UNIVERSITÄT LEIPZIG

COPENHAGEN CENTRE ON ENERGY EFFICIENCY
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EXPLORING THE ROLE OF STAKEHOLDER DYNAMICS IN RESIDENTIAL PHOTOVOLTAIC ADOPTION DECISIONS: A QUANTITATIVE SURVEY IN GERMANY

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INTRODUCTION & MOTIVATION

- Residential rooftop photovoltaics is a mean to abate anthropogenic climate change.
- Though general public acceptance and high potential, adoption rates remain low.
- Residential decision-making with respect to low-carbon technologies has been studied intensively.
- Yet, in behavioral studies to date, individuals are typically assessed in isolation from their social environments.
- Relevant stakeholder interactions and their effects are barely accounted for in existing energy transition modelling approaches.

❖ **This research gap is addressed by investigating stakeholder dynamics in residential PV decision-making from a procedural perspective.**

RESEARCH OBJECTIVE

- What are drivers and barriers for residential PV adoption?
- Which stakeholders influence the adoption decision and how can the influence be explained by psychographic attributes?
- What can be learned from the decision process of house owners who already adopted PV to enhance adoption rates?
- Which policy measures can be derived?

METHODOLOGY

- Investigation of the perceived influence of various stakeholders on the residential PV adoption decision based on a quantitative survey on house owners that are potential or current adopters in Germany (n=1165).
- Relative importance of different stakeholders in different stages receive special attention.
- Decision process is divided into three stages: Awareness stage, Interest stage and Planning stage.
- In each stage the perceived influence of stakeholders is recorded.
- Psychographic attributes of stakeholders are recorded.
- Furthermore, socio-economic characteristics and drivers/barriers for adoption intention of participants are recorded.
- Statistical methods: regression models for marginal effects, tests for sub-sample comparisons etc.

