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Environmental and social attitudes and investments in crypto-assets

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ABSTRACT

The purpose of this study is to contribute to our understanding of the relationship of environmental and social attitudes of investors and their investment into crypto-assets compared to traditional assets. Given the controversies over the environmental footprint of some crypto-asset classes, primarily due to energy-intensive mining, they present an intriguing subject for investigation. Leveraging a unique household finance survey representative of the Austrian population, we examine whether environmental and social attitudes can elucidate the variance in individual portfolio exposure to crypto-assets. Results indicate a robust link between investors' environmental and social attitudes and their exposure to crypto-investments, yet no significant association was found with traditional asset benchmarks like bonds and shares.

KEYWORDS

Crypto-assets; investment portfolio; financial behaviour; financial literacy; environmental and social attitudes

JEL CLASSIFICATION

D14; G11

1. Introduction

In a standard asset pricing framework, financial decisions are determined by investors' attitudes and beliefs over asset returns. A more recent literature has also identified the relevance of investor environment and non-pecuniary effects in driving cross-sectional differences in investment decision (Chen, Hansen, and Hansen 2020; Jiang, Peng, and Yan 2021). Accordingly, an investor weighs between optimizing a standard mean-variance utility¹ and maintaining a 'target portfolio'. The mean-variance utility captures the pecuniary effect of standard mean-variance attitudes; investors' characteristics and personality differences affect investment decisions through these channels of beliefs and risk attitudes. The target portfolio, in a reduced form, reflects non-pecuniary effects, such as the social and ethical/moral concerns.

The focus of the present paper is on non-pecuniary effects related to environmental and social (E&S)² attitudes reflected in retail investor portfolio exposure to financial assets, including both traditional financial assets such as bonds and shares as well as new instruments such as crypto-

assets. Controversies surrounding the environmental, social, and governance (ESG) footprint of certain crypto-asset classes – mainly on grounds of their energy-intensive crypto mining – offer an informative object of inquiry.

In the financial investment literature, very little is known about E&S-conscious investor subjective beliefs about crypto-assets and how do these compare to traditional assets in the portfolio formation (Giglio et al. 2023). We aim to answer the question to what extent can environmental and social/ethical considerations explain cross-sectional differences in crypto-asset investments after controlling for investor individual characteristics and demographic variables. To benchmark our results, we compare how investors' E&S attitudes are related to their portfolio exposure to crypto-assets on the one side and 'E&S-blind' traditional financial assets, such as bonds and shares,³ on the other side.

The fact that crypto-assets are decentralized and rather anonymous compared to other centralized financial products is both a blessing and a curse for research. The blockchain – a back bone of crypto-assets – contains a wealth of information in digital

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¹The mean-variance utility assumes that random variables with the same mean and variance have equal desirability.

²Through the paper we use term 'E&S' since we can observe and measure only the environmental (E) and social (S) attitudes of individuals.

³Unlike the Swedish household survey utilized by Anderson and Robinson (2022), our survey questions do not identify separately E&S bonds/stocks and non-E&S assets.

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format and makes them near-real-time accessible for researchers. However, from a blockchain one can only get limited insight about investors actually holding these assets. Therefore, it is convenient to complement block-chain transactions with survey data to learn more about crypto-assets in the portfolio of private households.

This is the first paper that investigates if and to what extent E&S attitudes determine individual portfolio exposure to crypto-assets by leveraging representative individual-level portfolio data. The Austrian Survey of Financial Literacy (ASFL) data are unique because it includes separate data on crypto-asset holdings, a feature often lacking in standard household finance surveys. The ASFL data allow us to distinguish between individuals' investment choices between crypto-assets, bonds and shares. A common empirical challenge when estimating the effect of attitudes on portfolio composition is the potential endogeneity of investors' E&S attitudes. We take a number of steps in response to endogeneity concerns including an IV estimator. To deal with potential endogeneity in the absence of instruments for a standard IV approach, we employ an alternative identification strategy proposed by Lewbel (2012).⁴ It exploits variation on higher moment conditions of the error distribution from the first stage regression of the likely endogenous covariate on (a subset of) other covariates in the model.

There are two strands of literature our work is primarily related to. First, the household finance and asset pricing models in the sustainable and responsible investing (SRI) literature have examined the unconditional and conditional ESG stock return performance. The empirical literature has established that ESG assets might outperform non-ESG assets when positive shocks hit the ESG factor, which captures, for example, shifts in consumers' tastes for green products and investors' tastes for green holdings (e.g. Pastor, Stambaugh, and Taylor 2021). The explosive growth in responsible investing has given rise to a growing theoretical asset pricing literature that relies on non-pecuniary

utility functions (e.g. Ahmed, Gao, and Satchell 2021; Liu and Peifer 2022; Pastor, Stambaugh, and Taylor 2021). The conceptual explanation of the relationship between ESG attitudes and investment decision-making relies on the idea that social attitudes can affect investment decisions because they serve as a proxy for value-relevant information or risk, they can enhance performance or reduce risk (Krueger et al. 2020). Empirically, the link between ESG attitudes and portfolio choice is not that clear. Anderson and Robinson (2022) find no relationship between ESG attitudes and pro-environmental portfolios. Even less is known about non-pecuniary utility and its relation to crypto-assets. How do E&S-conscious investors value crypto-assets and do more sustainable based crypto investment products – such as those based on Proof-of-Stake (PoS)⁵ – offer superior risk-adjusted returns? Distinctively bridging the literature on non-pecuniary utility in financial decisions with the rapidly evolving world of crypto-assets, our study pioneers an exploration of how E&S-consciousness impacts individual exposure to this contemporary asset class. Our study contributes to a better understanding of non-pecuniary effects in individual investment decisions by assessing the role of an E&S-driven motivation in individual crypto investment decisions and benchmarking results against traditional asset holdings.

Second, a rich crypto-asset literature estimates the realized ESG footprint of crypto-assets (e.g. Barone and Masciandaro 2019; Foley, Karlsen, and Putnin 2019; Kohler and Pizzol 2019; Krause and Tolaymat 2018; Parmentola et al. 2022; Richman, Frankovitz, and McDonald 2021; Teichmann and Falker 2021). On the one hand, this literature suggests that crypto-assets have the potential to generate a variety of social and governance benefits either directly via a decentralized governance mechanism or via the way crypto-assets and the underlying blockchain technology are deployed (e.g. Chapron 2017; Ciaian, Rajcaniova, and Kancs 2016; Richman, Frankovitz, and McDonald 2021). On the other hand, crypto-

⁴The use of this estimation technique is increasingly popular in the household finance literature (e.g. Bannier and Schwarz 2018; Deuffhard, Georgarakos, and Inderst 2019). Practical application of this estimation procedure is detailed in Baum and Lewbel (2019).

⁵The PoS consensus mechanism is considered to be relatively energy-efficient, resulting in lower negative environmental impacts, especially when compared to the Proof-of-Work (PoW) consensus mechanism. The evidence suggests that PoS's energy efficiency may be several orders of magnitude lower than that of PoW (Ibañez and Rua 2023; Platt et al. 2021; Wendt, Doan, and Sassen 2023).

assets are sometimes associated with undesirable social activities, such as illicit trade, money laundering and tax evasion (e.g. Barone and Masciandaro 2019; Foley, Karlsen, and Putnin 2019; Teichmann and Falker 2021). Further, due to a continuously growing energy consumption to maintain the underlying blockchain network, certain crypto-assets are associated with negative environmental impacts. Particularly, the Proof-of-Work (PoW) consensus mechanism consumes large amounts of energy generating negative environmental externalities (e.g. Dilek and Furuncu 2019; Ghosh and Bouri 2022; Kohler and Pizzol 2019; Krause and Tolaymat 2018; Wendl, Doan, and Sassen 2023).

Overall, the literature findings of the relationship between social, environmental and governance aspects of crypto-assets on individual portfolio exposure to crypto holdings is largely inconclusive; it depends among others on the specific crypto-asset and individual perceptions of investors. Our main finding that stronger E&S attitudes go along with lower probability to hold crypto-assets, but not with traditional assets such as shares or bonds, conceivably ties in with previous literature on ESG attitudes and financial portfolio choice (see Anderson and Robinson 2022).

