Consumer behavior change journey

NOVA IMS Information Management School

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HARP
Heating Appliances Retrofit Planning

1. HARP project

- **HARP stands for Heating Appliances Retrofit Planning.** It is a project funded by the **European Union through the Horizon 2020 framework**, focusing on 5 EU Member States: Portugal, Spain, France, Italy and Germany.
- **The main idea** behind the project is to **motivate individuals to plan the replacement** of their often old and inefficient heating appliances, with more efficient alternatives.
- Through an **application the HARP project** will enable individuals to get an indication of the labelling classification of their heating system.

18 partners	**3** years
1,5 million consumers expected to be reached	**10,000** consumers could be motivated to replace their heating

Universidade Nova de Lisboa – Nova Information Management School

- Definition of the consumer behaviour change model regarding the adoption of efficient heating systems;
- Dissemination of project results within academia/scientific forums.

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2. Introduction

TARGET

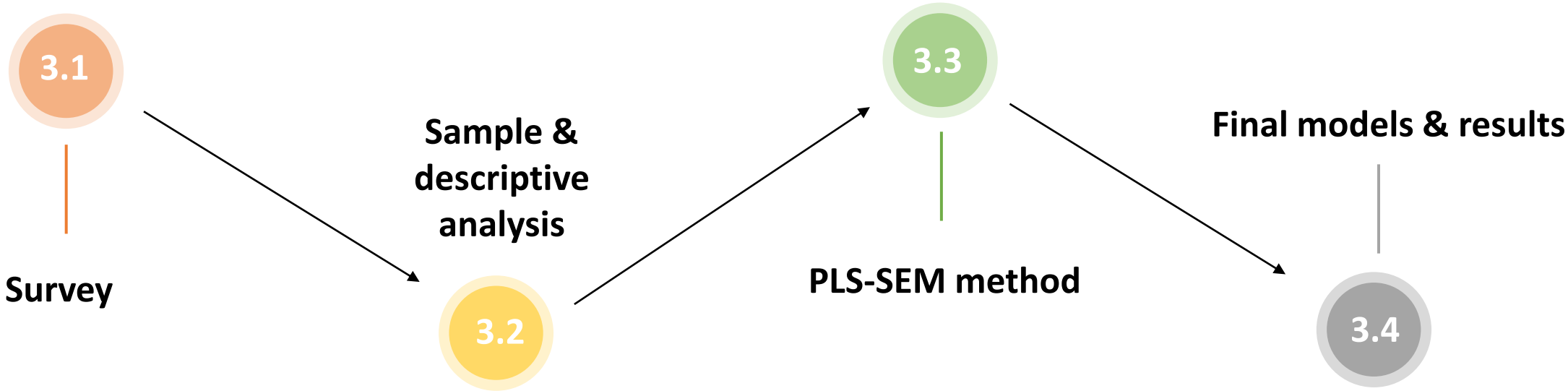
Consumer with old and inefficient heating systems → more than 50% of equipment performing as C or lower.

