	0.420	0.494	0	1
Female founder	0.171	0.377	0	1
Opportunity	0.830	0.376	0	1
Academic	0.520	0.500	0	1
Profit	0.708	0.455	0	1
Exporting	0.216	0.411	0	1
Team founders	0.251	0.433	0	1
Ln(Employees)	1.341	0.659	0	6.009
Ln(R&D)	2.726	4.579	0	14.91
East Germany	0.141	0.348	0	1
Firm age	3.244	1.675	1	7
Limited liability	0.561	0.496	0	1
SECTOR:				
Cutting-edge manufacturing	0.065	0.247	0	1
High-tech manufacturing	0.061	0.239	0	1
Technical services	0.216	0.411	0	1
Software	0.087	0.282	0	1
Low-tech manufacturing	0.100	0.300	0	1
Other manufacturing	0.099	0.299	0	1
Knowledge-intensive services	0.074	0.261	0	1
Creative services	0.063	0.242	0	1
Other services	0.055	0.227	0	1
Construction	0.091	0.287	0	1
Trade	0.090	0.287	0	1

Notes: N = 11,496.

Table A.6: Sample distribution across sectors

Industry Classification	Freq.	Percent	Cum.
Cutting-edge technology	749	6.52	6.52
High-tech manufacturing	702	6.11	12.62
Technical services	2,478	21.56	34.18
Software	1,002	8.72	42.89
Low-tech manufacturing	1,148	9.99	52.88
Knowledge-intensive services	1,141	9.93	62.80
Other company services	847	7.37	70.17
Creative services	718	6.25	76.42
Other services	629	5.47	81.89
Construction	1,042	9.06	90.95
Retail / Trade	1,040	9.05	100.00
Total	11,496	100.00	

Table A.7: Descriptive Statistics for the green innovation variables

	Mean	Std. Dev.	Min	Max
Innovations with environmental benefits				
Innovation: Energy reduction	0.479	0.717	0	2
Innovation: Resource reduction	0.403	0.675	0	2
Innovation: Increased durability	0.322	0.660	0	2
Innovation: Improved recycling	0.301	0.625	0	2
Innovation: Emissions reduction	0.272	0.588	0	2
Predicted factor scores:				
Green innovations	0.000	1.000	-0.725	3.526

Table A.8: Robustness test CMP regression result for green innovation

	(1)	(2)	(3)				
	Green innovation	Green innovation	Energy reduction	Resource reduction	Increased durability	Emissions reduction	Improved recycling
Risk tolerance	**-0.014**	**0.003**	**0.010**	**-0.007**	**0.015**	**0.011**	**-0.010**
	(0.010)	**(0.010)**	**(0.013)**	**(0.013)**	**(0.014)**	**(0.014)**	**(0.014)**
Openness	**0.088*** **	**0.088*** **	**0.092*** **	**0.087*** **	**0.123*** **	**0.080*** **	**0.055*** **
	(0.010)	**(0.010)**	**(0.013)**	**(0.013)**	**(0.015)**	**(0.014)**	**(0.014)**
Conscientiousness	**0.087*** **	**0.062*** **	**0.043*** **	**0.071*** **	**0.009**	**0.075*** **	**0.070*** **
	(0.010)	**(0.010)**	**(0.012)**	**(0.013)**	**(0.014)**	**(0.014)**	**(0.014)**
Extraversion	**0.059*** **	**0.044*** **	**0.054*** **	**0.076*** **	**0.018**	**0.002**	**0.067*** **
	(0.010)	**(0.010)**	**(0.013)**	**(0.013)**	**(0.015)**	**(0.014)**	**(0.014)**
Agreeableness	**0.048*** **	**0.027*** **	**0.031*** **	**0.040*** **	**0.010**	**0.058*** **	**0.049*** **
	(0.010)	**(0.010)**	**(0.012)**	**(0.012)**	**(0.014)**	**(0.013)**	**(0.013)**
Neuroticism	**-0.047*** **	**-0.034*** **	**-0.011**	**-0.020**	**-0.058*** **	**-0.035*** **	**-0.009**
	(0.010)	**(0.010)**	**(0.012)**	**(0.013)**	**(0.014)**	**(0.013)**	**(0.014)**
Control variables	no	yes			yes		
Observations	11,496	11,496			11,496		
Joint sign. Pers. (F-Test)	44.43***	32.65***			345.13***		
Joint sign. Sectors (F-Test)	-	34.32***			1,036.86***		
R^2	0.027	0.094			-		
Log likelihood	-	-			-33,893.42		
Correlations between equations (ρ)	-	-	$\rho_{1_2} = 0.698^{***}$	$\rho_{1_3} = 1.031^{***}$	$\rho_{1_4} = 0.586^{***}$	$\rho_{1_5} = 0.517^{***}$	$\rho_{2_3} = 0.757^{***}$
	-	-	$\rho_{2_4} = 0.792^{***}$	$\rho_{2_5} = 0.634^{***}$	$\rho_{3_4} = 0.645^{***}$	$\rho_{3_5} = 0.615^{***}$	$\rho_{4_5} = 0.918^{***}$