The present study contributes to enhancing our knowledge about the interplay between revealed E&S beliefs and portfolio holdings by providing novel insights about the relationship between environmental and social attitudes and individual portfolio exposure to crypto-assets. Indirectly, it therefore also conveys information about the perceived E&S footprint of crypto-assets by retail investors. Furthermore, it illustrates the value added of augmenting the information on crypto-assets in standard household finance surveys for enhancing our understanding about crypto-asset holdings and investment decisions within a general portfolio choice context and along with socio-economic information. Finally, the paper contributes to the growing literature on investor behaviour regarding cryptocurrencies (Almeida and Gonçalves 2023). Existing studies have analysed the role of various drivers in influencing cryptocurrency investment decisions, including news and media attention, emotions and investor sentiment

(e.g. Flori 2019; Kristoufek 2013; Mai et al. 2018), investors' herding behaviour (Bouri, Gupta, and Roubaud 2019; da Gama Silva et al. 2019; King and Koutmos 2021; Raimundo Júnior et al. 2020), investors' speculative behaviour (Grobys and Junttila 2021; Kukacka and Kristoufek 2023), diversification, hedging, and safe-haven properties of cryptocurrencies (e.g. Borri 2019; Petukhina, Reule, and Härdle 2021; Petukhina et al. 2021), intrinsic investor characteristics (e.g. financial literacy, attitudes towards risk) (e.g. Gemayel and Preda 2021; Gupta et al. 2020; Pelster, Breitmayer, and Hasso 2019) and socio-demographic characteristics of investors (e.g. Fahlenbrach and Frattaroli 2021; Xi, O'Brien, and Irannezhad 2020). Our paper expands this literature by specifically examining ESG investor behaviour in the context of crypto-asset decisions.

The paper proceeds as usual. Data and variables are described in section 2 and section 3 presents the implemented empirical framework and strategies. The results of the multivariate analysis, along with several robustness checks, are presented and discussed in section 4. Finally, section 5 concludes and offers policy implications.

II. Data and variables

Austrian survey of financial literacy

We leverage a unique individual portfolio data from the Austrian Survey of Financial Literacy (ASFL) for 2019 – the Austrian contribution to the OECD/INFE (International Network for Financial Education) survey on adult financial literacy. The standard OECD/INFE survey comprises questions on financial knowledge, attitudes and behaviour, used by the OECD to calculate the respective financial literacy scores, as well as several control variables and demographics (see OECD 2018). The ASFL survey was conducted with 1,418 respondents through computer-assisted personal interviews (CAPIs) between April and May 2019. After verifying individual responses and cleaning the data, the final working sample consists of 1,016 individual-level observations. The main descriptive results of the ASFL as well as methodological details are reported in Fessler

et al. (2020). First results on crypto-assets owners in Austria are reported in Stix (2021).

The description of variables used in empirical estimations is provided in Table A1 of the Appendix. Our main dependent variable measures whether an individual owns crypto-assets (*Crypto-assets ownership*). To compare how investors' behaviour differs between crypto-assets and traditional financial assets, we construct two further dependent variables capturing individuals' ownership of bonds (*Bonds ownership*) and shares (*Stocks/shares ownership*). In the empirical analysis, we focus solely on household investment participation decisions without considering the specific amounts invested in the particular asset class. This limitation is common in empirical household/personal finance literature that relies on observational survey data (e.g. Cupak, Fessler, and Schneebaum 2021; Ehrlich and Yin 2022). Additionally, our data does not differentiate between various types of crypto-assets, especially those using PoW versus PoS consensus mechanisms. The future potential extension of the scope of crypto-asset questions in larger household surveys will allow accounting for these important issues.

The explanatory variables of particular interest are those capturing environmental and social attitudes of retail investors. We consider one variable proxying environmental attitudes, *Attitudes for enviro. issues* (E), and two alternative variables capturing social attitudes, *Attitudes for social issues* ($S1$) and *Attitudes for social issues* ($S2$), respectively. All three environmental and social attitudes variables take values between 1 and 5 with a higher value indicating stronger attitude. More specifically, for environmental variable (E) a higher score indicates a stronger attitudes for environmental impact reduction over prioritizing financial returns.⁶ As for the first social variable ($S1$), a higher value indicates stronger positive attitudes towards financial choices with a stronger ethical stance. Regarding the second social variable ($S2$), a higher value suggests a stronger commitment to ethical choices, even when they might lead to a financial disadvantage. We also construct composite E&S indicators that measure combined environmental and social

attitudes of surveyed individuals. The composite E&S indicators are constructed by summing up the values of environmental and social attitude variables: i.e. $E\&S1$ is calculated as the sum of E and $S1$ and $E\&S2$ as the sum of E and $S2$. Distributions of the computed E&S scores are shown in Figure 1.

Drawing from the financial literature related to traditional financial assets, which argues that investors' non-pecuniary ESG beliefs can influence their investment choices (Ahmed, Gao, and Satchell 2021; Chen, Hansen, and Hansen 2020; Jiang, Peng, and Yan 2021; Liu and Peifer 2022; Pastor, Stambaugh, and Taylor 2021), we expect that the variables proxying E&S attitudes will impact investors' decisions regarding crypto-asset. This relationship is expected to hold as long as investors associate cryptocurrencies with positive or negative environmental and social effects. The literature identifies both positive and negative environmental effects related to cryptocurrencies (e.g. Dilek and Furuncu 2019; Ghosh and Bouri 2022; Ibañez and Rua 2023; Kohler and Pizzol 2019; Saleh and Jiang 2021; Wendl, Doan, and Sassen 2023) as well as positive and negative social impacts (e.g. Barone and Masciandaro 2019; Chapron 2017; Ciaian, Rajcaniova, and Kanacs 2016; Foley, Karlsen, and Putnin 2019; Richman, Frankovitz, and McDonald 2021; Teichmann and Falker 2021). Overall, if we estimate a positive (negative) relationship between the variables proxying E&S attitudes and crypto holdings, it will imply that the positive (negative) E&S concerns among investors more than offset the negative (positive) ones. Conversely, if the estimation yields statistically insignificant coefficients related to E&S attitudes, this will imply that investors fail to associate cryptocurrencies with either positive or negative environmental and social effects, or that these positive and negative social effects offset each other out (as perceived by investors).⁷

Following previous studies on individual investors' portfolio composition and returns and risky financial behaviour (e.g. Duarte et al. 2021; Ehrlich and Yin 2022), we include a number of control variables to account for individual characteristics such as age, gender, education (*Primary education*, *Secondary education*, *Tertiary education*) and income (*Individual monthly income*). An important driver of investment

⁶Note that we have reversed the response scale for the environmental attitudes variable compared to the original formulation of the question on which this variable is constructed. We made this adjustment to align it with the social attitudes variables.

⁷Similar arguments hold for traditional financial assets (shares and bonds) considered in the regression.

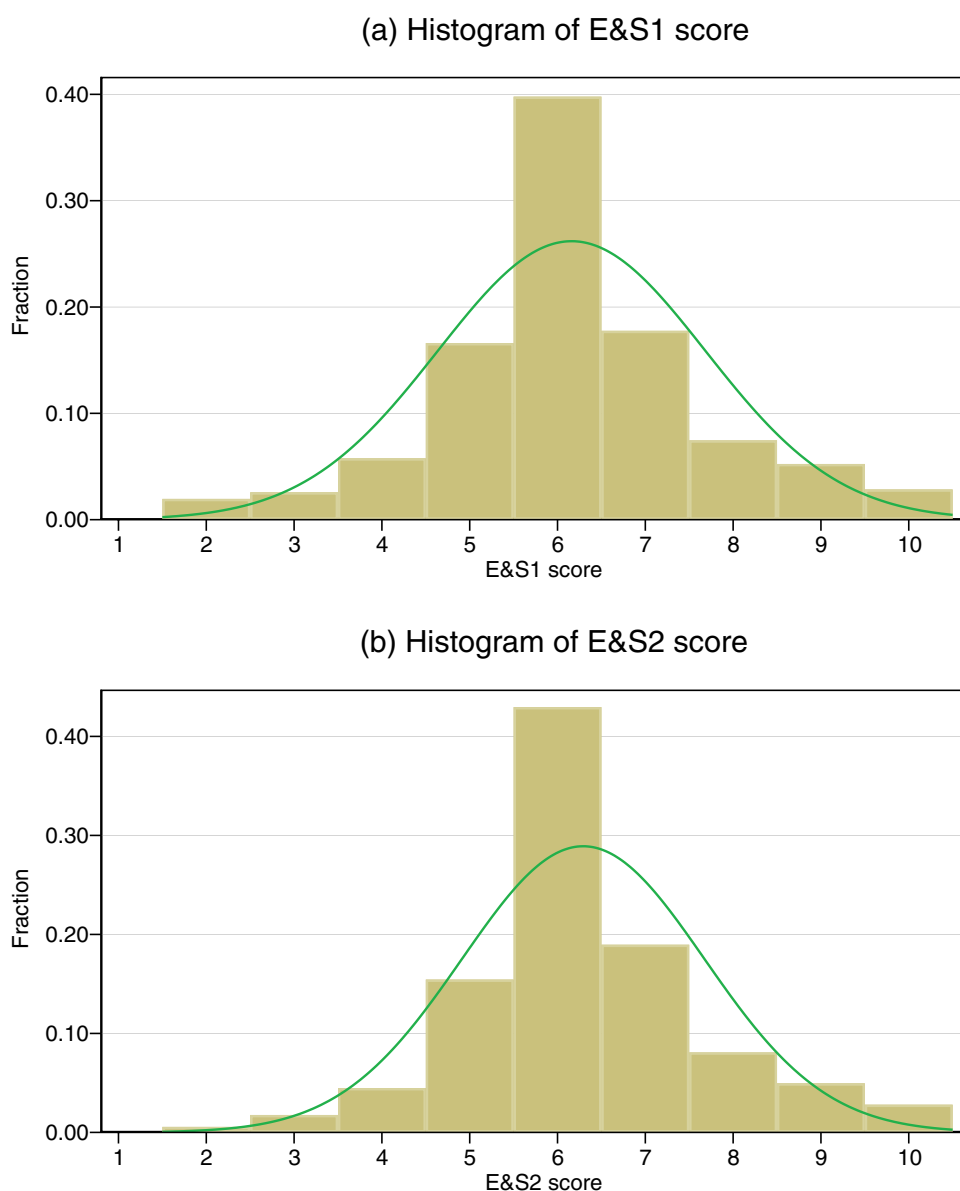


Figure 1. Distribution of E&S attitudes. This graph shows the distribution of two E&S attitudes overlaid by the normal density curve (green solid line). Source: ASFL 2019.