GOAL

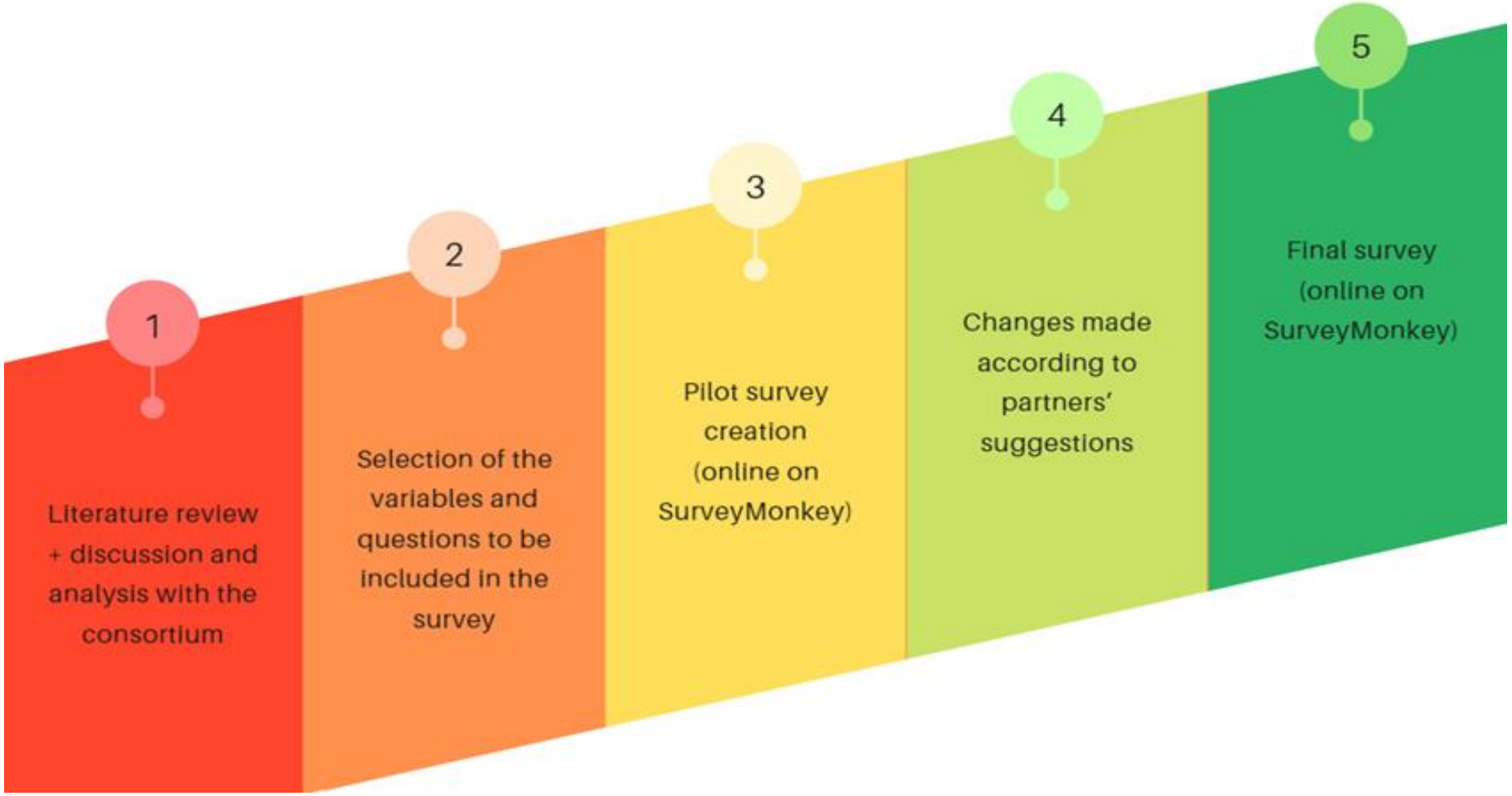
Motivating consumer to plan and replace their old and inefficient heating systems

3. Methodology & results

To achieve our goal, the work carried out went through different stages in order to be able to produce a final model that explains what makes individuals change to more efficient heating equipment.

