THE RELATIVE IMPORTANCE OF BEHAVIORAL FACTORS IN SOLAR PHOTOVOLTAIC PROJECT FINANCING

Florian Lüdeke-Freund[(a),(b)] & Nina Lucia Hampl[(c),1]

[(a)] University of Hamburg, Faculty of Economics & Social Sciences, Chair of Capital Markets and Management
[(b)] Research Fellow at Centre for Sustainability Management (CSM), Leuphana University of Lüneburg
Von-Melle-Park 9, D-20146 Hamburg
florian.luedeke-freund@wiso.uni-hamburg.de

[(c)] Vienna University of Economics and Business, Institute for Strategic Management,
Nordbergstrasse 15, AT-1090 Vienna, Austria
nina.hampl@wu.ac.at

Abstract

Global investments in renewable energies exceeded $200 billion in 2013. However, this is only a small share of what is required for the transition to a global sustainable energy system. Substantial financial investments from the public and private sector are needed over the next decades. Solar photovoltaic (PV) is one of the most important energy technologies with the highest share of new power capacity added worldwide in 2013. Even though the costs of this technology have sharply declined, weakening policy support, especially in some European countries, exerts high pressure on PV project developers. They struggle to attain funding for their installations as banks and equity investors only cherry-pick projects of highest quality. Building on previous research in this area, we conducted a ratings-based conjoint experiment comprising 684 hypothetical project ratings made by 57 banks and equity investors mainly from Europe. Our preliminary results strengthen earlier findings that non-financial factors, such as PV module brand, play a significant role in project financing, whereas this 'brand effect' is stronger pronounced among equity investors than among banks.

Conference theme addressed

Short termism and structural market failures: What is the future of Renewable Energy Investment? This paper deals with solar PV project financing from a behavioral finance perspective. It adds to an emerging research stream that tries to understand if and how investors' decisions to invest in renewable energies are biased by non-financial and qualitative descision criteria. A better understanding of debt and equity investors' preferences is crucial for a bright future of solar PV in particular and renewable energies in general. This is our contribution to build stronger bridges between academic research and practical needs.

Keywords

renewable energies, solar photovoltaic, project financing, behavioral finance, conjoint experiment

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1. Introduction

For the fourth year in a row global investments in renewable energies exceeded $ 200 billion (FS-UNEP & BNEF, 2014). But nevertheless, this is only a small share of the total investments required for the transition to a sustainable energy system (cf. IRENA, 2014; WBGU, 2012). Thus, substantially increasing financial investments from both the public and private sector are needed over the next decades to achieve the policy goals set for renewable energies and the reduction of energy-related carbon emissions. Germany, for example, aims for a 30 %-share of renewables-based electricity in 2030; the State-level goals in the U.S. range from 30 to 40 % in the same timeframe; and China defined ambitious targets for wind and solar power capacities to be online in 2015 (100 GW and 15 GW, respectively).[2] Achieving these goals requires large amounts of financial capital. While public programs, e.g. supporting research and development, will provide some funding, the lion's share will have to come from private banks and investors willing to finance the expansion of renewable energies (cf. Jacobsson & Jacobsson, 2012; Wüstenhagen & Menichetti, 2012).

In this context, solar photovoltaic (PV), i.e. the direct conversion of solar radiation into electricity, is one of the most important technological options. Solar PV contributed the highest share of new power capacity added worldwide in 2013 (39 GW compared to 35 GW of new wind power capacity; EPIA, 2014; GWEC, 2014).[3] Despite this all time high in annual installations, the amount invested went down by 23 % to $ 104 billion due to lower equipment costs (FS-UNEP & BNEF, 2014). Although solar PV is approaching cost competitiveness and 'new' markets like China and Japan are rapidly developing (ibid.), changing public policy frameworks and weakening support exert high pressure on solar PV companies along the industry's value chain, especially on European manufacturers and project developers (cf. Abboushi, 2014; Jacobsson & Jacobsson, 2012; the latter identify a general funding gap for the European energy sector).

Under these circumstances, project developers – i.e. companies who develop, finance, and install large solar PV capacities – struggle to attract funding since banks and equity investors cherry-pick projects of 'highest quality' according to their investment criteria and decision-making guidelines; an effect that became increasingly visible after the financial crisis due to dried up and nervous financial markets (Hampl et al., 2011).[4] In the face of general project risks and additional policy-induced uncertainties (cf. FS-UNEP & BNEF, 2014; Lüthi & Wüstenhagen, 2012), which might also be

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[2] See IRENA renewable energy country profiles, http://www.irena.org

[3] 1Gigawatt (GW) = 1,000 Megawatt (MW); according to the U.S. Energy Information Administration, the average coal-fired power plant in the U.S. has a nominal capacity of 245 MW and the average nuclear power plant 1,028 MW.