decisions of individuals identified in the literature is their objective financial literacy as well as their self-assessment of their own financial knowledge (see Bannier and Schwarz 2018; Bannier et al. 2019; Cupak, Kolev, and Brokešová 2019; Lusardi and Mitchell 2014). Two alternative explanatory variables describe financial literacy: the objectively measured financial literacy (*Objective fin. literacy*) and the self-

reported financial literacy (*Confidence in own fin. knowledge*).⁸ In an attempt to control for risk attitudes of surveyed responders, which were identified in the literature to affect investment decisions (Bekhtiar, Fessler, and Lindner 2019; Jiang, Peng, and Yan 2021), we also include a variable capturing self-reported willingness to take investment risk (*Risk attitude score*).

⁸Note that, investors interact with different virtual asset service providers (e.g., (de)centralized exchanges, wallets, banks, etc.) when acquiring crypto-assets. The use of different service providers may require varying levels of knowledge and skills among investors to execute crypto-assets acquisition transactions. For example, an investor using a decentralized cryptocurrency exchange is likely to possess more knowledge about different service providers than an investor using a standard method of acquiring crypto-assets, such as a centralized cryptocurrency exchange. We expect that the knowledge and skill variance across investors concerning different service providers is indirectly (and at least partially) captured by financial literacy and/or education variables.

Table 1. Descriptive statistics.

	N	Mean	SD	Min	Max
Crypto-assets ownership	1,402	0.03	0.18	0	1
Bonds ownership	1,398	0.07	0.25	0	1
Stocks/shares ownership	1,404	0.11	0.31	0	1
Attitudes for enviro. issues (E)	1,274	2.28	1.15	1	5
Attitudes for social issues (S1)	1,198	3.82	1.01	1	5
Attitudes for social issues (S2)	1,363	3.97	0.97	1	5
E&S1	1,126	6.17	1.52	2	10
E&S2	1,250	6.25	1.42	2	10
Objective fin. literacy	1,418	5.32	1.64	0	7
Confidence in own fin. knowledge	1,382	3.27	0.98	1	5
Risk attitude score	1,418	1.57	0.82	1	4
Primary education	1,382	0.14	0.35	0	1
Secondary education	1,382	0.76	0.43	0	1
Tertiary education	1,382	0.10	0.30	0	1
Individual monthly income	1,188	1,642.25	812.35	0	5,250
Gender: female	1,418	0.52	0.50	0	1
Age	1,418	49.08	18.20	16	97

Summary statistics computed using survey weights. There are three main regions (Region of East Austria, Region of South Austria, and Region of West Austria), which are equally represented in the survey.

Source: ASFL 2019.

Descriptive statistics

Table 1 reports descriptive statistics of surveyed individuals. Overall, around 3% of Austrian individuals report holding crypto-assets,⁹ while the share of individuals owning bonds or shares is 7% and 11%, respectively.¹⁰ The average score for environmental attitudes (3.7) exceeds the social attitudes scores (2.2 and 2.0, respectively) suggesting that the Austrian population might find environmental issues related to finance more important than social ones. Note that while S1 relates to ethics with regard to experienced choices of financial agents, S2 relates more generally to an assessment of one own's weight placed on ethics in financial decisions. That is why the first measure contains more missing values than the latter as not all individuals experience (regular) choices of financial assets (see Table 1). Both the objective and subjective financial literacy scores (average values of 5.3 and 3.3, respectively) place Austria to a group of OECD countries with a high financial awareness (see OECD 2018, for international comparison). Summary statistics of other relevant variables used in the empirical analyses are detailed in Table 1.

To gain further insights about the underlying ASFL data, we correlate the computed E&S1 and E&S2 scores with the probability of holding various

financial assets: crypto-assets, bonds and shares by means of binned scatter plots (Figure 2). A nuanced and somewhat unexpected pattern emerges: while we observe no relationship between environmental and social attitudes and the probability to own bonds or shares, the relationship is negative and statistically significant for crypto-assets.

III. Estimation approach

Our objective is to estimate the relationship between stated investors' E&S attitudes and the probability that individuals hold crypto-assets (non-pecuniary effect hypothesis), which we compare to traditional financial asset holdings. In particular, we estimate a linear probability model (LPM)¹¹ by means of OLS separately for each of the three asset classes (crypto-assets, bonds, shares) using the ASFL data:

$$\text{Ownership}_{ik} = \alpha + \beta_j E\&S_{ij} + \gamma X_i + \lambda + \varepsilon_i, \quad (1)$$

where Ownership_{ik} indicates whether i -th individual owns k financial asset, with $k = \text{crypto} - \text{assets}, \text{bonds}, \text{shares}$. $E\&S_{ij}$ are i -th individual's attitudes for environmental and social issues, for $j = E, S1, S2, E\&S1, E\&S2$ (see Table A1 in Appendix). X_i represents a set of control

⁹This estimated ownership rate is in line with external statistics on crypto-assets holding (see Figure 1, Appendix A).

¹⁰Note, that while there is some overlap between bonds and shares owners, it is far from perfect. About 62% of those holding bonds hold also shares and about 40% of those holding shares hold also bonds.

¹¹Note that one can also use logit and probit models, which result in estimates of marginal effects of similar order of magnitude. However, the linear probability model (LPM) specification, which is commonly used in the literature to analyse binary outcomes (e.g. Cupak, Kolev, and Brokešová 2019; Gan, Song, and Zhou 2022), ties in better with the approach of Lewbel (2012) we use later in our paper.