SURVEY STRUCTURE

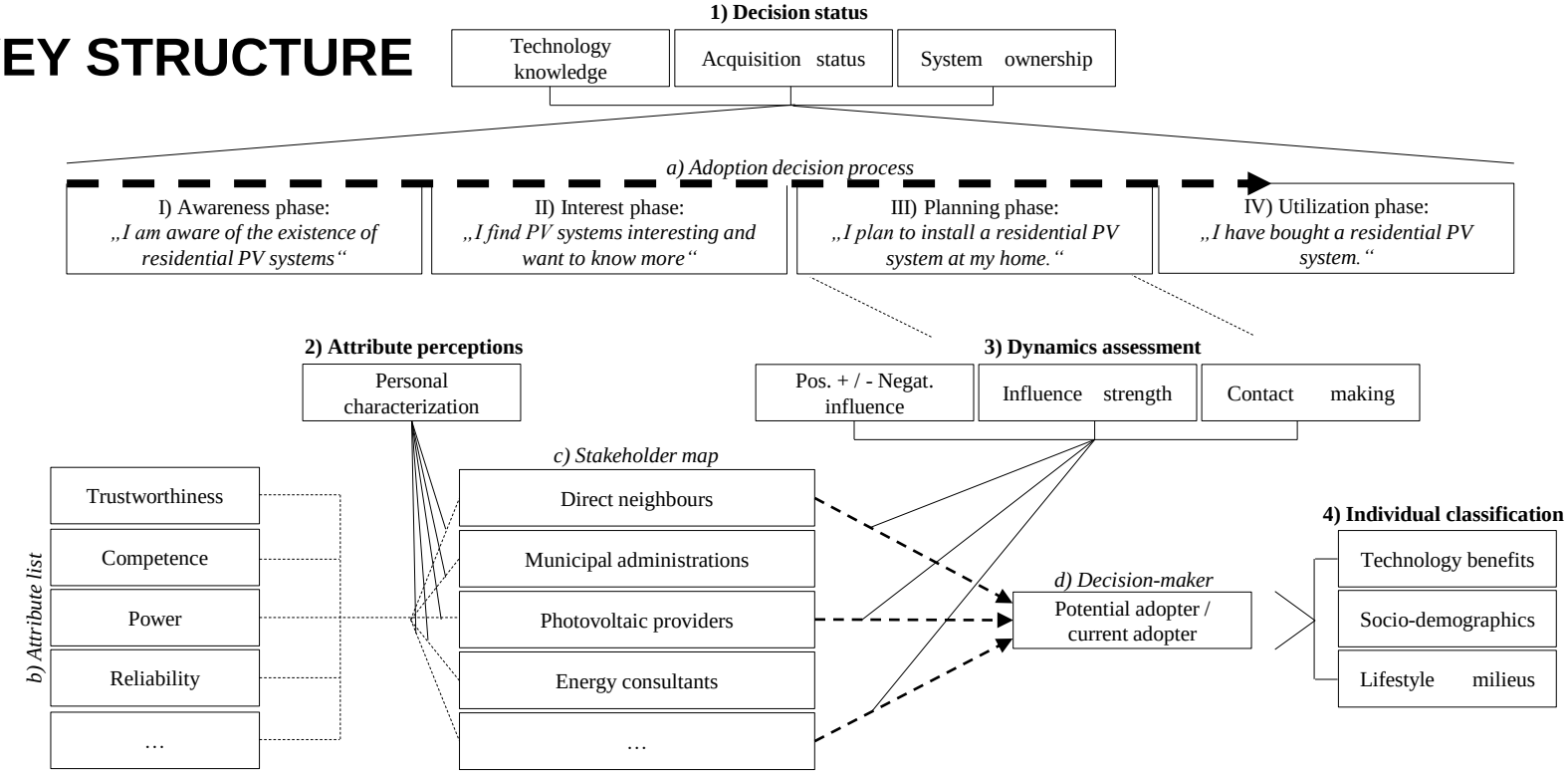

Figure 1: Composition and structure of the computer-aided survey (1-4 set out the general structure, I-IV represent the different stages of the decision process, a-d are answer possibilities of the participants).

METHODOLOGY

- Stakeholders comprise
  - Family & Relatives, Friends, Acquaintances & Colleagues, Neighbours, Other private persons, Local Utilities, National Utilities, Local governments, Private organizations & societies, Financial institutions, Contractors & Architects, Energy consultants, PV manufacturers & providers, Reporters & media corporations
- Respondents were asked to evaluate stakeholders' personal attributes on a 1 to 10 scale:
  - Trustworthiness, Competence, Power, Independence, Availability, Closeness, Likeability, Integrity, Reliability

METHODOLOGY

- Distribution of participants (n=1165) in subgroups:
  - Potential Adopters with low intention (n=486)
  - Potential Adopters with high intention (n=285)
  - Current Adopters (n=394)
- Low/high intention to adopt is determined by the question:
  - Will you adopt residential PV within the next three years? (5 Point-Lickert)
    - High intention: agree and strongly agree
    - Low intention: strongly disagree, disagree, neither agree nor disagree

Results and findings

DRIVERS & BARRIERS

RESULTS AND FINDINGS

- Intention as dependent variable in ordered probit regression on benefits/barriers exhibits
  - Positive marginal effects
    - investing time (β=.32, p<.01) and money (β=.26, p<.01) to get information on PV systems
    - having enough money to install a PV system (β=.11, p<.05)
    - believing to save money on the long run with a PV system (β=.25, p<.01)
    - knowing persons owning a PV system (β=.07, p<.1)
    - raising social status (β=.17, p<.01)
    - gaining independence from energy utilities (β=.15, p<.01)
  - Negative marginal effects
    - perceiving risk and cost (β=-.15,p<.01).
  - Environmental concerns and technological leadership were not significant in the regression and are only weakly to moderately correlated to the intention (ρ=.25 and ρ=.35, p<.01).

