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Empower the consumer!: Energy-related financial literacy and its socioeconomic determinants

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Empower the consumer! Energy-related financial literacy and its socio-economic determinants*

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Abstract

To be aware of the potential for energy savings in their homes, individuals need specific energy-related and financial knowledge. In addition, they also need the cognitive skills to apply this knowledge, for example when it comes to the calculation of the lifetime cost of household appliances or energy-efficient renovations. This set of knowledge and skills is related to two literacy concepts, i.e. energy and financial literacy. In this paper, we propose a new concept of literacy that we call “energy-related financial literacy”. Further, we present information on the level of financial literacy as well as on the level of energy-related financial literacy for a sample of European households. In the empirical part of the paper we estimate several ordered probit models in order to analyse the determinants of the level of energy-related financial literacy, with a particular interest to understanding the role of gender. Our results show that the level of energy-related financial literacy is relatively low and heterogeneous across the European countries. Moreover, the results confirm previous findings about the gender gap in financial literacy, with males being associated with higher levels of the index. We also identify such a gender gap for energy-related financial literacy.

Keywords: Energy literacy; financial literacy; energy-related financial literacy; consumer awareness; energy knowledge.

JEL Classification Codes: D12, D91, Q40

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1. Introduction

Previous research in energy economics has provided ample evidence of households underinvesting in new and more energy-efficient appliances and energy-efficient renovations of their houses, although these investments would be financially viable (see for example Allcott & Taubinsky, (2015)). In the literature, this is referred to as the “energy efficiency gap” (Jaffe & Stavins, 1994). In the household sector this gap could be considerable in size given that several studies show a relatively large potential for residential energy efficiency improvements (Filippini & Hunt, 2011; Blasch et al., 2017a; Boogen, 2017; McKinsey & Company, 2009; Weyman-Jones et al., 2015).

There are many possible explanations for the energy efficiency gap and a large body of literature has identified barriers that hamper the diffusion of energy efficient technologies (Broberg & Kazukauskas, 2015; Gillingham & Palmer, 2014). Two main types of explanations can be distinguished: market failures and behavioural failures. Possible market failures range from information asymmetries and transaction costs to credit constraints. In contrast, behavioural failures account for the fact that consumers do not behave as predicted by standard economic models. In this paper, we are mainly focusing on the behavioural failure of bounded rationality, i.e. the observation that a significant share of individuals have limited capacities to process information and therefore often fail to make optimal decisions based on rational calculations (Simon, 1959). Instead, many individuals use simple rules of thumb when making their choices (Blasch et al., 2017b).

Recent research in different countries suggests that large shares of the population are unaware of the savings they could realise by replacing their appliances by more energy efficient ones (Yamamoto et al., 2008; Attari et al., 2010a; Dianshu et al., 2010; Blasch et al., 2017b,c). In fact, to be aware of the savings, individuals need specific skills: on the one hand, they need to know about the energy consumption and the lifetime of their appliances and of possible new appliances that could replace the old ones. Furthermore, they need to know the cost of electricity and make assumptions on how frequently they plan to use their appliances. On the other hand, individuals also need to know how to process all this knowledge in order to calculate the lifetime cost of their current appliances and to compare them with the lifetime cost of new, more energy efficient appliances. Awareness about the possible savings thus requires both knowledge and the ability to apply this knowledge to compare two or more appliances. These energy-related knowledge and skills have sometimes been referred to as “energy literacy”. However, so far, the literature has not developed a common concept of literacy in the context of energy-related decision making in the residential sector.

An established stream of literature (DeWaters & Powers, 2011, 2013) has used a definition of “energy literacy” that focuses on an individual’s energy-related knowledge, attitudes and behaviour. However, recent empirical literature measures “energy literacy” as an individual’s ability to calculate and compare lifetime costs of energy consuming durables (Brounen et al., 2013; Kalmi et al., 2017).

Moreover, another group of papers (Blasch et al., 2017a,b,c) consider two separate literacy indicators, one for energy-related knowledge and another for investment literacy.

In this paper, we summarize the current state of research in this field and the various possible definitions of the terms “energy literacy” as well as its relation to the concept of “financial literacy” (Lusardi & Mitchell, 2014). Moreover, we propose a new concept of literacy that we call “energy-related financial literacy”. This concept combines both (1) the energy-related knowledge households need in order to take informed energy-related decisions and (2) the set of skills needed to process this information, which is comparable to the set of skills that is needed for financial investment decisions like pension planning. The proposed concept of “energy-related financial literacy” thus can be defined as the *combination of energy-related knowledge and cognitive abilities that are needed in order to take decisions with respect to the investment for the production of energy services and their consumption*. In our opinion, this definition is more appropriate than the ones introduced above, as it considers two important elements for a sound and informed investment decision in the energy sector: knowledge and ability to process information.

In the empirical part of the paper, we propose to measure this new literacy concept using a set of specific questions that we implemented in a large household survey in several European countries. Furthermore, we compare the level of this new literacy concept with the level of literacy obtained using different definitions of energy and financial literacy. In the second part of the empirical analysis we estimate several ordered probit models with the aim of investigating the determinants of the level of energy-related financial literacy, with particular emphasis on the role of gender. Previous literature provides evidence for a gender gap in financial literacy with women having a lower level of financial literacy than men (Almenberg & Dreber, 2015; Lusardi & Mitchell, 2014). We investigate whether such a gender gap can also be observed with respect to the energy-related financial literacy.

This paper contributes to the existing literature in several ways: *First*, it summarizes and clarifies the various concepts and definitions of “energy literacy” and proposes the new concept of “energy-related financial literacy” that captures the bounded rationality of individuals associated with energy-related decision-making in a more comprehensive way than other concepts. *Second*, the paper provides an econometric analysis of the determinants of “energy-related financial literacy” to better understand the drivers of this specific set of knowledge and skills among a large sample of European households. *Third*, this paper is the first to analyse the role of gender in the context of energy-related investment decisions. And *fourth*, the paper provides empirical evidence for the relevance of various types of literacies for energy-related investment decisions.

The rest of the paper is organised as follows. Section 2 discusses the existing literature in the field of energy and financial literacy and the concepts and definitions that are used in these papers. Section 3 presents the data used for our analysis and sample characteristics. Section 4 offers the

descriptive results of the level of energy-related financial literacy among the sample of European households. Section 5 provides the results of the empirical analysis of the determinants of energy-related financial literacy and Section 6 concludes.