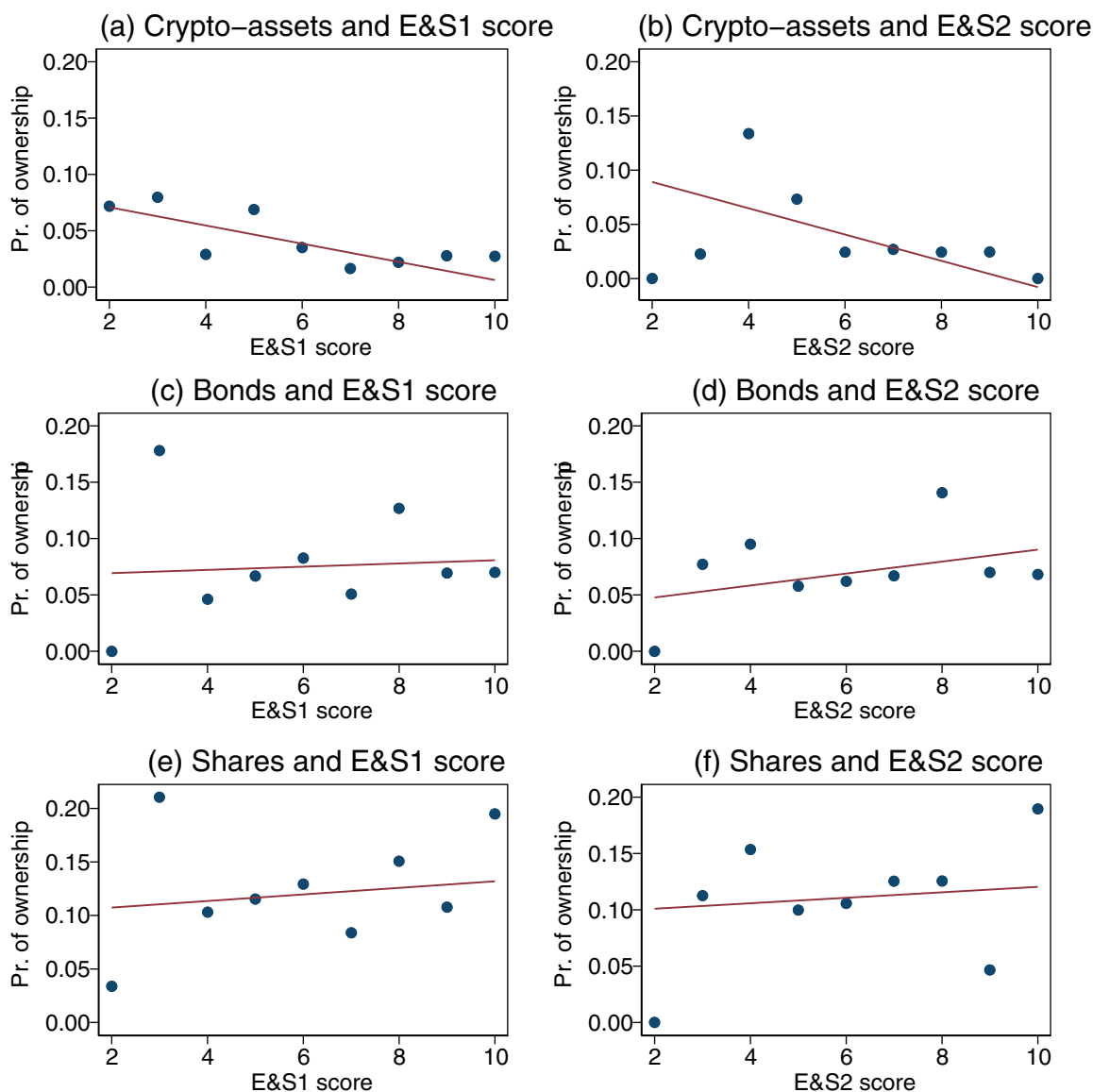


Figure 2. Correlation between environmental and social attitudes and holdings of different assets. This graph shows binned scatter plots (i.e. reduced form scatter plot) of E&S attitudes and holdings of different assets. The probability to hold a certain asset is shown on the vertical axis, while the E&S scores are shown on the horizontal axis. Source: ASFL 2019.

variables relevant for individual i 's investment decisions, such as age, gender, education, objective and self-assessed financial literacy, risk aversion, income, etc. To absorb time-invariant cross-sectional variation e.g. in informal institutions, social norms across Austrian provinces, we include regional fixed effects, λ , in all regressions. As usual, ε_i denotes the error term.

The choice of a portfolio allocation by an individual may itself affect E&S attitudes through different channels such as media exposure about related developments, interactions with investment fund managers or specific marketing targeting. We

attempt to mitigate such omitted variable bias by including economically-relevant covariates related to higher education and financial literacy in the regression model.

Despite the useful guidance of accumulated evidence from previous studies, it is impossible to know if all important variables have been included. Hence, the concern of the E&S endogeneity remains. To address the remaining confounders related to potentially endogenous E&S attitudes, we use an instrumental variables (IV) approach. Linear regression models containing endogenous regressors are generally identified using outside

information such as exogenous external instruments or by parametric distribution assumptions.

As argued above, in our main model (see Equation (1)), $E\&S_{ij}$ attitudes can be viewed as endogenous and hence correlated with ε_i . In the ASFL data, we have no exclusion assumption, meaning we have no outside source of instruments. As shown by Lewbel (2012), in such situations the model can be identified by exploiting variation on higher moment conditions of the first-stage error distribution.

Following Lewbel (2012) we first regress endogenous attitudes, $E\&S_{ij}$, on a constant and a set of covariates X_i : $E\&S_{ij} = \psi X_i + \omega_i$. Then, we take the estimated residuals $\hat{\omega}_i$ from the first-stage regression and let $R_i = (X_i - \bar{X})\hat{\omega}_i$, where \bar{X} is the sample average of X_i . Lewbel (2012) shows that under certain assumptions regarding heteroscedasticity

in the first-stage regression, which is a feature of our data (see Table 2), R_i is a valid vector of instruments for $E\&S_{ij}$ in Equation (1), resulting in consistent estimates.

IV. Results

Main results

Our baseline model specifications of Equation (1) – M1 and M2 – consider alternative composite E&S variables alongside the above detailed explanatory variables. The estimation results employing OLS and Lewbel (2012) IV approach (correcting for potential endogeneity of the E&S attitudes) for crypto-assets, bonds, and shares are displayed in Table 2. For a comparison with baseline results, we estimate four additional OLS specifications of Equation (1)

Table 2. Results on E&S attitudes for financial assets (OLS and Lewbel (2012) IV method).

	Crypto-assets				Bonds				Shares			
	(M1) OLS	(M1) IV	(M2) OLS	(M2) IV	(M1) OLS	(M1) IV	(M2) OLS	(M2) IV	(M1) OLS	(M1) IV	(M2) OLS	(M2) IV
E&S1	-0.008* (0.005)	-0.026** (0.012)			-0.004 (0.005)	-0.010 (0.015)			0.006 (0.009)	0.010 (0.029)		
E&S2			-0.010** (0.005)	-0.028* (0.015)			0.003 (0.006)	0.001 (0.015)			0.012 (0.009)	0.024 (0.034)
Objective fin. literacy	0.013** (0.006)	0.014** (0.006)	0.016*** (0.005)	0.017*** (0.006)	0.001 (0.006)	0.001 (0.006)	0.002 (0.005)	0.002 (0.006)	0.016* (0.009)	0.016* (0.009)	0.016** (0.008)	0.015* (0.009)
Confidence in own fin. knowledge	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013 (0.009)	0.013 (0.009)	0.012 (0.008)	0.012 (0.008)	0.019 (0.012)	0.020 (0.012)	0.022** (0.011)	0.022** (0.011)
Risk attitude score	0.056*** (0.014)	0.054*** (0.014)	0.058*** (0.014)	0.053*** (0.013)	0.044*** (0.012)	0.044*** (0.012)	0.049*** (0.012)	0.048*** (0.013)	0.128*** (0.018)	0.129*** (0.018)	0.127*** (0.017)	0.130*** (0.019)
Secondary education	0.004 (0.016)	0.004 (0.016)	0.003 (0.014)	0.002 (0.015)	0.032* (0.018)	0.032* (0.018)	0.024 (0.016)	0.024 (0.017)	0.042 (0.030)	0.042 (0.030)	0.027 (0.026)	0.028 (0.026)
Tertiary education	-0.025 (0.026)	-0.023 (0.027)	-0.029 (0.024)	-0.024 (0.026)	0.075* (0.043)	0.076* (0.043)	0.064 (0.041)	0.064 (0.040)	0.092* (0.055)	0.091* (0.054)	0.062 (0.050)	0.059 (0.047)
Individual monthly income	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Gender: female	-0.008 (0.012)	-0.003 (0.013)	0.004 (0.013)	0.008 (0.014)	-0.004 (0.016)	-0.003 (0.017)	-0.017 (0.015)	-0.016 (0.015)	0.011 (0.020)	0.010 (0.022)	-0.005 (0.019)	-0.007 (0.019)
Age	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.000)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Constant	-0.057 (0.048)	0.195** (0.077)	-0.053 (0.042)	0.211** (0.093)	-0.256*** (0.058)	0.128 (0.089)	-0.277*** (0.062)	0.057 (0.093)	-0.538*** (0.077)	0.045 (0.175)	-0.538*** (0.072)	-0.044 (0.207)
Regional fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R ²	0.100		0.110		0.116		0.117		0.212		0.205	
N	902	902	1,000	1,000	904	904	998	998	903	903	1,000	1,000
F-statistics		11.429		16.093		11.593		16.614		11.590		16.284
Breusch-Pagan test		25.004		55.105		24.883		56.325		24.841		54.704
p-value		0.005		0.000		0.006		0.000		0.006		0.000
Hansen J-test		8.887		8.495		9.554		11.947		12.954		7.791
p-value		0.448		0.485		0.388		0.216		0.165		0.555
Pagan-Hall test		112.554		138.939		133.875		171.490		289.830		322.216
p-value		0.000		0.000		0.000		0.000		0.000		0.000

Regressions estimated using survey weights. Robust standard errors are reported in parentheses. Dummy variable for 'Primary education' category is the reference category of the respective dummy variables set. All RHS covariates (i.e. instruments) in the IV models have been generated according to the Lewbel (2012) methodology which is implemented within the Stata 'ivreg2h' estimation command (Baum and Lewbel 2019).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.

in order to account for a potential multi-collinearity between the explanatory variables and to check the robustness of estimated coefficients. Models 3 and 4 consider E&S variables individually alongside the relevant socio-economic explanatory variables. Models 5 and 6 are similar to Models 3 and 4 except that they also include financial literacy and financial self-confidence. The estimated OLS results are reported in Tables 3, 4 and 5 for crypto-assets, bonds, and shares, respectively.

A striking key result is that the non-pecuniary effect hypothesis cannot be rejected based on the ASFL data: E&S-consciousness of investors has a statistically significant negative impact on individual portfolio exposure to crypto-assets. We observe this negative significant effect of E&S attitudes on crypto-asset portfolio composition for both baseline specifications in the IV estimations in Table 2. This

novel result is also confirmed across most OLS specifications in Table 3: in models M1, M2, M4 and M6. In line with crypto-asset perceptions often shaped by news media regarding their ESG footprint, our results confirm that retail investors with stronger E&S attitudes are less likely to invest in crypto-assets than their less E&S-conscious peers.