[4] The term 'project' refers to a particular organisational and financial approach, sometimes called Special Purpose Vehicle (SPV), which is commonly used to develop and finance large one-time ventures as stand-alone entities (e.g. Esty, 2004; Vinter et al., 2013; Yescombe, 2014). Large-scale solar power plants are mostly developed, financed, and operated through SPVs (cf. Lüdeke-Freund & Loock, 2011a, b).

interpreted as waning policy support for the maturing solar PV industry, banks and equity investors have to distinguish ‘high quality’ from ‘low quality’ projects (Lüdeke-Freund & Loock, 2011a, b). Scientific studies show that investment decisions under risk or uncertainty – here, referring to partly unknown effects of endogenous and exogenous contingencies like project size, technology employed, or project location – are not only based on quantitative risk-return calculations, but also on qualitative and non-financial criteria (e.g. Barberis & Thaler, 2003; Kahneman & Tversky, 1982; Shiller, 2003). That is, rational decision-making theory alone will not fully capture and explain investment decisions for or against solar PV projects, which calls for a behavioral finance perspective (cf. e.g. Hampl, 2012; Loock, 2010, 2012; Lüdeke-Freund & Loock, 2011a, b; Lüthi & Wüstenhagen, 2012; Masini & Menichetti, 2012, 2013).

Against this background, our research question is: *Which characteristics of solar photovoltaic projects influence banks and equity investors’ investment decisions and how important are behavioral factors in this context?*

To answer this question we build on behavioral finance theory with a focus on renewable energies as well as the authors’ previous research on solar PV project financing (Section 3). We then report from a ratings-based conjoint experiment conducted between April and July 2012 that delivered 684 hypothetical project ratings made by 57 banks and equity investors (50 % each) mainly from Europe (Section 4). Our preliminary results strengthen the finding from a preceding conjoint experiment showing that non-financial factors, such as solar module brand, play an important role in solar PV project financing (‘debt for brands’; Lüdeke-Freund & Loock, 2011a, b), whereas a new finding is that this ‘brand effect’ is much stronger pronounced among equity investors than among banks (Section 5). Here, we can only dip into a few results and thus present only preliminary conclusions (Section 6). To start with, Section 2 provides a short overview of the current state of global investments in solar PV, based on the latest available figures for 2013.

2. Global Solar Investments

According to the latest renewable energy investment report published by Frankfurt School UNEP Centre and Bloomberg New Energy Finance, global investments in new solar PV capacities totaled $ 104 billion in 2013 (FS-UNEP & BNEF, 2014). Despite an all time high of 39 GW of annual installations, investments decreased by 23 % compared to 2012 due to lower technology costs.[5]

Total new investments in solar PV reached $ 114 billion in 2013 (Table 1). That is, more than half of all new renewable energy investments covered by FS-UNEP and BNEF’s report, including wind energy, biofuels, small hydro energy, and others, went into solar PV (53 %). Around $ 5 billion were

[5] As a result, the levelised electricity costs of major PV technologies fell between 34 and 53 % during the last five years (FS-UNEP & BNEF, 2014, p. 38).

invested in technology development (corporate and government R&D) and roughly the same amount in new manufacturing capacities, e.g. for solar module production and upscaling of business operations (financed via public markets, venture capital, and private equity investments). New solar PV installations were financed either as small distribution capacities, i.e. private and commercial small- and medium-scale systems below one megawatt ($ 60 billion), or asset finance ($ 44 billion; including debt and equity capital investments, balance sheet and project financing). Our study focuses on project financing as a subclass of the asset finance position shown in Table 1.

Solar PV investments 2013	**(1) Solar bn $**	**(2) All RE bn $**	**Share of solar (1) / (2)**
Small distributed capacity	60	60	100%
Asset finance	44	133	33%
New capacity investment	**104**	**193**	**54%**
Public markets	5	11	43%
Venture capital / private equity	1	2	24%
Corporate R&D	3	5	54%
Government R&D	2	5	48%
Total new investment*	**114****	**216****	**53%**

* Excl. M&A, refinancing, and buy-outs ($ 15 bn solar, $ 54 bn total)
** Figures do not add up to totals and deviate slightly from the original source due to rounding

Table 1: Global solar PV investements in 2013 (source: FS-UNEP & BNEF, 2014)

3. Theoretical Background

Identifying and analysing behavioral factors influencing investment decisions for solar PV projects requires an understanding of the theoretical assumptions of behavioral finance theory. Behavioral finance is related to the broader field of behavioral economics which in turn has been inspired by fundamental critique of classic economic and financial theory, most notably the rational-agent model and the efficient market hypothesis (cf. Shleifer, 2000). Increasing knowledge about the psychology of human decision-making also calls for alternative approaches to describe and explain why economic agents behave the way they do (cf. Barberis & Thaler, 2003; Shiller, 2003; Shleifer, 2000; Simon, 1955). The necessary theoretical and psychological foundations were mainly developed by Simon, who coined the term bounded rationality (Simon, 1955), and Kahneman and Tversky, who studied biases and heuristics in decision-making under risk and uncertainty, developed the influential prospect theory, and identified so called framing effects and their implications for rational-agent models (e.g. Kahneman, 2003; Kahneman & Tversky, 1973, 1979; Tversky & Kahneman, 1974, 1981).