RESULTS AND FINDINGS

- average income of participants higher than national average (house owners)
- Current adopters and high intention potential adopters have equal income, but *low intention adopters lie significantly below* (-247€/month, $p<0.001$)
- *analogous results for a risk index* constructed from milieu indicator questionnaire (SINUS-Questions)
- analogous results for sub-sample comparisons:
  - Gender
  - Eastern vs. Western German Federal States

❖ **Monetary and risk-related considerations are eminent for adoption intention.**

Results and findings

INFLUENCE STRENGTH EXPLAINED BY ATTRIBUTES

RESULTS AND FINDINGS

- Participants were asked about the influence of stakeholders on their decision (1 to 10 scale)
  - Influence regressed step-wise ($p<0.1$) on stakeholders' attributes reveals that influence can be largely (R^2 between 0.4 and 0.7) explained by stakeholders' attributes.

Table 3: Influential stakeholder attributes in the awareness stage of the decision-making process (stage I).

	Social stakeholders				Institutional stakeholders				Commercial stakeholders				
	Family & relatives	Friends	Acquaintances & colleagues	Neighbours	Other private pers.	Local governments	Private org. & societies	Reporters & media	Local utilities	National utilities	Energy consultants	PV manufact. & Providers	Building professionals	Funding institutions
Trustworthiness	.146***		.299***	.258***										
	(.056)		(.066)	(.066)										
Competence	.213***	.280***	.161***	.330***										
	(.037)	(.042)	(.050)	(.051)										
Power	.084***	.149***	.161***	.134***										
	(.023)	(.026)	(.028)	(.030)										
Independence	-.042*	-.072**												
	(.023)	(.027)												
Availability	.102**	.112**												
	(.045)	(.047)												
Closeness		.119**	.107**	.152***										
		(.049)	(.051)	(.058)										
Likability	.298***	.268***	.138**											
	(.068)	(.060)	(.062)											
Integrity	.129**													
	(.058)													
Reliability														
Const.	0.357	1.156***	1.106**	1.060**										
	(.450)	(.438)	(.449)	(.504)										
Observations	458	421	360	336										
R^2	.4272	.4273	.4396	.4527										
Adj R^2	.4183	.419	.4317	.446										

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.
Step-wise regression ($p < 0.1$) of influence st
Coefficients are interpreted as marginal effec

Table 4: Influential stakeholder attributes in the interest stage of the decision-making process (stage II).

	Social stakeholders				Institutional stakeholders				Commercial stakeholders				
	Family & relatives	Friends	Acquaintances & colleagues	Neighbours	Other	Local	Private org.	Reporters	Local	National	Energy	PV manufact.	Building	Funding
Trustworthiness	.132**		.192***	.144**										
	(.056)		(.064)	(.065)										
Competence	.241***	.354***	.196***	.358***										
	(.035)	(.038)	(.051)	(.051)										
Power	.106***	.117***	.134***	.133***										
	(.022)	(.025)	(.029)	(.030)										
Independence														
Availability														
Closeness		.090*	.114**	.143**										
		(.048)	(.050)	(.059)										
Likability	.258***	.190***												
	(.073)	(.068)												
Integrity	.207***		.141**											
	(.063)		(.067)											
Reliability		.128**	.136**	.135**										
		(.055)	(.066)	(.056)										
Const.	.315	.970**	.542	.640										
	(.463)	(.444)	(.451)	(.519)										
Observations	464	453	386	355										
R^2	.4019	.4085	.4287	.4397										
Adj R^2	.3954	.4019	.4196	.4316										

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.
Step-wise regression ($p < 0.1$) of influence s
Coefficients are interpreted as marginal effe

Table 5: Influential stakeholder attributes in the planning stage of the decision-making process (stage III).