Turning to augmented OLS models, they provide additional specification and robustness checks by confirming that environmental attitudes have stronger negative impact on crypto-assets holdings than social attitudes of investors. Further, composite E&S coefficients tend to be as statistically significant as individual environmental but more statistically significant than social attitudes. This result is also confirmed by IV estimates¹² reported in Table 2 where all E&S coefficients are statistically significant and their magnitude is greater than in OLS models.

Table 3. Results on E&S attitudes for crypto-assets (OLS).

	(M1)	(M2)	(M3)	(M4)	(M5)	(M6)
Attitudes for enviro. issues (E)			-0.004 (0.005)	-0.011** (0.005)	-0.005 (0.005)	-0.012** (0.005)
Attitudes for social issues (S1)			-0.011 (0.008)		-0.013 (0.008)	
Attitudes for social issues (S2)				-0.004 (0.007)		-0.007 (0.007)
E&S1	-0.008* (0.005)					
E&S2		-0.010** (0.005)				
Objective fin. literacy	0.013** (0.006)	0.016*** (0.005)			0.013** (0.006)	0.015*** (0.006)
Confidence in own fin. knowledge	0.013* (0.007)	0.013* (0.007)			0.013* (0.007)	0.013* (0.007)
Risk attitude score	0.056*** (0.014)	0.058*** (0.014)	0.058*** (0.014)	0.060*** (0.013)	0.056*** (0.014)	0.059*** (0.014)
Secondary education	0.004 (0.016)	0.003 (0.014)	0.018 (0.017)	0.021 (0.015)	0.004 (0.016)	0.004 (0.014)
Tertiary education	-0.025 (0.026)	-0.029 (0.024)	0.002 (0.024)	0.001 (0.021)	-0.024 (0.026)	-0.029 (0.024)
Individual monthly income	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Gender: female	-0.008 (0.012)	0.004 (0.013)	-0.014 (0.013)	-0.002 (0.013)	-0.008 (0.012)	0.004 (0.013)
Age	-0.001** (0.000)	-0.001** (0.000)	-0.000 (0.000)	-0.001** (0.000)	-0.001* (0.000)	-0.001** (0.000)
Constant	-0.057 (0.048)	-0.053 (0.042)	0.023 (0.047)	0.005 (0.040)	-0.053 (0.048)	-0.058 (0.042)
Regional fixed effects	YES	YES	NO	NO	YES	YES
R ²	0.100	0.110	0.080	0.087	0.101	0.110
N	902	1,000	914	1,016	902	1,000
Wald test on E=S			0.768	0.844	0.856	0.339
p-value			0.381	0.358	0.355	0.560

Regressions estimated using survey weights. Robust standard errors are reported in parentheses. Dummy variable for 'Primary education' category is the reference category of the respective dummy variables set.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.

¹²First-stage regression results of the Lewbel (2012) approach are reported in Table A2. Holding other things equal, E&S attitudes positively correlate with being female, and with the level of individuals' financial literacy. These results are overall in line with the previous empirical literature (e.g. Gillan, Koch, and Starks 2021; Sabbaghi, Cavanagh, and Hipskind 2013). On the other hand, E&S attitudes are lower for risk-loving individuals.

Table 4. Results on E&S attitudes for bonds (OLS).

	(M1)	(M2)	(M3)	(M4)	(M5)	(M6)
Attitudes for enviro. issues (E)			0.002 (0.006)	0.002 (0.006)	0.001 (0.007)	0.002 (0.006)
Attitudes for social issues (S1)			-0.011 (0.008)		-0.011 (0.009)	
Attitudes for social issues (S2)				0.004 (0.010)		0.005 (0.011)
E&S1	-0.004 (0.005)					
E&S2		0.003 (0.006)				
Objective fin. literacy	0.001 (0.006)	0.002 (0.005)			0.002 (0.006)	0.002 (0.005)
Confidence in own fin. knowledge	0.013 (0.009)	0.012 (0.008)			0.012 (0.009)	0.012 (0.008)
Risk attitude score	0.044*** (0.012)	0.049*** (0.012)	0.047*** (0.012)	0.050*** (0.012)	0.045*** (0.012)	0.049*** (0.012)
Secondary education	0.032* (0.018)	0.024 (0.016)	0.037** (0.018)	0.031* (0.016)	0.032* (0.018)	0.025 (0.016)
Tertiary education	0.075* (0.043)	0.064 (0.041)	0.085** (0.042)	0.074* (0.041)	0.076* (0.043)	0.063 (0.042)
Individual monthly income	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Gender: female	-0.004 (0.016)	-0.017 (0.015)	-0.008 (0.016)	-0.019 (0.015)	-0.004 (0.016)	-0.017 (0.015)
Age	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Constant	-0.256*** (0.058)	-0.277*** (0.062)	-0.216*** (0.051)	-0.251*** (0.061)	-0.250*** (0.058)	-0.280*** (0.065)
Regional fixed effects	YES	YES	NO	NO	YES	YES
R ²	0.116	0.117	0.114	0.113	0.117	0.117
N	904	998	916	1,014	904	998
Wald test on E=S			1.463	0.044	1.246	0.097
p-value			0.227	0.834	0.265	0.755

Regressions estimated using survey weights. Robust standard errors are reported in parentheses. Dummy variable for 'Primary education' category is the reference category of the respective dummy variables set.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.

The results in Tables 2 and 3 further show that investment in crypto-assets varies by how risk averse investors are in their portfolio choices, by investor's financial literacy and age. Financially better educated and more risk-taking investors are more likely to invest in crypto-assets – a result also found in the recent empirical literature (e.g. Fujiki 2021). Regarding age, older individuals are less likely to invest in crypto-assets – as expected.

These results are in line with the previous literature (e.g. Krueger et al. 2020), as investors receive imperfect signals about the crypto-asset ESG footprint, which usually come from public sources such as news media or from their own idiosyncratic observations. Both risk and ambiguity lead to a cautious investor behaviour and an uncertainty premia in asset markets; learning under risk and ambiguity generates asymmetric responses to ESG-news. ESG attitudes affect investment decisions because they serve as a proxy for value-relevant information or risk, they enhance performance or reduce risk.

As a benchmark, we compare the crypto-asset holding probabilities with holding probabilities of traditional risky assets, namely bonds and shares in Table 2. While the estimated relationship between E&S attitudes and crypto holdings is statistically significant in most estimated models, we do not find such a statistically significant relationship between E&S attitudes and the probability to hold bonds or shares (see columns 1–4 in Table 2 compared to columns 5–8 and 9–12). OLS estimates in Tables 4 and 5 confirm these findings. This result finds strong support in the recent empirical literature on the ESG investing. For example, Anderson and Robinson (2022) have not found any statistically significant relationship between individuals' ESG attitudes and ownership of pro-environment portfolios (green bonds, stocks, and pension funds) in a sample of Swedish households. For our estimations, which are based on the AFLS data that do not identify separately E&S bonds/stocks and non-E&S assets,

Table 5. Results on E&S attitudes for shares (OLS).

	(M1)	(M2)	(M3)	(M4)	(M5)	(M6)
Attitudes for enviro. issues (E)			0.012 (0.010)	0.011 (0.010)	0.012 (0.011)	0.012 (0.010)
Attitudes for social issues (S1)			-0.000 (0.010)		-0.003 (0.011)	
Attitudes for social issues (S2)				0.016 (0.012)		0.013 (0.013)
E&S1	0.006 (0.009)					
E&S2		0.012 (0.009)				
Objective fin. literacy	0.016* (0.009)	0.016** (0.008)			0.017** (0.009)	0.016** (0.008)
Confidence in own fin. knowledge	0.019 (0.012)	0.022** (0.011)			0.019 (0.012)	0.022** (0.011)
Risk attitude score	0.128*** (0.018)	0.127*** (0.017)	0.131*** (0.018)	0.130*** (0.017)	0.128*** (0.018)	0.127*** (0.017)
Secondary education	0.042 (0.030)	0.027 (0.026)	0.058** (0.029)	0.047* (0.024)	0.042 (0.029)	0.027 (0.026)
Tertiary education	0.092* (0.055)	0.062 (0.050)	0.121** (0.052)	0.093** (0.047)	0.093* (0.054)	0.062 (0.050)
Individual monthly income	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Gender: female	0.011 (0.020)	-0.005 (0.019)	0.001 (0.021)	-0.013 (0.019)	0.011 (0.020)	-0.005 (0.019)
Age	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Constant	-0.538*** (0.077)	-0.538*** (0.072)	-0.418*** (0.065)	-0.433*** (0.069)	-0.532*** (0.077)	-0.539*** (0.074)
Regional fixed effects	YES	YES	NO	NO	YES	YES
R ²	0.212	0.205	0.198	0.189	0.213	0.205
N	903	1,000	915	1,016	903	1,000
Wald test on E=S			0.930	0.145	1.432	0.006
p-value			0.335	0.703	0.232	0.938

Regressions estimated using survey weights. Robust standard errors are reported in parentheses. Dummy variable for 'Primary education' category is the reference category of the respective dummy variables set.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.

this implies that the relationship between E&S attitudes and the probability to hold traditional assets are even less likely to be present if the findings of Anderson and Robinson (2022) were generalizable for Austria.