While classic financial theory assumes that investors behave like completely rational decision makers (like calculating “automatons”) who maximise their expected utility through an optimal balance of risks and returns (cf. Savage, 1954; von Neumann & Morgenstern, 1944), behavioral finance theory acknowledges the interplay of cognitive limitations and environmental complexity and suggests that investors' decisions are subject to biases like emotions, moods, or personal preferences and are based on rather simple heuristics instead of rational decision-making models (cf. Barberis & Thaler, 2003; Kahneman & Tversky, 1982; Shiller, 2003; Shleifer, 2000; Tversky & Kahneman, 1974). With its underlying assumption of bounded rationality (Simon, 1955) behavioral finance theory considers subjective biases and limitations of human cognition, acknowledges situational factors like informational complexity, as well as the importance of non-financial and qualitative aspects which influence decision-making under risk and uncertainty (cf. Kahneman, 2003).

With regard to investment decisions, Hampl (2012) provides an overview of venture capital studies that identify effects related to social ties and networks and their influence on entrepreneur-investor relationships (e.g. Franke et al., 2006; Landström et al., 1998; Sapienza, 1992; Shane & Cable, 2002). Shane and Cable (2002), for example, show that social ties can have an influence on the distribution of information, e.g. due to private communication, and can thus decide about the capital provision for early-stage ventures. In the context of stock market investments, several studies reveal behavioral biases on the side of individual as well as institutional investors (e.g. Baker & Nofsinger, 2002; Barber et al., 2003; Barber & Odean, 2008). For example, different forms of so called familiarity effects were found, showing that investors tend to prefer domestic over foreign stocks, or prefer investing in companies which are familiar to investors because they use their products or services (e.g. Aspara et al., 2008; Wang et al., 2011).

Studies on renewable energy investments emerge as a relatively new area within the broader domain of behavioral finance research (e.g. Hampl, 2012; Loock, 2010, 2012; Lüthi & Wüstenhagen, 2012; Masini & Menichetti, 2012, 2013; Wüstenhagen & Menichetti, 2012). Masini and Menichetti (2012), for example, propose a conceptual model to describe and explain the renewable energy shares in investors' portfolios as well as their financial performance. Their model is based on the inclusion of investors' a-priori beliefs, policy preferences, and technological risk attitudes.

A-priori beliefs are defined as "… the result of the investors' personal history, educational backgrounds, and personal previous experience with renewable energy investments" (ibid., p. 31). These beliefs are modelled as two basic types of trust: trust in the efficiency of market mechanisms and trust in the effectiveness of renewable energy technologies. Moreover, Masini and Menichetti's model includes *policy preferences.* Renewable energies in general, and solar PV in particular, depend on the public policy environment which therefore plays a crucial role as a behavioral factor: "… an agent's willingness to invest in a renewable energy project will be also strongly influenced by his preferences over different policy schemes" (ibid.). These policy preferences are modelled as the perceived importance of policy types, their support level and duration. Although policy risks are commonly used as a 'rational element' of variation in risk and scenario analyses (e.g. Lüdeke-Freund et al., 2012), scholars argue that de facto and perceived policy risks must be distinguished; i.e. individual perceptions may vary and over- or underestimate policy effects and thus bias investment decisions accordingly (see also Bürer & Wüstenhagen, 2009; Lüthi & Wüstenhagen, 2012;

Wüstenhagen & Menichetti, 2012). Finally, Masini and Menichetti argue that "… as renewable energy technologies are sometimes perceived as unproven technologies with greater technological uncertainty … an investor's attitude vis-à-vis technological risk has also a strong influence on his willingness to invest" (Masini & Menichetti, 2012, p. 32). Thus, an investor's personal attitude toward the *technological risk of renewable energies* is the third major behavioral factor that may influence the decision to invest in renewable energies in general and solar PV in particular.

4. Study Methodology

4.1 Conjoint experiment

Acknowledging the importance of private banks and equity investors for the further diffusion of solar PV as a source of renewable electricity (Sections 1 and 2), the aim of our study was to better understand if and how behavioral factors influence their decisions (Section 3). Since conjoint analyses have successfully been used to study renewable energy policy preferences and investment decisions (e.g. Hampl, 2012; Loock, 2012; Lüthi & Wüstenhagen, 2012; Masini & Menichetti, 2012), we developed a conjoint experiment to test the influence of a predefined set of criteria which were expected to be relevant for investment decisions for solar PV projects. These criteria were operationalised as project characteristics – in the following referred to as 'attributes' – to reveal potential biases as discussed above (cf. Masini & Menichetti, 2012).

The conjoint methodology allows for decomposing the decision-making process into underlying preferences for particular attributes that describe, for example, an investment opportunity. These preferences, known as part-worth utilities and relative importance weights of attributes (independent variables), are derived from the decisions (dependent variable) made in a series of choice or rating tasks (cf. Green & Rao, 1971; Green & Srinivasan, 1990; Louviere et al., 2003, 2008; McFadden, 1986). In particular, the format of indirect questioning gives this method an advantage over simply asking respondents to rate separate decision-making criteria according to their preferences. Previous studies have revealed that individuals may be biased with regard to their own behavior and thus may avoid discussing potential mistakes or non-rational decisions. Sometimes, they may even lack an understanding of their own preferences and decision-making processes.