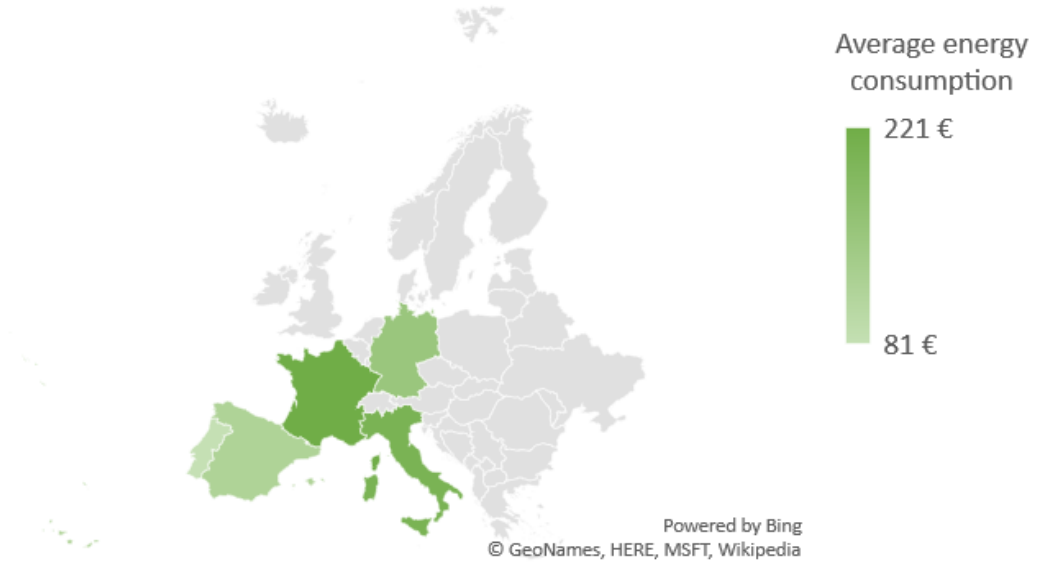


3.1. Survey


1
Literature review + discussion and analysis with the consortium
2
Selection of the variables and questions to be included in the survey
3
Pilot survey creation (online on SurveyMonkey)
4
Changes made according to partners' suggestions
5
Final survey (online on SurveyMonkey)

3.2.1 Descriptive Statistics

Country	N (the necessary number of complete responses)	Number of total responses	Number of complete responses	Number of randomly selected responses
France	237	453	411	**363**
Germany	163	300	179	**179**
Italy	264	649	387	**357**
Portugal	227	519	331	**262**
Spain	237	9531	4736	**450**
All	1128	11452	6044	**1611**



Descriptive statistics of all sample	
Sample characteristics (n=1611)	Descriptive statistics
Age	
18-39	31%
≥ 40	69%
Gender	
F	41%
M	59%
Responsible decision to change to an EEHA	77%
Houseowner	78%
Children	40%
Number of years of education	15.3
Country	
France	23%
Germany	11%
Italy	22%
Portugal	16%
Spain	28%

3.2.3. Factorial Analysis

	Factor 1 – Commun. channels media (CCM)	Factor 2 – Commun. channels organisations (CCO)	Factor 3 – Commun. channels web media (CCW)
Radio	**0.899**	0.171	0.158
TV	**0.763**	0.245	0.189
Newspaper	**0.705**	0.215	0.279
Installers and/or related professionals	0.090	**0.912**	0.104
Stores of EEHA	0.157	**0.678**	0.217
Organisations (local associations, energy agencies)	0.301	**0.504**	0.119
People that I know and have an EEHA	0.191	0.336	0.181
Websites	0.128	0.200	**0.695**
Mobile Applications	0.321	0.159	**0.534**
Explained variance	2.166	1.859	1.012
Explained variance (%)	24.1%	20.7%	11.2%
KMO		0.807	

The idea behind this analysis is that a set of variables may have similar patterns of response because they are associated with a latent variable. Thus, the factorial analysis attempts to build factors that are those latent variables, that are easily interpreted.

For the ***Communication Channels (CC)*** and the ***Co-Benefits (CB)***, a factorial analysis was performed to understand if there was any factor that could separate the variables into a more easily interpreted group. This analysis was performed for all responses together and also for each country.

3.2.3. Factorial Analysis

	Factor 1 – Co-benefits investment	Factor 2 – Co-benefits
Have better indoor air quality	**0.802**	0.080
Lower indoor noise level	**0.797**	0.086
Operate the EEHA more easily	**0.795**	0.084
Achieve a comfortable indoor temperature during the heating season more easily	**0.787**	0.033
Lower external noise level	**0.777**	0.074
Be more independent to energy prices	**0.758**	0.085
Have more useful living area	**0.740**	0.132
Have a reduced environmental impact	**0.714**	0.105
Have a more aesthetically pleasing EEHA	**0.687**	0.165
Value the dwelling in the real-estate market	**0.667**	0.233
It allows me to be independent from energy price fluctuations	0.072	**0.757**
It allows me to have a reduced environmental impact	0.160	**0.669**
It values the dwelling in the real-estate market (I will sell the house for a higher price if it is equipped with an EEHA)	0.121	**0.655**
Condensation, humidity and mould-related problems are avoided	0.091	**0.618**
It will not reduce my house's useful floor area	0.020	**0.570**
Explained variance	5.739	2.301
Explained variance (%)	38.3%	15.3%
KMO	0.899	