For the household finance literature that studies determinants of portfolio holdings, our results add a further piece of evidence that non-pecuniary effects indeed matter in explaining cross-sectional differences in investment decisions; whereby the association between E&S attitudes and crypto-assets is stronger compared to traditional risky assets like bonds and shares.

There are several environmental and social related factors at play that are likely perceived heterogeneously by investors and likely have implications for our findings. Regarding environmental factors, the leading cryptocurrency, Bitcoin, which holds the largest market share among crypto-assets, relies on a PoW consensus mechanism. This mechanism is often associated with high energy consumption and

adverse environmental effects. On the other hand, many other crypto-assets, particularly those in the PoS category, are more energy efficient resulting in lower environmental footprint. At the same time, the PoW-based blockchains are increasingly becoming more environmentally friendly by transitioning to renewable energy sources like solar, hydro or wind power (e.g. Dilek and Furuncu 2019; Ghosh and Bouri 2022; Ibañez and Rua 2023; Kohler and Pizzol 2019; Saleh and Jiang 2021; Wendl, Doan, and Sassen 2023). Similarly, from social dimension perspective, crypto-assets exhibit both negative and positive outcomes. While crypto-assets (regardless of being PoW and PoS based) have sometimes been associated with undesirable social activities, such as illicit trade, money laundering and tax evasion (e.g. Barone and Masciandaro 2019; Foley, Karlsen, and Putnin 2019; Teichmann and Falker 2021), they also hold the potential to bring forth various social benefits (e.g. privacy, financial inclusion, trust and transparency decentralization, charitable contributions) (e.g. Chapron 2017; Ciaian,

Rajcaniova, and Kanacs 2016; Richman, Frankovitz, and McDonald 2021).

Our findings, which reveal a negative relationship between E&S attitudes and crypto holdings, suggest that the negative E&S concerns among investors tend to more than offset the positive ones. Further, the finding that environmental attitudes have a stronger negative impact on crypto-asset holdings than social attitudes indicates that concerns related to the high energy consumption associated with PoW-based blockchains are more dominant. Social issues, on the other hand, either do not significantly concern investors or the positive and negative social outcomes associated with crypto-assets tend to offset each other out.

For the crypto-asset literature, the evidence we provide is supportive of crypto asset-related environmental concerns (e.g. high energy consumption in the PoW mining) being of first-order for crypto holdings, whereas social issues (e.g. financial inclusion) of second-order. E&S-conscious investors are less likely to invest in crypto-assets even though in the general crypto-asset class there are also crypto-currencies with neutral environmental effects (Platt et al. 2021). We find less support for a causal relationship between non-pecuniary effects related to social attitudes in the Austrian individual investor portfolio exposure to crypto-assets.

Further analysis and robustness

We estimate several additional models serving as robustness checks, for diagnostic purposes and transparency. First, we check if the coefficients remain stable after accounting for possible nonlinearities in effects of age and income. The results suggest that even considering the non-linear quadratic terms do not alter our main set of estimated E&S effects (see Table A3 in Appendix).

Second, given the binary nature of our dependent variable (ownership of crypto-assets), we estimate a set of probit regressions (results shown in Table A4) to check the robustness of our baseline estimates presented in Tables 2 through 5. Reassuringly, the probit marginal effects are somewhat smaller though of the same order of magnitude.

Furthermore, given the rare occurrence of the crypto-assets owners (around 3% of the sample), simple OLS or probit estimates might suffer from bias as suggested by King and Zeng (2001). Therefore, we have re-estimated our main OLS and probit models by means of a rare-events logit model.¹³ We report the estimation results from three rare-event specifications next to each other in Table A4 in Appendix. Once again, the OLS/LPM estimates are quite close to the marginal effects obtained from the estimated coefficients for rare-events logit model. This supports the OLS estimation approach also in the 2SLS IV framework.

Finally, we have checked the robustness of the estimated results with respect to the ordinal scales of each social and environmental attitude. Here, we consider a set of binary variables that take on a value of 1 if a respondent indicates that he or she cares about social and environmental issues, and 0 otherwise. The estimation results of this specification are presented in Table A5 and are qualitatively very similar to the baseline estimates presented in Table 2.

V. Conclusions

We studied the relevance of non-pecuniary effects in driving cross-sectional differences in individual investment decisions. In particular, we examined the relationship between E&S attitudes and holdings of crypto-assets; and compared how the investors' E&S attitudes effect on investment decisions differ between crypto-assets and traditional financial assets.

Our results suggest that on average individuals with stronger E&S attitudes tend to invest less frequently in crypto-assets than less E&S-conscious investors. Second, the association between environmental attitudes and crypto investments is of first-order, whereas social attitudes do not determine the portfolio exposure to crypto-assets of E&S-conscious investors. Our paper delivers a novel evidence regarding the E&S attitudes of individual investors exhibiting a subjective belief dynamics – in line with the household finance literature finding that a priori stated socially

¹³To estimate the rare-events logit model, we use the Stata estimation command 'relogit' implemented by Tomz et al. (2021).

‘desirable’ attitudes do not always match the attitudes revealed in the portfolio choice (Anderson and Robinson 2022). In line with a typical crypto-asset perception generated by news media with respect to their ESG footprint, our results confirm that retail investors with stronger E&S attitudes invest less likely in crypto-assets than their less E&S-conscious peers. We note, however, that there are also other potential reasons why such a result could actually be in line with consistent attitudes with regard to communication and actual portfolio choice. The individual investors who exhibit stronger nonpecuniary beliefs about their portfolio ESG footprint tend to be younger, above-average educated, and financially more literate compared to the general population or large corporate crypto-asset holders (Fujiki 2021; Mustafa et al. 2022; Stix 2021). Given the evident negative influence of E&S attitudes on crypto-asset investments, regulators and policymakers should therefore consider tailored financial education and awareness programmes, particularly targeting more affected or susceptible investors (e.g. younger, less educated), to ensure informed investment decisions in this rapidly evolving asset space.

These findings underscore the importance of considering non-pecuniary effects, such as the environmental, social, and ethical/moral attributes, when designing new digital currencies. As a number of central banks explore digital currency initiatives – i.e. central bank digital currency (CBDC) – recognizing these aspects is essential to ensure broader acceptance, particularly among ESG-conscious individuals. In this context, it is crucial for developers to disseminate educational programmes and materials aimed at raising awareness among the public, especially ESG-conscious individuals, regarding the ESG-related features and benefits of CBDC. This approach can help build trust and promote the adoption of CBDC. The relevance of the awareness campaign is highlighted by survey results of Abramova et al. (2022), which indicate rather small interest of Austrian residents in the digital Euro, especially in terms of its expected benefits.

Furthermore, our results demonstrate the added value of including separate items and more detailed information on crypto-assets and other alternative financial instruments in standard finance and wealth surveys. Our results also highlight the need

to collect detailed information on investor’s beliefs and attitudes within the household portfolio context, beyond the standard socio-economic variables, to gain a better understanding of individual investment decisions and behaviour. Moreover, given the growing interplay between E&S attitudes and investment dynamics, it becomes pertinent for financial institutions to offer clearer ESG disclosures and ratings specific to crypto-assets, enabling investors to align their portfolio decisions seamlessly with their ethical and social values.

While this paper delivered first insights, they are subject to a number of limitations which need to be kept in mind when interpreting these results. First, we need to mention a rather small sample size and the cross-section dimension of our data. Both limitations could be addressed with larger (both n and t) data sets. In this context, the relatively low proportion of individuals holding crypto-assets in the sample restricted the possibility to explore more nuanced relationships across different investor subgroups (e.g. by age, education, financial literacy, cryptocurrency literacy, large versus small investors). At the same time, a more detailed profile of individuals would also be required to further reduce potential sources of endogeneity. Further, our reliance on cross-sectional data limited to the year 2019 prevented us from capturing temporal dynamics of investors’ decision-making, especially considering the historical significant market volatility and the variable media exposure of cryptocurrencies over different time periods. Second, as the data is from Austria, the findings may not be generalizable to other countries or regions with different socio-economic, cultural, or regulatory contexts. Third, the binary nature of the dependent variable for crypto-asset ownership, without considering investment amounts or portfolio distributions restricted the possibility to provide more in-depth analyses regarding the full scope of investors’ financial behaviours in relation to E&S attitudes of investors. Finally, the data used in the paper does not differentiate between various types of crypto-assets, particularly those employing different consensus mechanisms (e.g. PoW and PoS). These variations could influence investors’ E&S perceptions and impact their portfolio choices differently.