In our conjoint experiment, debt capital and equity investors were asked if they would invest in hypothetical solar PV projects which were characterised in terms of quantitative financial indicators representing the overall financial risk (debt service cover ratio (DSCR), internal rate of return (IRR), equity ratio); a module brand attribute addressing a particular type of a-priori belief, i.e. trust in particular module producers; a project location attribute standing for different policy environments; and a track record attribute testing respondents' sensitivity toward technological risks (Table 2 below). Our research design followed a two-step approach to define these attributes and use them as conjoint variables.

In a first step, 23 German and Chinese experts from the fields of solar PV project development, financing, and manufacturing were interviewed between September 2010 and January 2011. These indepth interviews resulted in about 30 hours of audio recordings which were screened and partly transcribed and coded to identify the most relevant project characteristics from the perspective of lenders, equity investors, and project developers (Hampl et al., 2011; Lüdeke-Freund et al., 2012). The information from these interviews were used to refine and extend an initial set of project attributes used in a previous study (Lüdeke-Freund & Loock, 2011a, b). The main difference to this study is the inclusion of private equity investors. While Lüdeke-Freund and Loock looked into lenders' preferences only, the study at hand includes both debt *and* equity investors. Before the attributes were used in the experiment, which was the second step of our research design, they were pretested and calibrated with industry experts, leading to the final set shown in Table 2.

Attributes	**Attribute levels**
1a. Bank survey Minimum **DSCR** per year	DSCR: 1.10 1.175 1.25
1b. Equity investor survey Post-tax **IRR** on equity	IRR: 7.5% 11% 14.5%
2. **Module brand**	SolarWorld Yingli Solar Jinko Solar
3. **Track-record** of EPC contractor or project developer	< 10 projects in MW-range > 10 projects in MW-range > 10 projects in MW-range & personal experience
4. **Project location**	Germany France Italy
5. **Equity ratio**	15% 20% 25%

***Table 2: Solar PV project attributes and attribute levels used in the conjoint survey*[6]**

We used Sawtooth Software to design the conjoint experiment in a web-based format as well as for part-worth estimations (cf. Sawtooth Software, 2002). A full factorial design involving the five attributes at three levels (3^5) would have led to 243 project profiles, i.e. different attribute level combinations, which would not have been manageable for the respondents. Thus, we used a near-orthogonal, efficient fractional factorial design including full profiles of twelve rating tasks, i.e. each participant had to evaluate twelve hypothetical solar PV projects. Two separate questionnaires were

[6] It should be noted that these attribute levels represent experts' assessments as of early 2012. For example, while the DSCR levels might still be valid, realistic IRRs are likely to be lower today.

used, which were fully identical except for the financial attribute: the internal rate of return (IRR) was used in the survey for equity investors only, and debt service cover ratio (DSCR) in the survey for bank representatives.

An introductory note was presented at the beginning of the questionnaire to define a consistent setting for all respondents: "The projects that we will show you are all large-scale photovoltaic projects of 3 MW size and ground mounted. Please note the following additional information about these projects: in all cases the project is turnkey, i.e. construction is already completed; crystalline technology is used; the requested financing period is 17 years."

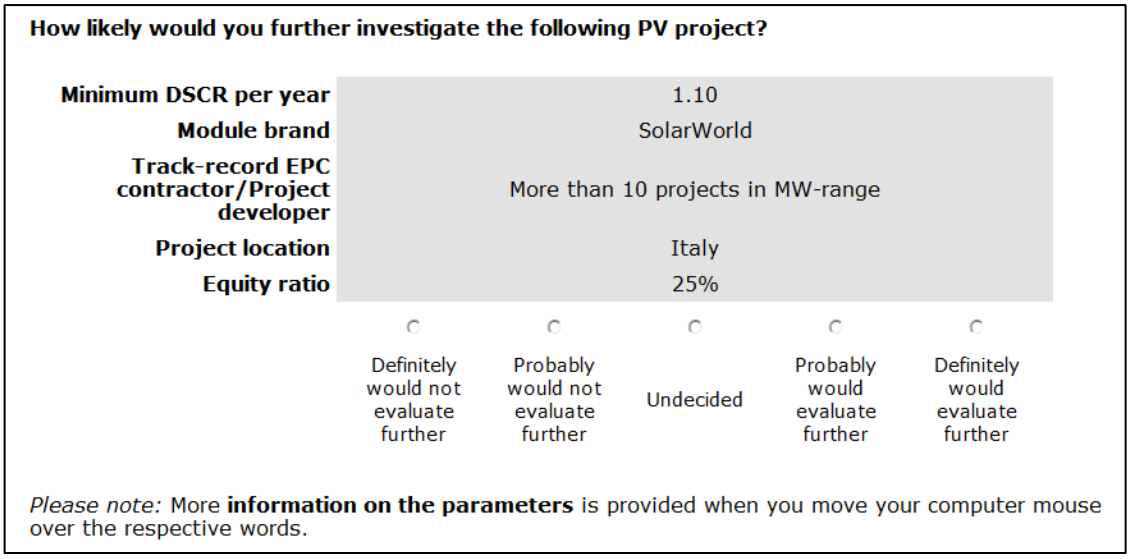

Figure 1: Rating task example (questionnaire for banks)

Figure 2 shows an example of a rating task from the bank questionnaire. Each participant had to evaluate twelve of such project descriptions showing varying combinations of the five attributes' levels. The given example proposes an Italian project developed by an EPC contractor or project developer with a track record of more than ten projects in megawatt range. This hypothetical project uses SolarWorld modules, has an equity ratio of 25 %, and achieves an annual DSCR of 1.10, i.e. the project's free cash flow exceeds annual debt service (loan repayment and interest) by ten percent. The conjoint methodology and the applied hierarchical Bayes model allowed for the calculation of the part-worth utilities and relative importance weights for the five attributes and their respective levels, revealing the respondents' underlying preferences (Section 5).