3.2.3. Factorial Analysis

Media

- Radio
- TV
- Newspaper

Organisations

- Installers and/or related professionals
- Stores of EEHA
- Organizations (local associations, energy agencies)
- People that I know and have an EEHA

Web media

- Websites
- Mobile Applications

Co-benefits investment

- Have better indoor air quality
- Lower indoor noise level
- Operate the EEHA more easily
- Achieve a comfortable indoor temperature during the heating season more easily
- Lower external noise level
- Be more independent to energy prices
- Have more useful living area
- Have a reduced environmental impact
- Have a more aesthetically pleasing EEHA
- Value the dwelling in the real-estate market

Co-benefits

- It allows me to be independent from energy price fluctuations
- It allows me to have a reduced environmental impact
- It values the dwelling in the real-estate market (I will sell the house for a higher price if it is equipped with an EEHA)
- Condensation, humidity and mold related problems are avoided
- It will not reduce my house's useful floor area

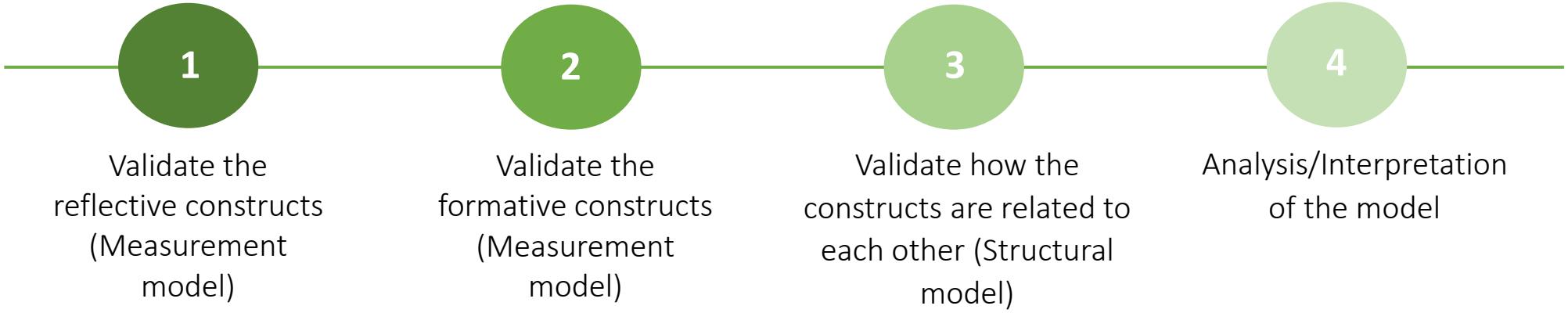
3.3. PLS-SEM method

There are two families of structural equation modelling (SEM) techniques : (i) covariance-based techniques and (ii) variance-based techniques. Partial least squares (PLS) is a variance-based technique as discussed in this investigation since:

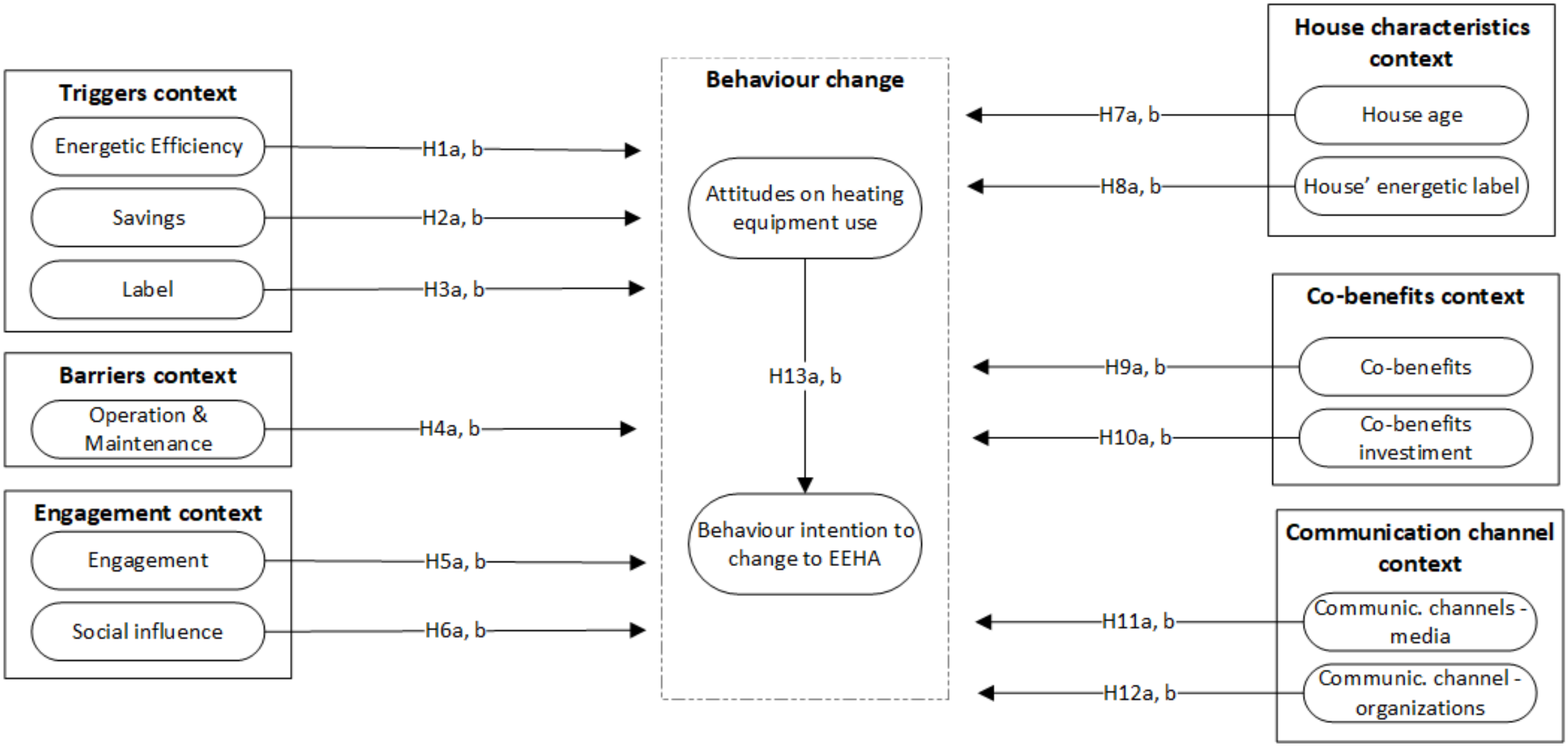
I. *not all items in our data are distributed normally ($p<0.01$ based on Kolmogorov–Smirnov's test);*
II. *the research model has not been tested in the literature;*
III. *the research model presents formative constructs;*
IV. *the research model is considered as complex;*

Smart PLS 3.0 (Ringle, Wende, & Becker, 2015) was the software used to estimated the models.

Steps for achieving the correct model in PLS-SEM



3.3.2. Final conceptual model



3.3.3. Measurement models

Reflective constructs

- Internal consistency → Composite Reliability (> 0.7)
- Convergent validity → Average Variance Extracted (AVE) (>0.5)
  - → Indicator reliability

Construct	Mean	STD	CR	EE	Sav	Lab	OM	EG	SI	HA	HEC	Att	BIC
EE	6.104	1.356	1.000	1.000									
Sav	5.952	1.201	0.894	0.489	0.861								
Lab	6.132	1.135	0.927	0.452	0.491	0.900							
OM	3.162	1.625	0.938	-0.247	-0.143	-0.157	0.914						
EG	4.355	1.541	0.960	0.233	0.120	0.218	-0.184	0.961					
SI	3.710	1.741	0.974	0.195	0.153	0.215	-0.088	0.601	0.962				
HA	4.305	1.924	1.000	0.094	0.066	-0.029	-0.072	-0.026	0.027	1.000			
HEC	3.332	2.600	1.000	0.016	-0.074	0.020	-0.078	0.306	0.249	-0.239	1.000		
Att	3.984	1.725	0.884	0.314	0.263	0.304	-0.159	0.314	0.311	0.056	0.023	0.890	
BIC	4.875	1.660	0.925	0.430	0.320	0.360	-0.287	0.457	0.439	0.084	0.121	0.680	0.897