Only survey data which includes both extensive and intensive margins of crypto-asset holdings along with the rest of the household balance sheet as well as a large number of socio-economic characteristics and attitudes will allow to create a deeper understanding of portfolio choice with regard to crypto-assets. Overall, we strongly believe that more research is needed using larger household finance datasets which allow for a more detailed and comprehensive socio-economic analysis of the relationship of ESG attitudes and portfolio choice with regard to crypto-assets. For these reasons, we call for an inclusion of crypto-asset questions into standard household finance surveys such as the Survey of Consumer Finances (US), the Wealth and Asset Survey (UK) or the Household Finance and Consumption Survey (Continental Europe). Such a micro-evidence-based understanding is urgently needed given the quick rise of crypto-assets especially among the younger investor cohorts, not only for potential regulation purposes but also to monitor the financial behaviour of households and potential risks created for the financial stability.

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Data availability statement

The paper uses non-public, individual-level microdata from the Austrian Survey of Financial Literacy (ASFL) collected by the Austrian Central Bank (Oesterreichische Nationalbank, OeNB). The ASFL data, which is part of the OECD/INFE 2020 International Survey of Adult Financial Literacy, can be officially applied for via an email address: SecretariatINFE@oecd.org.

Disclaimer

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Appendix A.

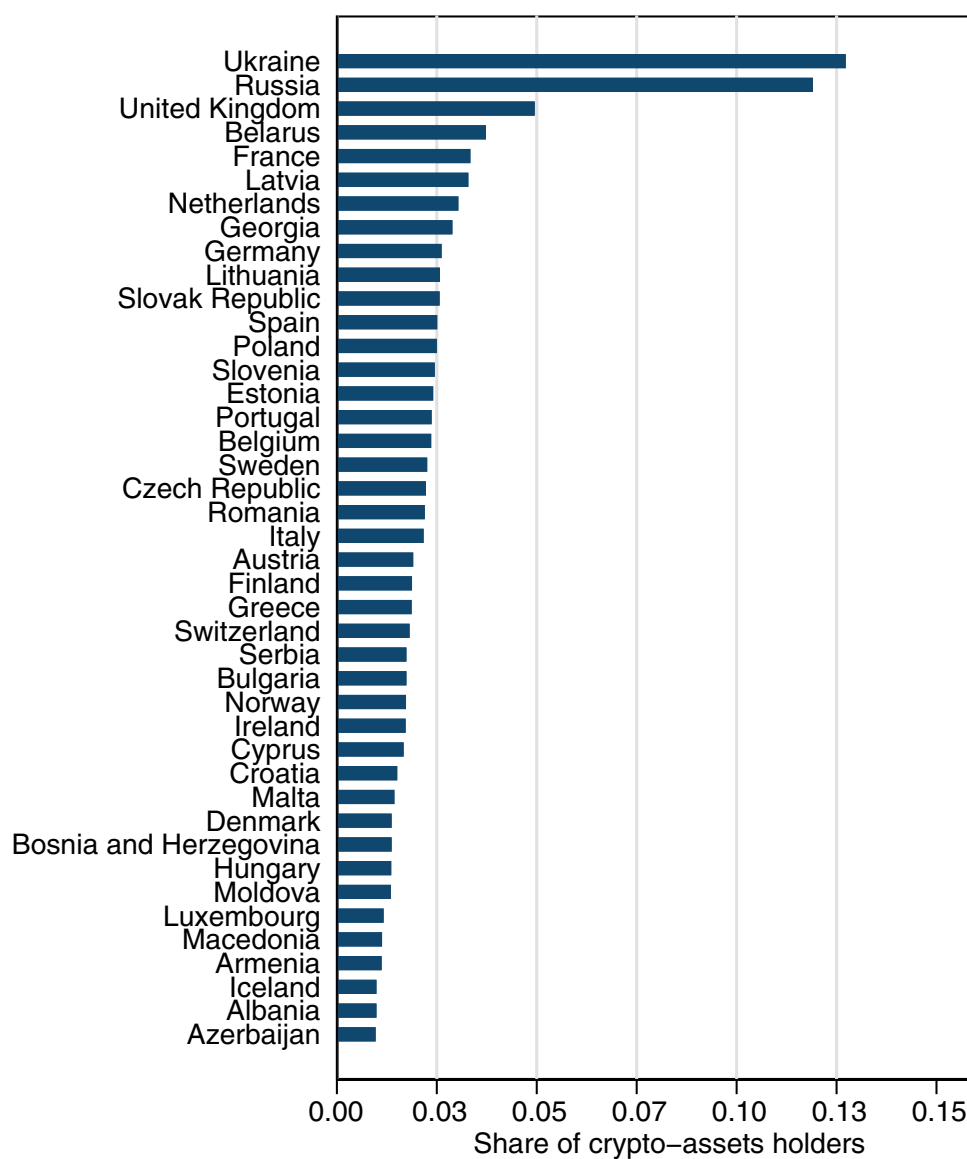


Figure A1. Share of population holding crypto-assets across Europe. Source: Based on data from <https://triple-a.io/crypto-ownership/>.

Table A1. Description of variables used in empirical analysis.

Variable	Description
Crypto-assets ownership	Dummy variable equal to 1 if an individual currently owns crypto-assets (including initial coin offerings), and 0 otherwise.
Bonds ownership	Dummy variable equal to 1 if an individual currently owns bonds, and 0 otherwise.
Stocks/shares ownership	Dummy variable equal to 1 if an individual currently owns stocks/shares, and 0 otherwise.
Attitudes for enviro. Issues (E)	Environmental attitudes score ranging from 1 to 5 (higher score means stronger attitudes); based on the survey question: <i>'I think it is more important for investors to choose companies that are making a profit than to choose companies that are minimizing their impact on the environment'</i> . Ranking of categories aligned with social attitudes scores for reasons of comparability.
Attitudes for social issues (S1)	Social attitudes score ranging from 1 to 5 (higher score means stronger attitudes); based on the survey question: <i>'I prefer to use financial companies that have a strong ethical stance'</i> .
Attitudes for social issues (S2)	Social attitudes score ranging from 1 to 5 (higher score means stronger attitudes); based on the survey question: <i>'I am honest even if it puts me at a financial disadvantage'</i> .
E&S1 (E + S1)	Combined environmental/social score by summing E and S1 variables.
E&S2 (E + S2)	Combined environmental/social score by summing E and S2 variables.
Objective fin. literacy	Financial literacy score ranging from 0 to 7; based on correct answers to 7 financial literacy survey questions (time value of money, interest paid on loan, interest plus principal, compound interest, risk and return, definition of inflation, diversification), see OECD (2018) for details.
Confidence in own fin. knowledge	Self-rated knowledge of financial matters ranging from 1 'very low' to 5 'very high'.
Risk attitude score	Willingness to take investment risk ranging from 1 'never' to 4 'always'.
Education	Dummy variables set for the three main education categories: no or primary education, secondary education, tertiary education.
Individual monthly income	Individual monthly net income in euros. 'Continuous' income is generated as mid points from very detailed income intervals asked to respondents: 0–450; 450–600; . . . , 4,800–5,100; 5,100 and above. Hence, measured income is top-coded.
Gender	Dummy variable equal to 1 if female, and 0 otherwise.
Age	Age in years.
Region	Dummy variables set for the three main regions: Region of East Austria, Region of South Austria, and Region of West Austria.

Source: Own processing based on the ASFL 2019 questionnaire.

Table A2. First-stage regression results (OLS).

	Crypto-assets		Bonds		Shares	
	(1) E&S1	(2) E&S2	(3) E&S1	(4) E&S2	(5) E&S1	(6) E&S2
Objective fin. literacy	0.041 (0.046)	0.075** (0.032)	0.038 (0.046)	0.071** (0.032)	0.037 (0.046)	0.073** (0.032)
Confidence in own fin. knowledge	-0.022 (0.072)	-0.024 (0.059)	-0.021 (0.072)	-0.025 (0.059)	-0.020 (0.072)	-0.023 (0.059)
Risk attitude score	-0.098 (0.080)	-0.279*** (0.064)	-0.098 (0.080)	-0.277*** (0.064)	-0.096 (0.080)	-0.279*** (0.064)
Secondary education	0.018 (0.208)	-0.066 (0.179)	0.018 (0.207)	-0.061 (0.179)	0.016 (0.207)	-0.070 (0.179)
Tertiary education	0.093 (0.277)	0.279 (0.261)	0.095 (0.276)	0.311 (0.262)	0.097 (0.277)	0.278 (0.262)
Individual monthly income	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Gender: female	0.277** (0.118)	0.231** (0.104)	0.274** (0.118)	0.225** (0.104)	0.279** (0.118)	0.226** (0.104)
Age	0.001 (0.004)	0.006* (0.003)	0.001 (0.004)	0.006* (0.003)	0.001 (0.004)	0.006* (0.003)
Region of South Austria	-0.273** (0.132)	-0.407*** (0.120)	-0.273** (0.132)	-0.400*** (0.120)	-0.269** (0.132)	-0.403*** (0.120)
Region of West Austria	-0.167 (0.131)	-0.333*** (0.107)	-0.155 (0.131)	-0.323*** (0.107)	-0.150 (0.131)	-0.325*** (0.107)
Constant	5.992*** (0.463)	6.239*** (0.382)	6.004*** (0.463)	6.264*** (0.382)	5.999*** (0.463)	6.257*** (0.382)
R ²	0.020	0.087	0.020	0.086	0.020	0.085
N	902	1,000	904	998	903	1,000

Regressions estimated using survey weights. Standard errors are reported in parentheses. Dummy variables for 'Primary education' and 'Region of East Austria' categories are the reference categories of the respective dummy variables sets.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.