4.2 Sample Description

Our sample consists of 57 respondents, 29 banks and 28 investors, who performed 684 project ratings according to the above given example (348 by banks and 336 by investors). Participants were recruited through the business networks of the involved project partners (see Footnote 1) and from databases developed in earlier studies (Hampl, 2012; Lüdeke-Freund & Loock, 2011a, b). They were invited personally, either via e-mail or telephone, and were provided with a link to the online survey. Table 3 summarises selected demographic characteristics of our realised sample (it should be noted that not all equity investors answered all demographic questions).

Banks			**Investors**		
Type of bank			**Type of equity investor**		
(n = 29)			(n = 28)		
National bank	10	34%	Investment fund	11	39%
International bank	17	59%	Project developer	6	21%
Other	2	7%	Local/regional utility (electricity)	1	4%
			Multinational utility (electricity)	1	4%
			Oil and/or gas company	1	4%
			PV Manufacturer	6	21%
			Other	2	7%
Location of company's headquarters					
(n = 28)			(n = 22)		
Germany	23	82%	Germany	11	50%
Italy	3	11%	France	2	9%
UK	2	7%	Rest of Europe	7	32%
			USA	2	9%
Respondent's personal position					
(n = 28)			(n = 22)		
Head of RE project financing	9	32%	CEO/CFO or similar	3	14%
Portfolio manager	4	14%	Senior executive/director	6	27%
Credit risk manager	4	14%	Head of department	5	23%
Other	11	39%	Senior investment/fund manager	3	14%
(e.g. key account manager renewable energy, project financing director)			Junior investment/fund manager	1	5%
			Research/analyst	1	5%
			Other	3	14%
			(e.g. project manager)		
Years of personal experience in PV project financing					
(n = 28)			(n = 22)		
average	7 years		average	5 years	
min	1 years		min	2 years	
max	19 years		max	15 years	
less than 5 years	12	43%	less than 5 years	14	64%
5 and more years	10	36%	5 and more years	7	32%
10 and more years	6	21%	10 and more years	1	5%
Countries in which company is active in PV project financing (top 5 only)					
(n = 28)			(n = 22)		
Cyprus	23	82%	Cyprus	13	59%
Estonia	12	43%	Greece	10	45%
Greece	12	43%	Italy	10	45%
Slovakia	12	43%	Estonia	7	32%
Sweden	10	36%	Spain	7	32%
Extend to which company invested in PV projects in the last 3 years					
(n = 28)			(n = 22)		
average	580 million EUR		average	179 million EUR	
min	0 million EUR		min	0 million EUR	
max	4,000 million EUR		max	1,200 million EUR	
up to 100 million	8	29%	up to 25 million	7	32%
>100 to 500 million	13	46%	>25 to 50 million	4	18%
>500 to 1000 million	3	11%	>50 to 250 million	6	27%
>1 billion	4	14%	>250 million	5	23%

Table 3: Sample description

The bank subsample is dominated by international banks (59 %), while the equity investor subsample mainly consists of investment funds (39 %), project developers, and solar PV manufacturers (each 21 %), which illustrates the diversity of investing companies. Nearly all respondents have their headquarters in Germany (82 % of all banks, 50 % of equity investors) or elsewhere in Europe (18 % of banks, 41 % of equity investors). At the time of the survey (first half of 2012), many of the surveyed companies were active in Cyprus, Estonia, and Greece. While Slovakia and Sweden were also among to the top five countries where banks were financing solar PV projects, equity investors were also engaged in Italy and Spain. In terms of financing volume banks show an average of 580 million Euro in the last three years, while equity investors report an average of around 180 million. The bank subsample shows an astonishing 46 % who invested between 100 and 500 million with a maximum of 4 billion Euro.

5. Preliminary Results (to be completed until conference)

For now, we will only present the relative importance of the attributes and their part-worth utilities. These measures were calculated based on a hierarchical Bayes model using Sawtooth Software (cf. Sawtooth Software, 2002).[7] Our results show that the *relative importance of the attributes* included in the conjoint experiment differs between banks and equity investors in various aspects. The percentage values per subsample add up to 100 %. That is, the higher the value of an attribute, the greater is the respective attribute's influence on, or explanatory power for, the observed ratings.

Banks rate project location as the most important rating criterion (30 %) relative to the other factors included in the project descriptions (in descending order according to their relative importance): debt service cover ratio (DSCR) (24 %), module brand (17 %), equity ratio (16 %), and track-record of the EPC contractor/project developer (13 %). *Equity investors* primarily focus on the internal rate of return (IRR) as the most important rating criterion (30 %), followed by module brand (24 %), project location (23 %), track-record of the EPC contractor/project developer (12 %) and equity ratio (11 %).