	Social stakeholders					Institutional stakeholders					Commercial stakeholders			
	Family & relatives	Friends	Acquaintances & colleagues	Neighbours	Other private pers.	Local governments	Private org. & societies	Reporters & media	Local utilities	National utilities	Energy consultants	PV manufact. & Providers	Building professionals	Funding institutions
Trustworthiness		.220***	.164*	.317***	.365***	.173**	.205***		.127*			.093*		
		(.075)	(.090)	(.073)	(.076)	(.073)	(.059)		(.067)			(.049)		
Competence	.221***	.414***	.143*	.167**	.175**			.337***		.152**	.171**	.142**	.124*	.155**
	(.060)	(.058)	(.084)	(.072)	(.077)			(.069)		(.072)	(.072)	(.064)	(.074)	(.068)
Power	.102***	.090***	.129***	.104***				.188***	.093**					
	(.031)	(.032)	(.038)	(.034)				(.054)	(.038)					
Independence		.082**	.101**	.154***	.205***	.124**			.210***	.073*	.115***		.138***	
		(.034)	(.040)	(.039)	(.045)	(.051)			(.039)	(.044)	(.034)		(.042)	
Availability	.146**		.237***	.209***		.211***	.145**		.221***	.185***	.196**		.143*	.141*
	(.064)		(.068)	(.071)		(.076)	(.062)		(.065)	(.062)	(.075)		(.073)	(.074)
Closeness		.158***			.294***		.220***	.171***		.262***	.099*	.101***	.134**	.135**
		(.058)			(.059)		(.050)	(.061)		(.048)	(.052)	(.034)	(.065)	(.063)
Likability	.311***					.178**	.220***						.163**	
	(.093)					(.090)	(.074)						(.082)	
Integrity						.335***	.246***	.221***	.120*	.183***	.173**	.151***		.204***
						(.070)	(.065)	(.075)	(.071)	(.070)	(.077)	(.055)		(.071)
Reliability	.149*		.190**						.203***	.172**	.208***	.302***	.138*	
	(.084)		(.079)						(.070)	(.077)	(.077)	(.067)	(.080)	
Const.	.407	.142	.125	.380	-.478	-.452	-.425	.597	.112	-.388	.199	1.701***	1.215**	.894**
	(.536)	(.480)	(.613)	(.504)	(.443)	(.439)	(.397)	(.414)	(.462)	(.415)	(.516)	(.460)	(.513)	(.432)
Observations	290	290	247	233	194	187	182	177	221	183	236	303	214	200
R^2	.4575	.5207	.494	.5205	.6641	.6694	.7356	.6577	.6052	.7154	.5294	.4224	.489	.5911
Adj R^2	.448	.5122	.4814	.51	.657	.6603	.7281	.6497	.5941	.7057	.5171	.4127	.4742	.5806

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.
Step-wise regression ($p < 0.1$) of influence strength against stakeholder attributes.
Coefficients are interpreted as marginal effects of attributes on influence strength. Standard deviation in parentheses.

RESULTS AND FINDINGS

- Depending on stakeholder and stage, different stakeholder attributes contribute (marginal effects) to perceived influence (examples):
  - For family members and relatives the highest m.e. is found for *likeability* for all stages I-III (*I* = .298, *II* = .258, *III* = .311) followed by *competence* (*I* = .213, *II* = .241, *III* = .221).
  - For local utilities, the highest m.e. are found for *trustworthiness* (*I* = .234) in the first stage (awareness), *independence* (*II* = .211) and *reliability* (*II* = .310) in the second stage (interest) and *availability* (*III* = .211) and *reliability* (*III* = .203) in the third stage (planning).
  - PV manufacturers have the highest m.e. for *availability* (*I* = .187) and *competence* (*I* = .183) in the first stage, *competence* (*II* = .201) and *reliability* (*II* = .195) in the second stage and *reliability* (*III* = .302) in the third stage.
  - Building professionals demonstrate the highest m.e. for *competence* (*I* = .252) and *reliability* (*I* = .230) in the first stage, *reliability* (*II* = .172) and *independence* (*II* = .169) in the second stage and *availability* (*III* = .143) and *reliability* (*III* = .138) in the third stage.