2. Literature review

2.1. The concept of energy-related financial literacy

Although the literature on the role of energy-related knowledge and skills for individuals' investment decisions in the energy-context is growing steadily (Attari et al., 2010b; Blasch et al., 2017a,b,c; Brounen et al., 2013b; Kalmi et al., 2017b), a common understanding of the related concepts has currently not been developed. For instance, some studies propose a concept of energy literacy that focuses on energy-related knowledge (DeWaters & Powers, 2011, 2013), whereas other propose a concept of energy literacy based on economic calculations (Brounen et al., 2013). On the other hand, (Blasch et al., 2017a,b,c) propose a concept of literacy that includes both, energy-related knowledge and economic calculations.¹

DeWaters & Powers (2011) consider an energy-literate individual to *“[have] a sound conceptual knowledge base as well as a thorough understanding of how energy is used in everyday life, [understand] the impact that energy production and consumption have on all spheres of our environment and society, [be] sympathetic to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources, [be] cognizant of the impact that personal energy-related decisions and actions have on the global community, and – most importantly – [strive] to make choices and exhibit behaviours that reflect these attitudes with respect to energy resource development and energy consumption”* (p.1700). They thus define energy literacy across three domains: cognitive (knowledge), affective (attitudes, values), and behavioural. Moreover, they refer back to the literature on technological literacy (Pearson & Young, 2002) and environmental literacy (e.g. Disinger & Roth, 1992; Roth, 1992; Hollweg et al., 2011). Several empirical studies elicit energy literacy in accordance with this definition and focus on individuals' energy-related knowledge and awareness. For example, Yamamoto et al. (2008) show for a Japanese sample that a large share of the respondents are not aware of the energy efficiency of appliances or their electricity rates. Similarly, Dianshu et al. (2010) state that awareness and knowledge about electricity is low among household in Liaoning Province, China. Moreover, Attari et al. (2010) assess the perception of

¹ In a UNESCO report from 2006, literacy is defined as “ability to use reading, writing and numeracy skills for effective functioning and development of the individual and the community”. Thus, the concept of literacy considers both the level of knowledge an individual has, as well as the individuals applied skills (of reading and writing). We argue that both these aspects are important when considering the role of literacy in the field of energy-related investment decisions.

energy use and savings potential of different household activities in the US and find that on average energy use is underestimated by a factor of almost 3.

Another stream of recent empirical literature measures “energy literacy” as an individual’s ability to calculate and compare lifetime costs of energy-consuming durables (Brounen et al., 2013; Kalmi et al., 2017). According to Brounen et al. (2013), energy literacy is related to *“whether households are able to make a trade-off between long-term savings from energy efficiency investments and the upfront investments that are required to achieve improvements in energy efficiency”* (p. 43). They observe that less than half of the respondents in their sample are able to correctly evaluate investment decisions in energy efficient appliances. Kalmi et al. (2017) use a similar, but slightly broader definition and include in their concept of energy literacy *“awareness of different actions that consume energy and the price formation of household energy; how to evaluate the long-term decisions related to investments that improve energy efficiency; the willingness to take energy conserving measures; and the information needs of consumers and their willingness to gather information.”* (p.2). Preliminary results indicate that households in Finland also exhibit a low level of energy literacy (Kalmi et al. 2017).

(Blasch et al., 2017a,b,c) consider that in order to take a sound energy-related investment decision it is important to have energy-related knowledge as well as the skills to do financial calculations. The findings in (Blasch et al., 2017a,b,c) as well as the insights gained by Attari et al., (2010), who show that participants with a higher numeracy score have a more accurate perception of the energy use and savings potential of different household activities, suggest that besides knowledge and awareness, the computational skills needed for financial decision-making play a substantial role. In Blasch et al. (2017a) it is shown that more literate households are more likely to tap the savings potentials in their homes: they live in households with an overall lower electricity consumption. The results presented in Blasch et al. (2017b,c) suggest that individuals with a higher level of energy and investment literacy are more likely to calculate rather than using a rule of thumb when comparing two appliances. Consequently, these individuals are much more likely to identify the appliances with the lowest lifetime cost. It seems thus justified to include also the component of financial literacy in an accurate measure of energy literacy.

The literature on financial literacy is extensive but faced a similar debate around different definitions and concepts of the term financial literacy (Hung et al. 2009). In PACFL (2008), financial literacy is defined as “the ability to use knowledge and skills to manage financial resources effectively for a lifetime of financial well-being” (PACFL, 2008, p.7). However, the most common concept cited in the literature was introduced by Lusardi & Mitchell (2008, 2011) who define financial literacy as the “knowledge of basic financial concepts, such as the working of interest compounding, the difference between nominal and real values, and the basics of risk diversification” (Lusardi & Mitchell, 2008,

p.2). In line with their definition, financial literacy is usually measured with three questions related to numeracy and the capacity to do (compound) interest calculations, understanding the concept of inflation and understanding the concept of risk diversification (Lusardi & Mitchell 2014).

The idea of using an integrated concept for measuring energy and financial literacy of individuals which includes both measures of energy-related knowledge and awareness was already introduced by (Blasch et al., 2017a,b,c). However, in these works, the authors employ a less sophisticated measure of both energy-related knowledge and investment skills. In this paper, we extend this measurement further by including the full set of questions on financial literacy suggested in Lusardi & Mitchell (2014) and a lifetime cost calculation task and propose a new concept of *energy-related financial literacy* that considers the energy-related knowledge of households and the cognitive skills to perform an investment analysis. The concept of “energy-related financial literacy” is therefore a combination and extension of the existing concepts of energy literacy and financial literacy, taking into account energy-related knowledge but also the cognitive abilities that are needed in order to take decisions with respect to the investment for the production of energy services and their consumption.