These preliminary results show that equity investors actually pay higher attention to non-financial factors such as module brand (an a-priori belief construct) in their ratings than banks, whereas the German solar PV module manufacturer (SolarWorld) was perceived as most favorable compared to Chinese competitors. Another finding is that the track-record of the EPC/project developer has only a minor effect on project ratings. Personal experience with the EPC/project developer has no value added for the average respondent in our experiment (this variable seems to be an insufficient proxy for technological risk attitudes).

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[7] The questionnaire contained further sections of which results will be discussed in the full paper. These sections included, inter alia, questions concerning corporate and technology 'bankability' (cf. Hampl et al., 2011), respondents' familiarity with particular solar PV module brands, a ranking of these brands with regard to their trustworthiness and credibility, as well as some questions about respondents' further financing practice.

	Subsample 1 Banks		**Subsample 2 Equity Investors**	
Number of Respondents	N = 29		N = 28	
Number of Observations	N = 348		N = 336	
Attributes and Levels	U *M*[a]	*SD*	U *M*[a]	*SD*
DSCR / IRR				
1.10 / 7.5%	-44.29	44.02	-72.29	69.08
1.175 / 11%	-4.31	35.54	24.66	43.15
1.25 / 14.5%	48.60	68.86	47.63	48.70
Module Brand				
SolarWorld	21.54	32.23	43.45	75.34
Yingli Solar	9.30	33.64	-2.65	49.72
Jinko Solar	-30.84	44.52	-40.80	59.74
Track-record EPC contractor/Project developer				
< 10 projects in MW-range	-12.97	29.09	-6.12	28.04
> 10 projects in MW-range	4.14	31.73	5.00	23.94
> 10 projects in MW-range & personal experience	8.83	31.56	1.12	32.64
Project location				
Germany	70.64	64.73	24.75	64.39
France	-30.37	60.97	10.81	65.59
Italy	-40.26	48.43	-35.56	40.65
Equity ratio				
15%	-34.00	41.33	3.79	29.69
20%	9.90	18.71	2.63	27.65
25%	24.10	39.00	-6.42	26.48

[a] The average utilities (U *M*) are equal to the posterior population means across the saved draws (as suggested by Train (2009) only every tenth was retained of a total of 10,000 draws after convergence had been achieved and used for calculation in order to reduce the correlation among draws from Gibbs sampling) reported with the standard deviation of the individual coefficients' values (across the respondents in the sample or subsample) per attribute level in the subsequent columns. Coefficient estimates are interval-scaled and zero-centered (according to the zero-centered diffs method by Sawtooth Software (1999)) within attributes. The average utilities for the samples 1 (N = 29) and 2 (N = 28) are estimated separately; estimates of the total sample are based on a consolidated dataset from sample 1 and 2 (N = 57).

Table 4: Results of the hierarchical Bayes estimation – attributes' part-worth utilities

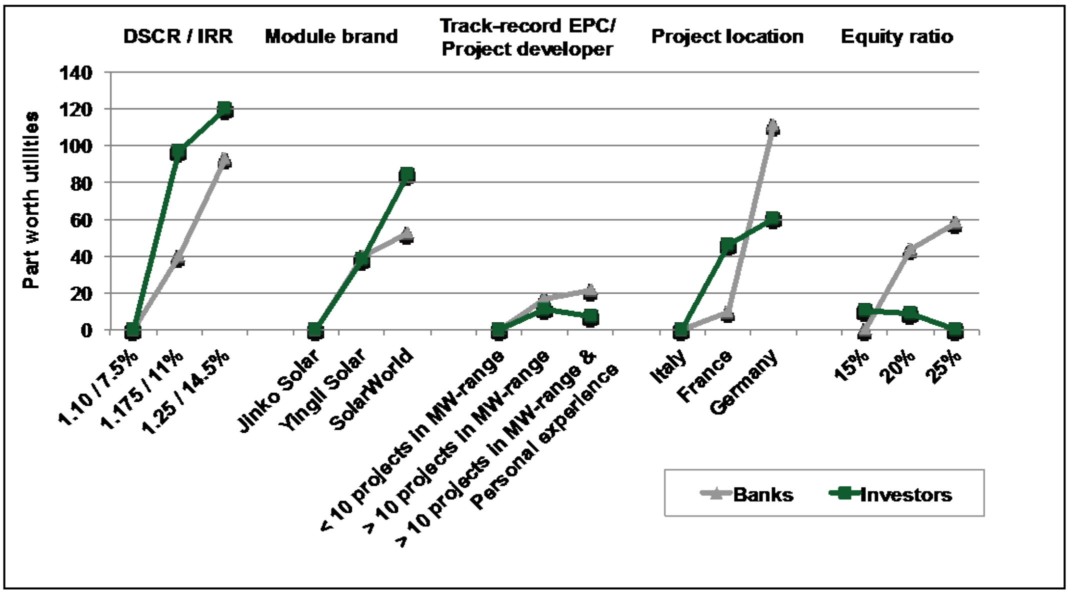

Figure 2: Part-worth utilities per attribute level based on hierarchical Bayes estimation