Table A3. Robustness of results on E&S attitudes for crypto-assets (OLS, nonlinear effects of age and income).

	(1)	(2)	(3)	(4)	(5)	(6)
E&S1	-0.008*	-0.008*	-0.008*			
	(0.005)	(0.005)	(0.005)			
E&S2				-0.010**	-0.010**	-0.010**
				(0.005)	(0.005)	(0.005)
Objective fin. literacy	0.013**	0.013**	0.013**	0.016***	0.016***	0.016***
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
Confidence in own fin. knowledge	0.013*	0.013*	0.014**	0.013*	0.013*	0.014**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Risk attitude score	0.056***	0.056***	0.056***	0.058***	0.058***	0.058***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Secondary education	0.004	0.003	0.004	0.003	0.002	0.006
	(0.016)	(0.015)	(0.016)	(0.014)	(0.013)	(0.015)
Tertiary education	-0.025	-0.025	-0.024	-0.029	-0.030	-0.025
	(0.026)	(0.027)	(0.026)	(0.024)	(0.025)	(0.024)
Individual monthly income	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Individual monthly income squared		-0.000			-0.000	
		(0.000)			(0.000)	
Gender: female	-0.008	-0.008	-0.008	0.004	0.004	0.004
	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)
Age	-0.001**	-0.001**	-0.001	-0.001**	-0.001**	-0.003
	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.002)
Age squared			0.000			0.000
			(0.000)			(0.000)
Constant	-0.057	-0.057	-0.049	-0.053	-0.056	-0.020
	(0.048)	(0.050)	(0.062)	(0.042)	(0.045)	(0.060)
Regional fixed effects	YES	YES	YES	YES	YES	YES
R ²	0.100	0.100	0.100	0.110	0.110	0.111
N	902	902	902	1,000	1,000	1,000

Regressions estimated using survey weights. Robust standard errors are reported in parentheses. Dummy variable for 'Primary education' category is the reference category of the respective dummy variables set.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.

Table A4. Robustness of results on E&S attitudes for crypto-assets (comparison of OLS, probit, and rare-events logit models).

	(1) OLS	(2) Probit	(3) Rare-events logit	(4) OLS	(5) Probit	(6) Rare-events logit
E&S1	-0.008* (0.005)	-0.002 (0.002)	-0.006 (0.006)			
E&S2				-0.010** (0.005)	-0.003* (0.002)	-0.009* (0.005)
Objective fin. literacy	0.013** (0.006)	0.004** (0.002)	0.014* (0.007)	0.016*** (0.005)	0.005*** (0.002)	0.018*** (0.007)
Confidence in own fin. knowledge	0.013* (0.007)	0.008** (0.004)	0.018* (0.009)	0.013* (0.007)	0.006* (0.003)	0.015* (0.008)
Risk attitude score	0.056*** (0.014)	0.016*** (0.005)	0.040*** (0.009)	0.058*** (0.014)	0.013*** (0.005)	0.042*** (0.009)
Secondary education	0.004 (0.016)	0.003 (0.014)	-0.000 (0.046)	0.003 (0.014)	0.006 (0.012)	0.012 (0.053)
Tertiary education	-0.025 (0.026)	-0.008 (0.016)	-0.029 (0.051)	-0.029 (0.024)	-0.003 (0.013)	-0.017 (0.055)
Individual monthly income	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Gender: female	-0.008 (0.012)	-0.001 (0.005)	-0.005 (0.015)	0.004 (0.013)	0.004 (0.005)	0.009 (0.014)
Age	-0.001** (0.000)	-0.001*** (0.000)	-0.001*** (0.001)	-0.001** (0.000)	-0.000*** (0.000)	-0.002*** (0.001)
Regional fixed effects	YES	YES	YES	YES	YES	YES
R ²	0.100			0.110		
Pseudo R ²		0.272			0.305	
Area under ROC curve		0.888			0.901	
N	902	902	902	1,000	1,000	1,000

For probit and rare-events logit models we report marginal effects (calculated at the means of explanatory variables). Rare-events logit models are estimated using 'relogit' Stata estimation command (Tomz, King, and Zeng 2021). Regressions estimated using survey weights. Robust standard errors are reported in parentheses. Dummy variable for 'Primary education' category is the reference category of the respective dummy variables set.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.

Table A5. Robustness of results on E&S attitudes for financial assets (OLS and Lewbel (2012) IV method, discretized measures of E&S attitudes).

	Crypto-assets				Bonds				Shares			
	(M1) OLS	(M1) IV	(M2) OLS	(M2) IV	(M1) OLS	(M1) IV	(M2) OLS	(M2) IV	(M1) OLS	(M1) IV	(M2) OLS	(M2) IV
E&S1 (dummy)	-0.026* (0.016)	-0.072** (0.031)			-0.026 (0.021)	0.002 (0.050)			0.038 (0.043)	0.139 (0.113)		
E&S2 (dummy)			-0.026** (0.011)	-0.029 (0.022)			-0.013 (0.022)	-0.006 (0.036)			0.011 (0.040)	0.101* (0.059)
Objective fin. literacy	0.013** (0.006)	0.014** (0.006)	0.015*** (0.005)	0.015*** (0.005)	0.001 (0.006)	0.001 (0.006)	0.002 (0.005)	0.002 (0.005)	0.016* (0.009)	0.014 (0.009)	0.017** (0.008)	0.015* (0.008)
Confidence in own fin. knowledge	0.014* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013 (0.009)	0.013 (0.009)	0.012 (0.008)	0.012 (0.008)	0.019 (0.012)	0.020 (0.012)	0.022* (0.011)	0.023** (0.011)
Risk attitude score	0.056*** (0.014)	0.056*** (0.014)	0.061*** (0.014)	0.061*** (0.014)	0.044*** (0.012)	0.045*** (0.012)	0.047*** (0.012)	0.048*** (0.012)	0.128*** (0.018)	0.130*** (0.018)	0.124*** (0.017)	0.126*** (0.017)
Secondary education	0.003 (0.016)	0.001 (0.016)	0.002 (0.014)	0.002 (0.014)	0.031* (0.018)	0.032* (0.018)	0.023 (0.016)	0.024 (0.016)	0.043 (0.030)	0.047 (0.030)	0.027 (0.027)	0.032 (0.026)
Tertiary education	-0.025 (0.026)	-0.024 (0.026)	-0.031 (0.024)	-0.031 (0.024)	0.076* (0.043)	0.075* (0.043)	0.065 (0.041)	0.065 (0.041)	0.091* (0.054)	0.089 (0.054)	0.065 (0.050)	0.063 (0.051)
Individual monthly income	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Gender: female	-0.009 (0.013)	-0.008 (0.013)	0.003 (0.013)	0.003 (0.013)	-0.005 (0.016)	-0.006 (0.016)	-0.016 (0.015)	-0.016 (0.015)	0.011 (0.020)	0.008 (0.021)	-0.002 (0.019)	-0.007 (0.019)
Age	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Constant	-0.101** (0.039)	0.042*** (0.008)	-0.113*** (0.036)	0.038*** (0.007)	-0.276*** (0.055)	0.066*** (0.010)	-0.257*** (0.049)	0.064*** (0.009)	-0.512*** (0.077)	0.092*** (0.014)	-0.462*** (0.068)	0.094*** (0.010)
Regional fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
R ²	0.097		0.107		0.116		0.117		0.212		0.202	
N	902	902	1,000	1,000	904	904	998	998	903	903	1,000	1,000
F-statistics		18.450		36.060		18.277		36.552		18.254		35.497
Breusch-Pagan test		61.007		138.296		59.716		139.821		59.675		136.405
p-value		0.000		0.000		0.000		0.000		0.000		0.000
Hansen J-test		16.696		16.032		10.769		10.602		6.089		6.510
p-value		0.054		0.066		0.292		0.304		0.731		0.688
Pagan-Hall test		107.512		125.785		130.304		159.564		282.677		332.055
p-value		0.000		0.000		0.000		0.000		0.000		0.000

Regressions estimated using survey weights. Robust standard errors are reported in parentheses. Dummy variable for 'Primary education' category is the reference category of the respective dummy variables set. All RHS covariates (i.e. instruments) in the IV models have been generated according to the Lewbel (2012) methodology which is implemented within the Stata 'ivreg2h' estimation command (Baum and Lewbel 2019).

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: ASFL 2019.