2.2. The role of gender in the decision-making in households

In this paper, we are interested in the influence of gender on energy-related decision-making and how this is related to the underlying decision-making processes within the household. From the literature on financial literacy, we know that there is a large and persistent gender gap in financial literacy that seems to be stable across countries and age groups (Lusardi & Mitchell, 2014). Almenberg & Dreber (2015) show that women’s lower levels of financial literacy can also explain the gender gap in stock market participation, especially when accounting for the numeracy aspect of financial literacy. A conclusive explanation for the gender gap in financial literacy has not been found yet. Hsu (2016) suggests that women’s lower level of financial literacy is a result of division of labour between husbands and wives. To support this hypothesis she studies couples and unmarried individuals in the US and shows that in households in which the husband takes the role of the financial decision-maker most women catch up in financial literacy once approaching widowhood (Hsu, 2016). According to Lusardi & Mitchell (2014), however, also single women show lower levels of financial literacy, which cannot be explained by this theory. On the contrary, Fonseca et al. (2012) find that married women are more financially literate than unmarried women. Based on their study, they suggest that the gender gap cannot be explained by differences in the characteristics of men and women per se but by differences in how men and women “produce” financial literacy. They explain their result also with division of labour among married couples and assume that in many marriages men invest traditionally more in acquiring financial decision-making skills while women invest in other forms of human capital. They show that the relative differences in financial literacy between partners determine who takes the role of the main financial decision-maker in the

household; usually it is the partner with the relatively higher level of financial literacy. Men and women with a similar level of education, however, are more likely to share financial responsibilities. The same seems to hold for similar levels of earnings. Schneebaum & Mader (2013) conclude that a lower discrepancy between the earnings of the spouses increases the likelihood that they make decisions together.

Also Hung et al. (2012) discuss various explanations for the gender gap in financial literacy. Besides differences in education and skills, they also suggest that cultural aspects and societal norms assign the primary responsibility for certain aspects of financial decision-making to men, which gives women less exposure to financial products and less opportunities for learning-by-doing. As a further explanation, they suggest that men and women differ in the way how they acquire financial knowledge, even if they dispose of the same skills and opportunities to learn. These differences may be related to the frequent observation that women self-report lower levels of confidence when it comes to learning mathematics, which may again be driven by cultural and societal norms (Cho, 2017). As Gneezy et al. (2003) have shown, women tend to underestimate their actual abilities, especially when competing with males. This might increase their hesitation to get engaged in decisions that are traditionally taken by male household members.

Whether there is a direct analogy between financial decision-making of households and energy-related decisions is unclear. Less research has been conducted on the decision-making processes in households when it comes to energy-related financial decision-making. However, findings of Albert & Escardíbul (2017), confirm the result of Fonseca et al. (2012) in the context of consumer durables: for a Spanish sample they show that a higher level of education of both spouses has a positive effect in terms of a more egalitarian decision-making process in relation to expensive purchases of consumer durables. Contrary to the daily shopping, expensive purchases of consumer durables are mostly the result of a joint decision-making of both spouses, according to Albert & Escardíbul (2017). Belch & Willis (2006), however, find that in the US the decisions around the purchase of new household appliances are mainly made by the female partner. This suggests that the women's level of energy-related financial literacy could have a particularly strong influence on the energy-related purchase decisions of households. When it comes to differences in intra-household decision making structures between European countries, Schneebaum & Mader (2013) show that in most southern European countries it is less likely that women are the main decision-maker in the household, irrespective of the area of decision-making. Again, a smaller difference in the incomes of the two spouses seems to be associated with joint decision-making. Overall, there is not enough evidence in the literature about the extent to which males and females influence the household decisions when it comes to the purchase of new electric appliances. It is therefore unclear how a potential gender gap in energy-related financial literacy would impact the overall level of energy-efficiency of a household.

3. Data and descriptive statistics

As anticipated in the introduction, in the empirical part of this paper we present information on the level of financial literacy as well as on the level of energy-related financial literacy for a sample of European households. The data used has been collected through a large household survey completed in 2017 in three different countries in Europe (Italy, Netherlands, Switzerland).² Within this survey we collected information on household characteristics, dwelling characteristics, energy consumption, and information on the level of energy-related financial literacy. The survey was implemented in collaboration with different utilities in the three countries (Italy: ENI, Netherlands: Qurrent, Switzerland: Stadtwerk Winterthur and Aziende Industriali Lugano). ENI and Qurrent serve customers everywhere in Italy and the Netherlands, respectively. Stadtwerk Winterthur is a city utility located in the German part of Switzerland and Aziende Industriali Lugano is a regional utility serving a region in the Italian part of Switzerland.

The target population of the survey are the customers of the four electric utilities.³ Customers of each electric utility were invited with a letter accompanying the electricity (or gas) bill to access an online questionnaire.⁴ In total 149,100 households were contacted. In Italy, households were selected to be representative at the customer level of ENI based on the place of residence, contract characteristics, and historical consumption. In the Netherlands, target households were those having a smart meter and that had been customers of Qurrent for at least 6 months at the time of the survey. In Switzerland, targeted households were randomly drawn from the population of customers in Winterthur and the district of Lugano.⁵ In Italy and the Netherlands, the households were contacted via e-mail, while in Switzerland postal letters were sent out as invitations. Table 1 reports details on the recruitment process.

In addition, Table 2 gives a summary of the number of participants in each country, how many individuals accessed the survey and the number of respondents that finished the questionnaire. Overall 3.22% of the households that received the invitation to take the survey completed the survey (the country-specific response rates can be found in Table 2). This low response rate may be due to the fact that the questionnaire was relatively long.

² The survey was conducted within the EU H2020 Project “PENNY” (Psychological social & financial barriers to energy efficiency), which applies a behavioural science approach to better understand individual behaviour in the domain of energy efficiency. The project runs from 2016-2019 and is funded by the European Commission, Horizon 2020 Programme and the Swiss Government.

³ Participants to the survey were randomly selected only in Switzerland, whereas the in the other countries customers were selected upon different criteria.

⁴ The survey questionnaire was pre-tested among university students and employees of the participating utility companies. Based on feedback from the expert review and the pre-tests, the survey questionnaire was further refined and adapted.

⁵ In Switzerland, the electricity market is not yet open to competition for residential customers. Thus, the partner utilities in Winterthur and Lugano serve the whole population in the respective service area.

Table 1: Implementation of the large sample survey in the different countries.

	Switzerland	Netherlands	Italy
No. of households contacted	28,100	19,000	102,000
Means of contact	postal letter	e-mail	e-mail
Recruitment	Random sample of customers of two utilities: 13,100 in Lugano (city and surrounding municipalities) and 15,000 in Winterthur (city)	Participants with a smart meter. Customer for at least 6 months ⁶	ENI customers who have provided ENI with an explicit and written consent to be contacted by third parties for research purposes. The customer sample is layered so that it is representative ⁷ based on the place of residence, contract characteristics, and historical consumption.

Table 2: Number of respondents in the sample.