Table 4 and Figure 2 summarise the estimated *part-worth utilities of the attributes' levels.* A negative value implies a negative utility, i.e. decision-makers or raters would on average avoid the respective attribute level. At a first glance, we see that equity investors are more responsive to higher IRR values than banks are to higher DSCR ratios. Moreover, we see a relatively stronger preference for SolarWorld among equity investors than among banks. Interestingly, both groups seem to be more or less unbiased when it comes to the EPC's or project developer's track record – a result which is counterintuitive and needs some more consideration. Both groups do clearly favor Germany as project location, whereas banks appear to have a relatively greater bias related to this rating criterion. Finally, as was to be expected, the part-worth utility curves associated to a project's equity ratio show a 'scissors-like' picture – banks clearly prefer higher equity shares, while equity investors want to profit from leverage effects due to low equity shares (Figure 2).

6. Preliminary Conclusions and Practical Implications (to be completed until conference)

In our study on PV project financing criteria and trade-offs we show that non-financial factors actually do play an important role in funding decisions by banks and equity investors. Specifically module brands seem to have a high influence on investment decisions by equity investors, however IRR, as a financial performance figure, is seen as the most relevant attribute for the decision to engage in a specific PV project. The findings of our study are specifically relevant for project developers in order to better understand the funding processes and criteria of banks and equity investors. Through an optimization of their project designs project developers will be able to increase the probability of funding and can thus generate competitive advantage in the market for solar PV power production.

References

Abboushi, S. (2014): Solar trade tariffs, Competitiveness Review, Vol. 24, No. 1, 59–65.

Baker, H.K. & Nofsinger, J.R. (2002): Psychological biases of investors, Financial Services Review, Vol. 11, No. 2, 97-116.

Barber, B.M. & Odean, T. (2000): Too many cooks spoil the profits: investment club performance, Financial Analysts Journal, Vol. 56, No. 1, 17-25.

Barber, B.M.; Heath, C. & Odean, T. (2003): Good reasons sell: reason-based choice among group and individual investors in the stock market, Management Science, Vol. 49, No. 12, 1636-1652.

Barberis, N. & Thaler, R. (2003): Chapter 18: A survey of behavioral finance, in: Constantinides, G.M.; Harris, M. & Stulz, R.M. (eds): Handbook of the Economics of Finance. North-Holland: Amsterdam, 1053-1128.

Bürer, M. & Wüstenhagen, R. (2009): Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international cleantech investors, Energy Policy, Vol. 37, No. 12, 4997–5006.

Esty, B. (2004): Why study large projects? An introduction to research on project finance, European Financial Management, Vol. 10, No. 2, 213-224.

European Photovoltaic Industry Association (EPIA) (2014): Global market outlook for photovoltaics 2014-2018. Brussels: EPIA, http://www.epia.org [4 June 2014].

Franke, N.; Gruber, M.; Harhoff, D. & Henkel, J. (2006): What you are is what you like – similarity biases in venture capitalists' evaluations of start-up teams, Journal of Business Venturing, Vol. 21, No. 6, 802-826.

Frankfurt School-UNEP Collaborating Centre for Climate & Bloomberg New Energy Finance (FS-UNEP & BNEF) (2014): Global trends in renewable energy investment 2014. Frankfurt a.M.: Frankfurt School of Finance & Management, http://fs-unep-centre.org [3 June 2014].

Global Wind Energy Council (GWEC) (2014): Global wind statistics 2013. Brussels: GWEC, http://www.gwec.net [4 June 2014].

Green P.E., Srinivasan V. (1990) “Conjoint analysis in marketing: new developments with implications for research and practice”, Journal of Marketing, 54(4), 3-19.

Green, P.E. & Rao, V.R. (1971): Conjoint measurement for quantifying judgmental data, Journal of Marketing Research, Vol. 8, No. 3, 355-363.

Green, P.E. & Srinivasan, V. (1990): Conjoint analysis in marketing: new developments with implications for research and practice, Journal of Marketing, Vol. 54, No. 4, 3-19.

Hampl, N. (2012): Energy Investment Decision-Making Under Uncertainty: The Influence of Behav-ioral and Social Effects. PhD Thesis. St. Gallen: D-Druck Spescha.

Hampl, N.; Lüdeke-Freund, F.; Flink, C.; Olbert, S. & Ade, V. (2011): The myth of bankability – Definition and management in the context of photovoltaic project financing in Germany. Munich and Hamburg: Goetzpartners and Colexon.

International Renewable Energy Agency (IRENA) (2014): REmap 2030 – A renewable energy roadmap. Abu Dhabi: IRENA, http://www.irena.org [3 June 2014].

Jacobsson, R. & Jacobsson, S. (2012): The emerging funding gap for the European energy sector – Will the financial sector deliver?, Environmental Innovation and Societal Transitions, Vol. 5, 49-59.

Kahneman, D. & Tversky, A. (1973): On the Psychology of Prediction, Psychological Review, Vol. 80, No. 4, 237-251.

Kahneman, D. & Tversky, A. (1979): Prospect Theory: An Analysis of Decision under Risk, Econometrica, Vol. 47, No. 2, 263-292.