Results and findings

INFLUENCE STRENGTH OF STAKEHOLDERS

RESULTS AND FINDINGS

- Box plots of influence strength by stage and stakeholder
- Actual adopters report highest influence strengths, followed by high intention potential adopters
- Low intention potential adopters report lowest influence strength
- Similar for contact rates (numbers below box plots)
- Two-sided t-tests were performed to prove differences in perceived influence strength

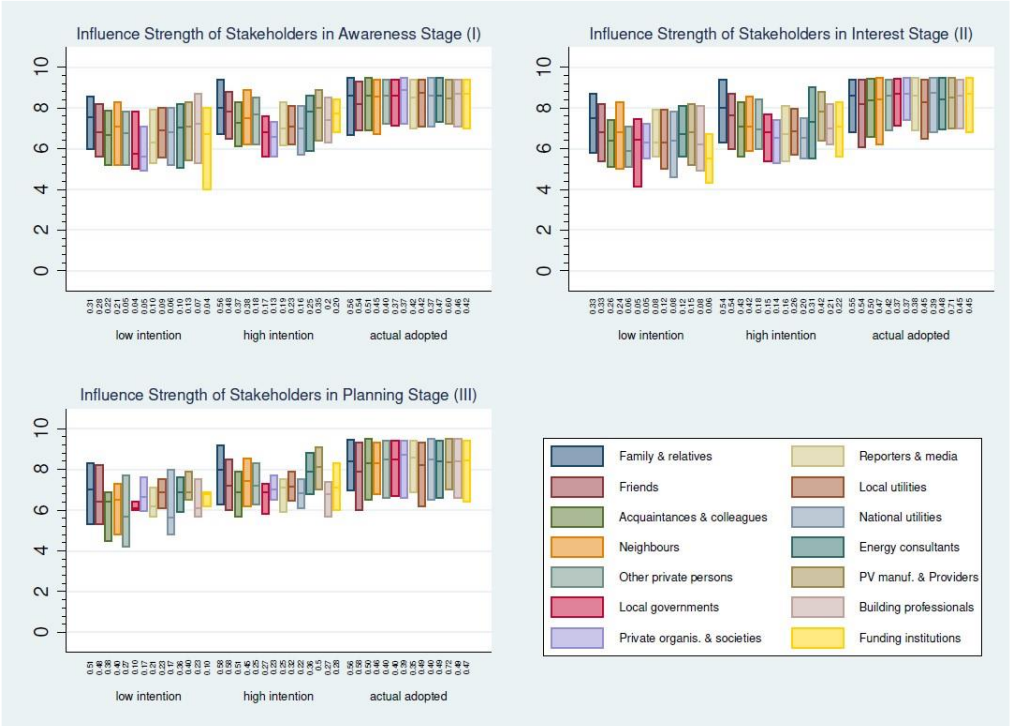

Figure 2: Influence strength of stakeholders through the stages by intention and adoption status. For various stakeholders the perceived influence (Q1, median, Q3) is shown for low intenders, high intenders and actual adopters.

CONCLUSIONS AND POLICY IMPLICATIONS

CONCLUSIONS AND POLICY IMPLICATIONS

- Monetary and risk-related considerations are eminent for adoption intention
  - → Policy measures to reduce risk and monetary insecurities
  - ❖ Income dependent tax benefits
  - ❖ Location dependent feed-in tariffs
- Stakeholders' attributes can explain perceived influence on adoption decision: for *institutional and commercial* stakeholders competence, reliability, trustworthiness and likability have highest influence
  - → Investments in the enhancement of these attributes
  - ❖ certification and training

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THANK YOU FOR YOUR ATTENTION!

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