No. of respondents	Switzerland	Netherlands	Italy
Entered the survey	1,477	2,252	1,508
Completed the survey	1,080	1,923	1,475
Response rate	3.69%	11.85%	1.48%

A total of 4,796 households took part in the survey in the three countries. Representativeness of the sample cannot be ensured ex-ante due to two reasons: (1) Part of the sample has not been randomly drawn from the target population and (2) a self-selection might occur when invited individuals decide to take the survey. For this reason, we compare some relevant characteristics in the sample to corresponding statistics at the national level in order to provide indication of the representativeness of the sample. The majority of households in the Dutch sample (around 73%) and in the Swiss sample (51%) live in single-family houses, while 56% of the Italian households in the sample live in multi-family houses. The majority of the households in the sample also own the dwelling they live in. Compared to the national statistics, home-owners are slightly overrepresented in the sample in all three countries. The median gross monthly household income in the sample varies substantially across countries: In the Italian and the Dutch sample this figure ranges between 1'500 and 4'500 Euros, in the Swiss sample it ranges between 6'000 and 9'000 CHF. This is consistent with the median household income for the three countries as reported by OECD statistics. Further, educational attainments in the sample differ largely across the countries, with the share of respondents with tertiary education ranging from around 35% in Italy to around 70% in the Netherlands.

⁶ The research team in the Netherlands tried to go for 12 months (instead of 6 month), but then there would not be enough customers.

⁷ Representative on the customer level of ENI.

In Table 3, we provide descriptive statistics about the relevant socio-economic characteristics that we will use in the econometric analysis in Section 5, such as age of the respondent, household income, educational attainment and the working status. Unfortunately, due to missing information on some literacy questions and socio-economic variables, in the empirical analysis we were obliged to use only one part of the sample (N= 2823).

Table 3: Summary statistics (N=2,823).

Variable	Mean	Std. Dev.
Age	51.3475	14.5361
Income: Below 4'500 (Reference)	0.4577	0.4983
Income: 4'501-6'000	0.1431	0.3502
Income: 6'001-9'000	0.1552	0.3621
Income: Above 9'000	0.2356	0.4244
Up to lower secondary school (Reference)	0.0616	0.2405
Upper secondary school diploma	0.1888	0.3914
Vocational secondary school diploma	0.1676	0.3735
3-year university degree	0.2473	0.4315
5-year university degree and more	0.3348	0.4720
Rented dwelling (Reference)	0.2717	0.4449
Owned dwelling	0.7283	0.4449
Male (Reference)	0.6784	0.4672
Female	0.3216	0.4672
Switzerland (Reference)	0.2593	0.4383
Italy	0.2926	0.4550
Netherlands	0.4481	0.4974
Working (Reference)	0.6695	0.4705
Not working	0.3305	0.4705
Couple household, partner has university degree	0.3401	0.4738
Couple household, partner is not working	0.2728	0.4455

4. Level of energy-related financial literacy in Europe

One important goal of the paper is to assess the level of energy-related financial literacy of the households in the European sample. For this purpose, we elicit the respondents level of this type of literacy using eight questions. The first question asks about the knowledge of the average electricity price in the respondent's country. The second and third questions aim at assessing the level of knowledge of the households about the operating costs of appliances. We ask about the approximate cost of using a desktop computer for one hour and that of running a washing machine with a load of 5 kg at 60°C. The fourth question aims at understanding whether respondents are aware about the savings potential of LED technology. The three standard financial literacy questions on compound

interest, inflation and risk diversification introduced by Lusardi & Mitchell (2014) are also included. The latter are included to capture the extent to which respondents are familiar with fundamental concepts related to investment decisions. Finally, we include a question that aims at understanding whether respondents can perform an investment calculation in the context of energy-efficiency. Thus, respondents are asked to calculate and compare the lifetime cost of two different fridges. Summarising, the index of energy related financial literacy has three components: the energy knowledge component (questions 1-4), the financial literacy component (questions 5-7) and the energy related investment component (question 8). The complete set of these eight questions can be found in the Appendix.

Figure 1 shows the share of respondents answering correctly to the different questions in the entire sample, while a cross-country comparison is reported in Table 4. Results indicate that, while respondents perform well in the standard financial literacy questions, a substantial lack of knowledge in the field of energy literacy emerges. Only around 27 percent of the respondents know about the electricity price in their country, while 73% either indicate a wrong value or don't know at all.⁸ The level of knowledge about the electricity price varies substantially across countries in the sample, with the share of respondents answering correctly ranging from around 11% in Italy to almost 37% in the Netherlands. The data are also informative that respondents are quite illiterate with respect to the appliances' operating cost. Only around 29% of the respondents in our sample are aware of the monetary costs of running a washing machine and, similarly, around one third of respondents know the costs of running a desktop PC for one hour. Country-level information shows that the indicators of knowledge related to the appliances' operating cost differ significantly across countries, with Swiss respondents answering correctly more often. Moreover, only about half of the respondents are aware of the energy savings potential associated with using a LED light bulb compared to a conventional halogen bulb (70-80%). The share of households aware of the LED saving potential is greater in Switzerland (around 59%) and smaller in Italy (around 42%).

A large majority of respondents answered correctly to the three standard questions that aim at measuring financial literacy as introduced by Lusardi & Mitchell (2008, 2011). In particular, 90%, 84% and 80% of households in our sample answered correctly to the questions on compound interest rate, inflation and risk diversification, respectively.⁹ The share of respondents answering correctly varies significantly across countries, with higher levels of financial literacy measured for Dutch and Swiss respondents. As for the evidence on the standard financial literacy questions,

⁸ The average electricity price per kWh actually charged to residential customers in the first semester 2017 ranges between 0.16 eurocents in the Netherlands to 0.21 eurocents in Italy. We define respondents as correct in their answer when the value they estimate for electricity price in kWh ranges between 15 and 25 cents.

⁹ These statistics compare to the 67, 75 and 52 percent of respondents answering correctly to the same three financial literacy questions in the 2004 HRS Planning Module for the United States, as computed by Lusardi & Mitchell (2014).

substantial heterogeneity in the share of respondents answering correctly emerge from the data, with the figure ranging from around 30% in Italy to around 55% in the Netherlands.