Kahneman, D. (2003): Maps of Bounded Rationality: Psychology for Behavioral Economics, The American Economic Review, Vol. 93, No. 5, 1449–1475.

Landström, H.; Manigart, S.; Mason, C. & Sapienza, H.J. (1998): Contracts between entrepreneurs and investors: terms and negotiation processes, in: Reynolds, P.; Bygrave, W.; Carter, N.; Manigart, S.; Mason, C.; Meyer, D. & Shaver, K. (eds): Frontiers of Entrepreneurship Research. Boston, MA: Babson College, 571-585.

Loock, M. (2010): Business Models for Renewable Energy: Determinants of Financial Performance and Investment Decisions. PhD Thesis. Zürich: Adag Copy AG.

Loock, M. (2012): Going Beyond Best Technology and Lowest Price: On Renewable Energy Investors' Preference for Service-driven Business Models, Energy Policy, Vol. 40, 21-27.

Louviere, J.J.; Hensher, D.A.; Swait, J. & Adamowicz, W. (2003): Stated Choice Methods Analysis and Applications. Cambridge, UK: Cambridge University Press.

Louviere, J.J.; Islam, T.; Wasi, N.; Street, D. & Burgess, L. (2008): Designing discrete choice experiments: do optimal designs come at a price?, Journal of Consumer Research, Vol. 35, No. 2, 360-375.

Lüdeke-Freund F., Loock M. (2011a) “Debt for brands: tracking down a bias in financing photovoltaic projects in Germany”, Journal of Cleaner Production, 19(12), 1356-1364.

Lüdeke-Freund, F. & Loock, M. (2011b): What Kinds of Photovoltaic Projects do Lenders Prefer to Finance?, in: Marcus, A.; Shrivastava, P.; Sharma, S. & Pogutz, S. (Hrsg.): Cross-Sector Leadership for the Green Economy. New York: Palgrave Macmillan, 107-124.

Lüdeke-Freund, F., Hampl, N., Flink, C. (2012) “Bankability von Photovoltaik-Projekten”, in: Böttcher, J. (ed.): “Solarvorhaben – Wirtschaftliche, technische und rechtliche Aspekte”, Munich: Oldenbourg, 285-302.

Lüthi, S. & Wüstenhagen, R. (2012): The price of policy risk – Empirical insights from choice experiments with European photovoltaic project developers, Energy Economics, Vol. 34, No. 4, 1001-1011.

Masini, A. & Menichetti, E. (2012): The impact of behavioural factors in the renewable energy investment decision making process: Conceptual framework and empirical findings, Energy Policy, Vol. 40, 28–38.

Masini, A. & Menichetti, E. (2013): Investment decisions in the renewable energy sector: An analysis of non-financial drivers, Technological Forecasting and Social Change, Vol. 80, No. 3, 510–524.

McFadden, D. (1986): The choice theory approach to market research, Marketing Science, Vol. 5, No. 4, 275-297.

Sapienza, H.J. (1992): When do venture capitalists add value?, Journal of Business Venturing, Vol. 7, No. 1, 9-27.

Savage, L.J. (1954): The Foundations of Statistics. New York, NY: Wiley.

Sawtooth Software (1999): Scaling conjoint part worths: points vs. zero-centered diffs, http://www.sawtoothsoftware.com [31 August 2012].

Sawtooth Software (2002) "CVA/HB technical paper", http://www.sawtoothsoftware.com [14 March 2013].

Shane, S. & Cable, D. (2002): Network ties, reputation, and the financing of new ventures, Management Science, Vol. 48, No. 3, 364-381.

Shiller, R.J. (2003): From efficient markets theory to behavioral finance, Journal of Economic Perspectives, Vol. 17, No. 1, 83-104.

Shleifer, A. (2000): Inefficient Markets: An Introduction to Behavioral Finance. Oxford: Oxford University Press.

Simon, H.A. (1955): A behavioral model of rational choice, Quarterly Journal of Economics, Vol. 69, No. 1, 99-118.

Train, K. (2009): Discrete Choice Methods with Simulation. Cambridge, UK: Cambridge University Press.

Tversky, A. & Kahneman, D. (1974): Judgment under uncertainty: heuristics and biases, Science, Vol. 185, No. 4157, 1124-1131.

Tversky, A. & Kahneman, D. (1981): The Framing of Decisions and the Psychology of Choice, Science, Vol. 211, No. 4481, 453–458.

Vinter, G.; Price, G. & Lee, D. (2013): Project finance. 4th ed. London: Sweet & Maxwell.

von Neumann, J. & Morgenstern, O. (1944): The Theory of Games and Economic Behavior: Princeton, NJ: Princeton University Press.

Wissenschaftlicher Beirat Globale Umweltveränderungen [German Advisory Council on Global Change] (WBGU) (2012): Financing the global energy-system transformation. Berlin: WBGU, http://www.wbgu.de [4 June 2014].

Wüstenhagen, R. & Menichetti, E. (2012): Strategic choices for renewable energy investment: Conceptual framework and opportunities for further research, Energy Policy, Vol. 40, 1–10.

Yescombe, E. (2014): Principles of project finance. 2nd ed. Oxford: Academic Press.