Note: The columns for models 1 and 2 show OLS regression results and the column for model 3 presents CMP regression result (ordered probit for individual items).
All models contain a constant and industry dummies. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: Robustness test CMP regression result

	(1) Green product	(2) Green innovation
Risk tolerance	0.020*	0.003
	(0.010)	(0.010)
Openness	0.070***	0.088***
	(0.010)	(0.010)
Conscientiousness	0.005	0.062***
	(0.010)	(0.010)
Extraversion	0.038***	0.044***
	(0.009)	(0.010)
Agreeableness	-0.010	0.027***
	(0.009)	(0.010)
Neuroticism	-0.031***	-0.034***
	(0.010)	(0.010)
Controls	yes	yes
Observations	11,496	
Joint sign. Personality (F-test)	245.24***	
Joint sign. Sectors (F-Test)	1,399.28***	
Correlation equ. (1) and (2)	0.530*** (0.011)	
Log likelihood	-30,035.7	

Note: The model contains a constant and the full set of controls. Robust errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure A.1: Green start-up innovative activities by dimension of greenness (item responses)

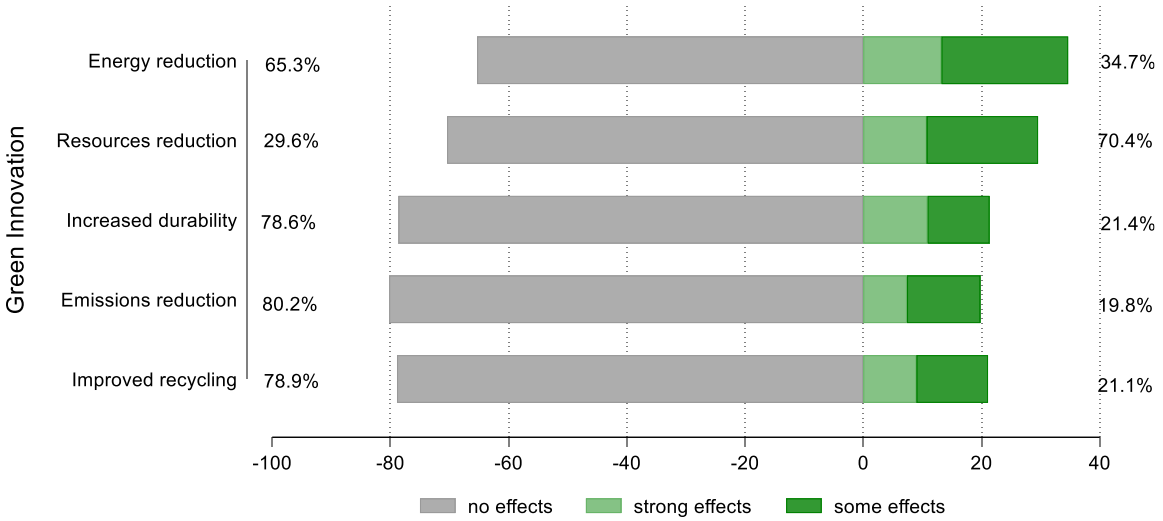


Figure A.2: Green innovation by sector

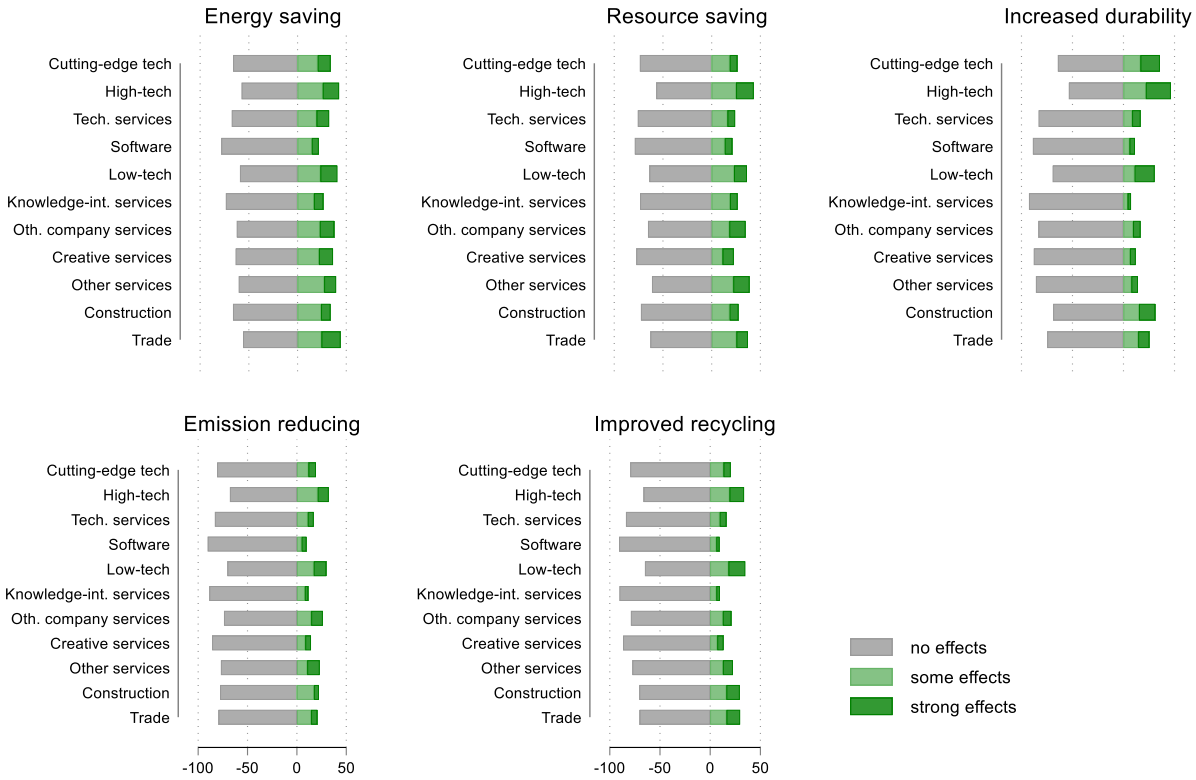
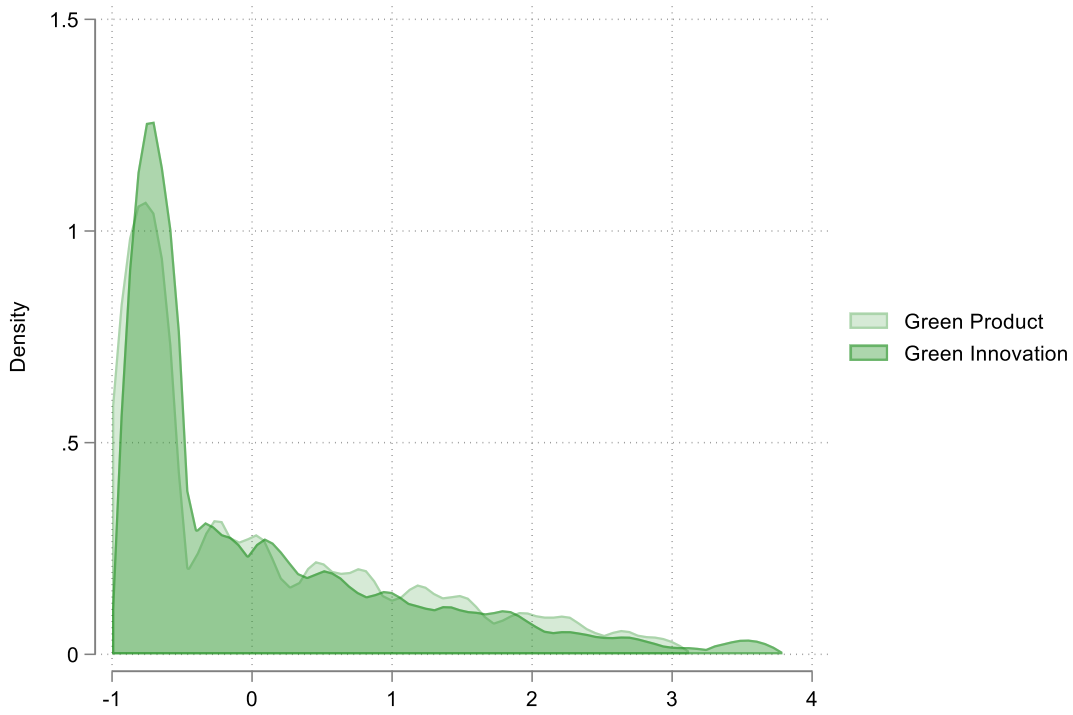


Figure A.3: Density distribution of the predicted factor scores



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