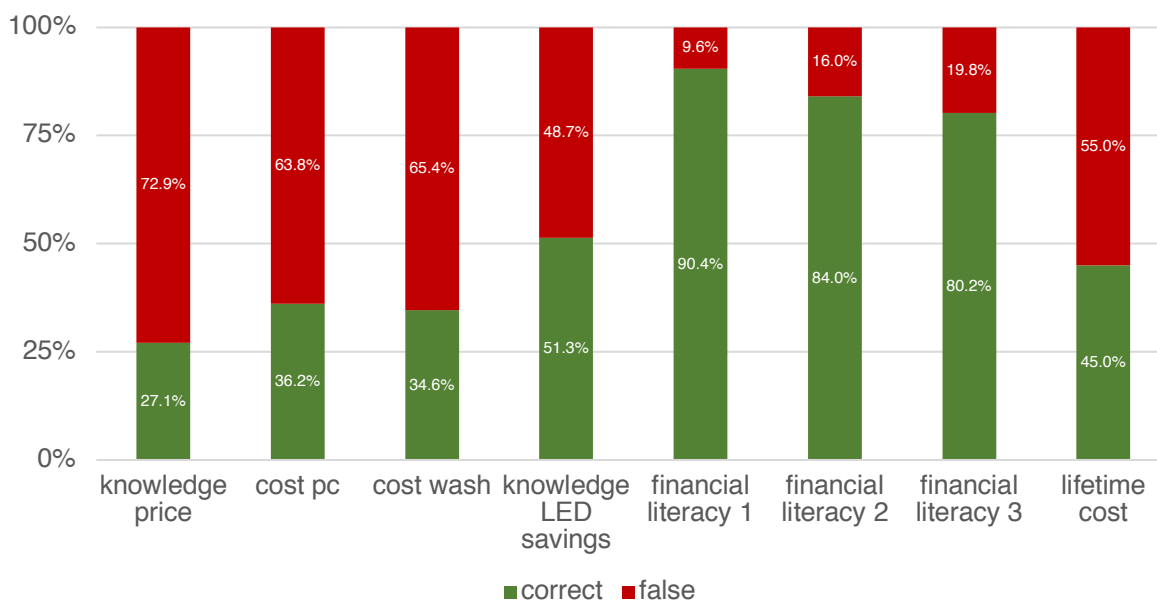


Figure 1: Results of survey questions on energy-related financial literacy.

Table 4: Results of survey questions on energy-related financial literacy across countries.

		Italy (%)	Netherlands (%)	Switzerland (%)
Knowledge price	Correct	11.41	36.77	29.15
	False/Don't know	88.59	63.23	70.85
Cost of washing	Correct	29.03	33.91	44.09
	False/Don't know	70.97	66.09	55.91
Cost of PC	Correct	31.1	33.73	48.37
	False/Don't know	68.9	66.27	51.63
Knowledge LED savings	Correct	41.78	54.46	59.13
	False/Don't know	58.22	45.54	40.87
Compound interest rate	Correct	84.62	92.65	94.49
	False/Don't know	15.38	7.35	5.51
Understanding of inflation	Correct	76.99	87.84	86.97
	False/Don't know	23.01	12.16	13.03
Risk diversification	Correct	72.08	83.59	85.42
	False/Don't know	27.92	16.41	14.58
Lifetime cost calculation	Correct	30.17	54.96	47.78
	False/Don't know	69.83	45.04	52.22

4.1. The importance of the different components of energy-related financial literacy

When assessing the importance of jointly considering the different components of literacy in the context of energy-related decision making, we are interested in both the correlation between (sub-groups of) components as well as the reliability and internal consistency of the scales adopted.

First, we explore the correlation between the different components of energy-related financial literacy distinguishing between those related to energy-related knowledge and those related to the set of skills required to process this knowledge. We then build an index of energy-related knowledge (index

1) summing the scores obtained from the questions about the knowledge of the average electricity price in the respondent's country, the cost of running a desktop computer and a washing machine, and the awareness of the savings potential of the LED light bulbs. We further consider an index obtained using the three standard financial literacy questions (index 2) as well as an indicator for the ability to perform a lifetime cost calculation (index 3). The correlation between the three indices ranges between only around 25 percent (lifetime cost calculation indicator and financial literacy index) and 27 percent (energy-related knowledge and financial literacy index).

Table 5: Correlation of the energy-related knowledge index, the financial literacy index and the lifetime cost calculation indicator.

	(Index 1)	(Index 2)	(Index 3)
	Energy-related knowledge	Financial literacy	Lifetime cost calculation
Energy-related knowledge	1.0000		
Financial literacy	0.2695	1.0000	
Lifetime cost calculation	0.2566	0.2460	1.0000

Table 4: Internal consistency of indices of literacy in the context of energy-related decision making

	(Index 1)	(Index 1 & 3)	(Index 2)	(Index 2 & 3)	(Index 1 & 2 & 3)
	Energy-related knowledge	Energy-related knowledge & Lifetime cost calculation	Financial literacy	Financial literacy & Lifetime cost calculation	Energy-related financial literacy
Cronbach's alpha	0.5773	0.5870	0.5811	0.5688	0.6501
Observations	3653	3653	3653	3653	3653

Although the correlation between these measures of literacy is low, the data suggest a good degree of internal consistency reliability. In Table 4, we report the values of Cronbach's alpha for the components used to build the energy-related knowledge (Column 1), the latter together with the lifetime cost calculation indicator (Column 2), the three standard components of financial literacy indicator (Column 3), components of financial literacy and lifetime cost calculation indicator (Column 4). Finally, in Column 5 we report the value of Cronbach's alpha for the set of components considered to build indices 1, 2 and 3 (energy-related financial literacy).¹⁰ The highest level of internal consistency reliability (Cronbach's alpha = 0.65) is associated with the scale that combines all eight components. The results of this descriptive correlation analysis inform about the importance of measuring the dimensions of energy-related knowledge and investment-related skills jointly when aiming at studying the implications of lack-of literacy in energy-related decision making.

¹⁰ Cronbach's alpha measures internal consistency, in particular how closely related a set of items are as a group. In addition, it is used to measure scale reliability. See for instance Tavakol & Dennick (2011) for further discussion.

4.2. Descriptive evidence

We then build an index of energy-related financial literacy summing the scores obtained from each of the eight questions.¹¹ Therefore, the index takes values from 0 to 8. Figure 2 shows the distribution of the energy-related financial literacy index, and that of an index built by summing the scores from only the three standard financial literacy questions. From Figure 2 we can observe that the level of financial literacy is relatively high, whereas the level of energy-related financial literacy seems to be mediocre. Finally, we would like to stress that the answers to the question on the lifetime costs calculation shows that only around 48% of the respondents in the sample correctly carried out the investment calculation.

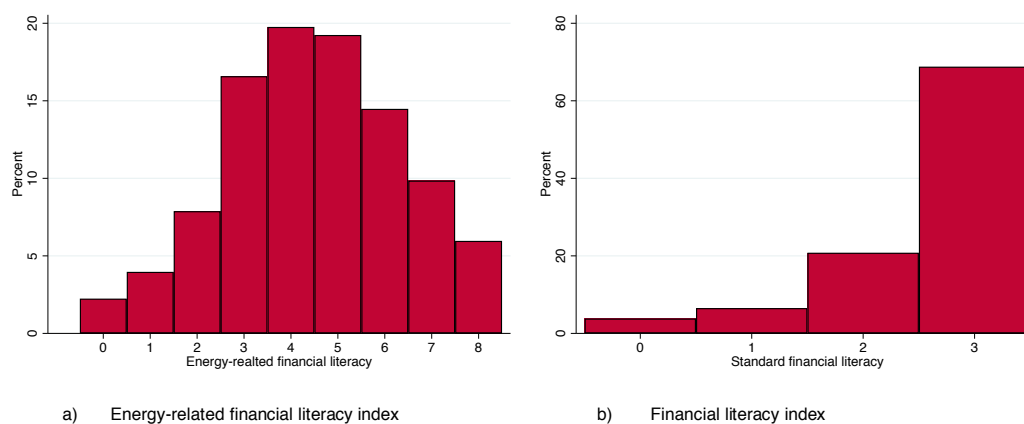
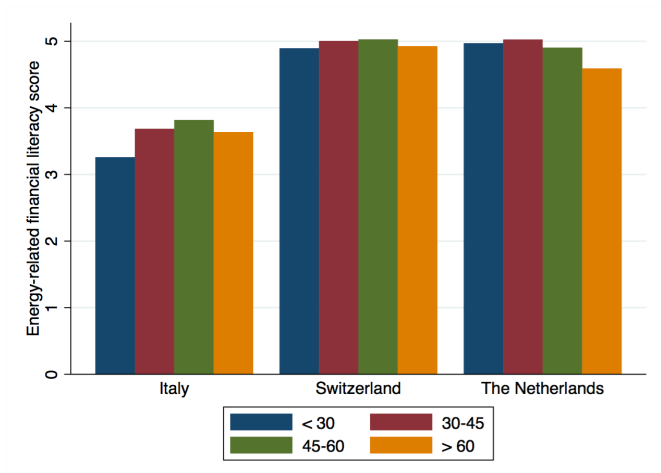


Figure 2: Distribution of the energy-related financial literacy index

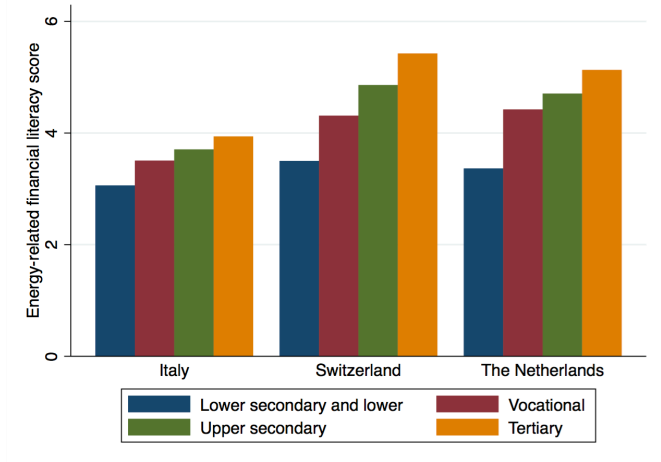
The disaggregation of the energy-related financial literacy index by household characteristics can provide a first insight about its determinants and possible consequences on energy-related decision making. Figure 3 shows the heterogeneity in energy-related financial literacy among different age groups (panel a), education groups (panel b) and gender (panel c), in each country. The data show three striking patterns that are consistent in the three countries: (i) the index is hump-shaped in the respondents' age, with lower levels of literacy among the young and elderly; (ii) individuals with higher education levels are associated with higher scores of energy-related financial literacy; (iii) male respondents are associated with substantially higher levels of literacy than females. These results are consistent with those previously shown for financial literacy (Lusardi and Mitchell, 2014).¹² Clearly, without additional information, it is not possible to identify direct links between individuals' characteristics and the level of literacy. The econometric analysis presented in the next section aims at formally identifying the most relevant determinants of the level of energy-related financial literacy.

¹¹ Alternatively, the general index of energy-related financial literacy can also be split in two specific literacy indices. The first index with values from 0 to 5 reflects the level of energy-related knowledge, whereas the second index takes values from 0 to 3 and represents the level of cognitive abilities of the households in doing an investment calculation.

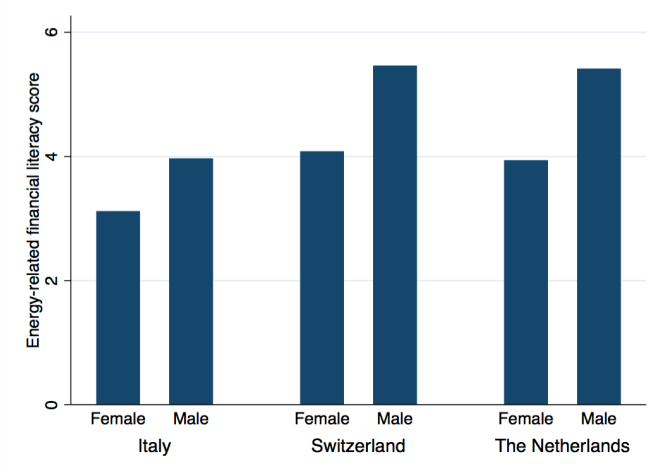
¹² The patterns observed are similar when excluding the three questions typically used to measure financial literacy from the calculation of the energy-related financial literacy index.



a) By age group



b) By educational attainment



c) By gender

Figure 3: Energy-related financial literacy by country and household characteristics

5. Estimation method and results

One of the goals of this paper is to identify the most relevant socio-economic characteristics that can explain the differences in, e.g., the level of energy-related financial literacy across the respondents. In particular, we are interested in estimating the impact of gender on the level of energy-related financial literacy. From the econometric point of view, these literacy indicators can be considered ordinal outcome variables, i.e. variables for which the values have a natural ordering. For instance, a respondent with a high outcome of the energy-related financial literacy index has a better degree of literacy with respect to a respondent with a low outcome of the index.

The two standard econometric models that can be used with ordinal dependent variables are the *ordered probit* and the *ordered logit* (see Greene (2003) and Wooldridge (2002) for more details). In this paper we decided to estimate an ordered probit model. In this model it is assumed that the latent and continuous indicator of energy-related financial literacy cannot be observed directly but rather obtained from other variables that are observable. Following this approach, the latent variable can be described as a linear function of several explanatory variables:

$$y_i^* = X_i \beta + \varepsilon_i \quad (1)$$

where X_i is a vector of socio-economic characteristics of household i such as age, income, education, gender, household type and employment status; β is the vector of parameter to be estimated; and ε_i is an i.i.d. stochastic error term that represents the unobserved heterogeneity. The probability of reaching the level of literacy j (where $j = 0 \dots 8$) is defined as

$$\Pr (y_i = j) = \Pr (k_{j-1} < y_i^* \leq k_j);$$

$$-\infty = k_0 < k_1 < \dots < k_J = +\infty, j \in \{1, 2, \dots, J\} \quad (2)$$

where the k_j are the threshold parameters. The error term ε_i is assumed to follow a normal distribution with mean zero and variance σ^2 . The model in equation (1) can be estimated using maximum likelihood estimation methods.

We estimate model (1) using three different dependent variables: (i) the energy-related financial literacy index (this index takes values from 0 to 8); (ii) the financial literacy index (this index takes values from 0 to 3); and (iii) an indicator for whether respondents could carry out the lifetime cost calculation correctly. Clearly, our main goal is to try to identify the factors that affect the level of energy-related financial literacy.

In Table 6 we show the results obtained estimating an ordered probit regression for equation (1) using the three literacy indices. Generally, the majority of the coefficients across the three model specifications are statistically significant and have the expected sign.

Further, the results highlight age as a significant determinant of energy-related financial literacy, with the latter showing a hump-shape profile over an individual's lifetime. Moreover, the empirical evidence suggests that higher income levels and higher educational attainments are associated with higher levels of energy-related financial literacy. Our index of literacy relates then to income and education similarly to the standard index of financial literacy by (Lusardi & Mitchell, 2014). Furthermore, our results show that education plays a less important role in the application of the lifetime cost calculation, possibly suggesting that formal education is more important for the accumulation of knowledge rather than the application of this knowledge. Whether the respondent owns its dwelling or not seems to play a very important role, with owners associated to show a higher literacy. This result is stable over all three literacy models.

Table 6: Regression results.

	Energy-related financial literacy		Financial literacy		Lifetime cost calculation	
	Coef.	P>z	Coef.	P>z	Coef.	P>z
Age	0.0170	0.087 *	0.0200	0.110	-0.0025	0.846
Age^2	-0.0002	0.014 **	-0.0002	0.110	-0.0001	0.506
Income: 4'501-6'000	0.1185	0.053 *	0.0680	0.396	0.1474	0.057 *
Income: 6'001-9'000	0.0837	0.189	0.1347	0.121	0.1268	0.116
Income: Above 9'000	0.1236	0.034 **	0.1235	0.096 *	0.1806	0.015 **
Upper secondary school diploma	0.4694	0.000 ***	0.6041	0.000 ***	0.3090	0.010 **
Vocational secondary school diploma	0.2033	0.032 **	0.2607	0.015 **	0.0287	0.817
3-year university degree	0.4600	0.000 ***	0.5272	0.000 ***	0.1696	0.160
5-year university degree and more	0.6666	0.000 ***	0.9444	0.000 ***	0.4271	0.000 ***
Owned dwelling	0.2412	0.000 ***	0.2156	0.000 ***	0.1524	0.014 **
Female	-0.7515	0.000 ***	-0.6404	0.000 ***	-0.5532	0.000 ***
IT	-0.7659	0.000 ***	-0.5803	0.000 ***	-0.4986	0.000 ***
NL	0.0336	0.615	-0.0018	0.985	0.2356	0.005 ***
IT*female	0.1380	0.225	0.1630	0.239	0.2904	0.049 **
NL*female	-0.1363	0.182	0.1070	0.414	0.2052	0.113
Not working	-0.0301	0.639	-0.1234	0.137	-0.0286	0.726
Not working*female	0.1633	0.069 *	0.0670	0.536	0.0231	0.842
Couple households, partner has university degree	0.1210	0.010 ***	0.1060	0.095 *	0.0594	0.314
Couple households, partner is not working	0.0963	0.050 *	0.0692	0.274	0.0638	0.307
μ 1	-2.0599		-1.2259		0.0113	
μ 2	-1.5151		-0.6444			
μ 3	-0.9580		0.3195			
μ 4	-0.2503					
μ 5	0.3449					
μ 6	0.9670					
μ 7	1.5330					
μ 8	2.1996					
N	2,823		2,823		2,823	
Pseudo R-squared	0.0700		0.0916		0.0825	
Log likelihood	-		-		-	
	5226.45		-2089.67		-1792.10	

Note: * p<0.10, ** p<0.05, *** p<0.01

Gender is found to be a strong determinant of the three measures of literacy we consider. In particular, our results confirm previous findings about the gender gap in financial literacy, with males being associated with higher levels of the index (Lusardi & Mitchell, 2014). We find a significant gender gap also for our measure of energy-related financial literacy. Interesting heterogeneity in the literacy indices is found across countries. Italian respondents in the sample are associated with a significant lower value of the index for energy-related financial literacy than Dutch and Swiss respondents. Furthermore, the Dutch respondents are associated with a higher probability of getting the lifetime cost calculation correctly than both Italian and Swiss respondents. This is neither the case for the energy-related financial literacy, nor for the financial literacy, with Swiss respondents performing similar to the Dutch.

Respondent's employment status generally does not seem to play an important role for the attainment of the level of energy-related financial literacy, except when interacted with gender: female non-working respondent are correlated with higher literacy levels. Additionally, in couple households where the respondent's partner is not working, the respondent is associated with a higher level of energy-related financial literacy. Further, in couple households where the respondent's partner has a university degree, the respondent also attains a higher level of energy-related financial and financial literacy.

To analyse the substitution patterns between the outcome of the energy-related financial index among different respondents in a proper way, we calculated and presented the average marginal effects of some variables in

Table 7.¹³ In this table we only show the marginal effects for some interesting variables only for intermediate and advanced level of literacy (5 to 8). The columns denoted with "dy/dx" show the effect of a switch of given dummy explanatory variable (or a one-unit change in the case of a continuous explanatory variable) on the probability of attaining a certain level of the index. The results indicate, for instance, that being female decreases the probability to attain an outcome of 8 (high level of literacy) by 8.8 per cent, while the probability for women to attain an outcome of 5 (medium level of literacy) is only 1.7 per cent lower. Being Italian decreases the probability to reach a medium level of energy-related financial literacy (outcome 5 to 6) by 1 to 6 per cent, and a high level (outcome 7 to 8) by 9 per cent.

¹³ We do not compute the marginal effects at the mean, because in our model we use several dummy variables. Using marginal effects at the mean would therefore not refer to any observation in our data set.

Table 7: Average marginal effects.

	energy-related financial index											
	5			6			7		8			
	dy/dx	P>z		dy/dx	P>z		dy/dx	P>z	dy/dx	P>z		
Owned dwelling	0.0054	0.0000	***	0.0204	0.0000	***	0.0277	0.0000	***	0.0284	0.0000	***
Female	-0.0170	0.0000	***	-0.0635	0.0000	***	-0.0862	0.0000	***	-0.0884	0.0000	***
IT	-0.0173	0.0000	***	-0.0647	0.0000	***	-0.0879	0.0000	***	-0.0901	0.0000	***
Not working*female	0.0037	0.0830	*	0.0138	0.0700	*	0.0187	0.0690	*	0.0192	0.0700	*
Partner has university degree	0.0027	0.0180	**	0.0102	0.0100	**	0.0139	0.0100	**	0.0142	0.0110	**
Partner is not working	0.0022	0.0610	*	0.0081	0.0510	*	0.0111	0.0510	*	0.0113	0.0520	*

Note: * p<0.10, ** p<0.05, *** p<0.01. For dummy variables the effects are obtained from probability differences.

6. Conclusion

The academic literature has not yet developed a common terminology of the concept of “energy literacy”. In this paper, we summarize the existing literature on energy literacy and summarise what different authors understand under “energy literacy” and the related concept of “financial literacy”. Moreover, we introduce the concept of “energy-related financial literacy”, that measures the level of energy-related knowledge and cognitive abilities consumers need in order to take decisions with respect to the investment for the production of energy services and their consumption. We believe that this concept is more appropriate than the ones introduced so far in the literature, as it considers two important elements for a sound and informed investment decision in the energy sector: on the one hand energy-related and financial knowledge and, on the other, the cognitive skills to apply this knowledge to the evaluation of an investment for a new household appliances or energy-efficient renovations.

The empirical analysis indicates that, while the majority of the respondents in our sample perform well in the standard financial literacy questions, a substantial lack of knowledge in the field of energy literacy and in the ability to compute the lifetime cost of appliances emerges. For instance, only around 27 percent of the respondents know about the average electricity price in their country of residence, while 73% either indicate a wrong value or don’t know at all. Further, only around 48% of the respondents in the sample correctly carried out the lifetime costs calculation for appliances.

The econometric analysis provides insights into the main socio-economic determinants of energy-related financial literacy. For instance, we find a significant gender gap for our measure of energy-related financial literacy. Our results confirm previous findings about the gender gap in financial

literacy, with males being associated with higher levels of the index (Lusardi & Mitchell, 2014). A conclusive explanation for this observation has not been found yet. However, Fonseca et al. (2012) explain this result with division of labour among married couples and assume that in many marriages men invest traditionally more in acquiring financial decision-making skills while women invest in other forms of human capital. Less research has been conducted on the decision-making processes in households when it comes to energy-related financial decision-making. Findings of Albert & Escardíbul (2017) show that expensive purchases of consumer durables are mostly the result of a joint decision-making of both partners. However, Belch & Willis (2006), show that in the US the purchase decisions of new household appliances are mainly made by the female partner. This might suggest that the female household members' level of energy-related financial literacy could have a particularly strong influence on the energy-related purchase decisions of a household.

The literature on financial literacy suggests that women are more aware of, and more likely to self-report their lack of financial literacy as compared to men (Hung et al., 2012; Lusardi & Mitchell, 2014). This makes women ideal candidates for financial education programs. If the same would hold for energy-related decision-making, it could be worthwhile to explore ways to specifically educate women in energy-related investment decisions. Hung et al. (2012) raise the question whether financial literacy programs specifically targeted to women can be effective. According to their study, there is some preliminary evidence that programs that particularly address women's needs in financial education can increase the financial literacy of women. Unfortunately, a systematic and more robust evaluation of the existing financial education programmes targeting women is still lacking. Therefore, future research should explore what drives the differences in energy-related financial literacy across gender and countries and how target-specific education programs could reduce the inequality in literacy. Lastly, further research is needed to explore the consequences of (a lack of) energy-related financial literacy on energy-related decision making, with a particular focus on the role of women on decision making within the family.

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Appendix

Knowledge of electricity price: How much do you think 1 Kilowatt hour (kWh) of electricity currently costs in Switzerland (on average after taxes)? Please indicate your best guess without checking your bill or other resources.

- Amount in Rappen (no decimals)
- Don't know

Running cost of desktop computer: How much do you think it costs in terms of electricity to run:
A desktop PC for 1 hour

- 0-19 Rappen
- 20-39 Rappen
- 40-59 Rappen
- 60-79 Rappen
- 80-100 Rappen
- More than 100 Rappen
- Don't know

Running cost of a washing cycle: How much do you think it costs in terms of electricity to run: A washing machine (load of 5 kg at 60°C)

- 0-19 Rappen
- 20-39 Rappen
- 40-59 Rappen
- 60-79 Rappen
- 80-100 Rappen
- More than 100 Rappen
- Don't know

Knowledge of LED technology savings: How much do you think is the energy saving associated with using a LED light bulb instead of a conventional Halogen bulb (with the same brightness)?

- 5-10 percent
- 30-50 percent
- 70-80 percent
- Don't know

Financial literacy 1: Suppose you had 100 CHF/euros in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow?

- More than €102
- Exactly €102
- Less than €102
- Don't know

Financial literacy 2: Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?

- More than today
- Exactly the same
- Less than today
- Don't know

Financial literacy 3: Please tell me whether this statement is true or false: "Buying a single company's stock usually provides a safer return than buying stocks of several companies."

- True
- False
- Don't know

Lifetime cost calculation: Suppose you own your home, your fridge breaks down and you need to replace it. As a replacement, you can choose between two alternatives that are identical in terms of design, capacity and quality of the cooling system. Fridge A sells for 400 CH and consumes electricity for the amount of 300 kWh per year. Fridge B has a retail price of 500 CHF and consumes electricity for the amount of 280 kWh per year.

Assume the average cost of energy is 0.20 CHF per kWh, the two models have both a lifespan of 15 years and that you would get a return of 0 percent from any alternative investment of your money.

Which choice of purchase minimizes the total costs of the fridge over its lifespan?

- Fridge A
- Fridge B
- Fridge A and B are equivalent in terms of total costs
- Don't know

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