Mean, Standard Deviation, CR, correlations and AVEs (square roots of the values in the diagonal) of reflective constructs

3.3.3. Measurement models

Reflective constructs

- Discriminant Validity
  - Fornell-Larcker criterion
  - Cross loadings
  - Heterotrait-Monotrait Ratio (HTMT) (<0.9)

Construct	EE	Sav	Lab	OM	EG	SI	HA	HEC	Att	BIC
EE										
Sav	0.530									
Lab	0.478	0.567								
OM	0.259	0.155	0.169							
EG	0.241	0.128	0.234	0.201						
SI	0.199	0.170	0.232	0.092	0.640					
HA	0.094	0.072	0.031	0.073	0.027	0.028				
HEC	0.016	0.089	0.038	0.082	0.322	0.254	0.239			
Att	0.365	0.334	0.374	0.192	0.379	0.370	0.065	0.027		
BIC	0.459	0.368	0.405	0.320	0.506	0.478	0.090	0.129	0.845	

Heterotrait-Monotrait Ratio (HTMT)

Consequently, the reflective constructs can be used to test the structural model.

Item	EE	Sav	Lab	OM	EG	SI	HA	HEC	Att	BIC
EE	**1.000**	0.489	0.452	-0.247	0.233	0.195	0.094	0.016	0.314	0.430
Sav1	0.311	**0.708**	0.325	-0.050	0.057	0.114	0.047	-0.102	0.186	0.188
Sav2	0.491	**0.936**	0.482	-0.168	0.139	0.172	0.065	-0.048	0.265	0.340
Sav3	0.435	**0.920**	0.441	-0.128	0.100	0.102	0.056	-0.058	0.220	0.274
Lab1	0.385	0.433	**0.887**	-0.073	0.137	0.161	-0.038	-0.025	0.263	0.276
Lab2	0.385	0.420	**0.927**	-0.136	0.225	0.222	-0.013	0.027	0.262	0.320
Lab3	0.443	0.466	**0.884**	-0.201	0.219	0.195	-0.028	0.045	0.291	0.366
OM1	-0.221	-0.118	-0.140	**0.891**	-0.187	-0.089	-0.013	-0.094	-0.131	-0.237
OM2	-0.206	-0.134	-0.126	**0.903**	-0.116	-0.034	-0.087	-0.036	-0.133	-0.242
OM3	-0.246	-0.138	-0.161	**0.946**	-0.196	-0.112	-0.090	-0.083	-0.167	-0.300
EG1	0.252	0.161	0.266	-0.164	**0.967**	0.575	-0.027	0.270	0.329	0.465
EG2	0.192	0.063	0.145	-0.192	**0.955**	0.580	-0.021	0.322	0.270	0.409
SI1	0.179	0.136	0.199	-0.085	0.594	**0.957**	0.026	0.251	0.303	0.424
SI2	0.177	0.143	0.202	-0.065	0.566	**0.969**	0.031	0.227	0.290	0.408
SI3	0.205	0.163	0.220	-0.103	0.574	**0.961**	0.022	0.239	0.304	0.435
HA	0.094	0.066	-0.029	-0.072	-0.026	0.027	**1.000**	-0.239	0.056	0.084
HEC	0.016	-0.074	0.020	-0.078	0.306	0.249	-0.239	**1.000**	0.023	0.121
Att2	0.325	0.287	0.311	-0.164	0.282	0.255	0.060	0.009	**0.894**	0.640
Att3	0.233	0.180	0.229	-0.118	0.276	0.299	0.039	0.033	**0.885**	0.569
BIC1	0.413	0.299	0.342	-0.257	0.437	0.405	0.067	0.126	0.614	**0.927**
BIC2	0.449	0.358	0.368	-0.258	0.351	0.370	0.108	0.054	0.579	**0.908**
BIC3	0.294	0.205	0.258	-0.256	0.438	0.405	0.053	0.144	0.635	**0.853**

Loadings and Cross loadings

3.3.3. Measurement models

Formative constructs

- Variance Inflation Factor (VIF)

↓

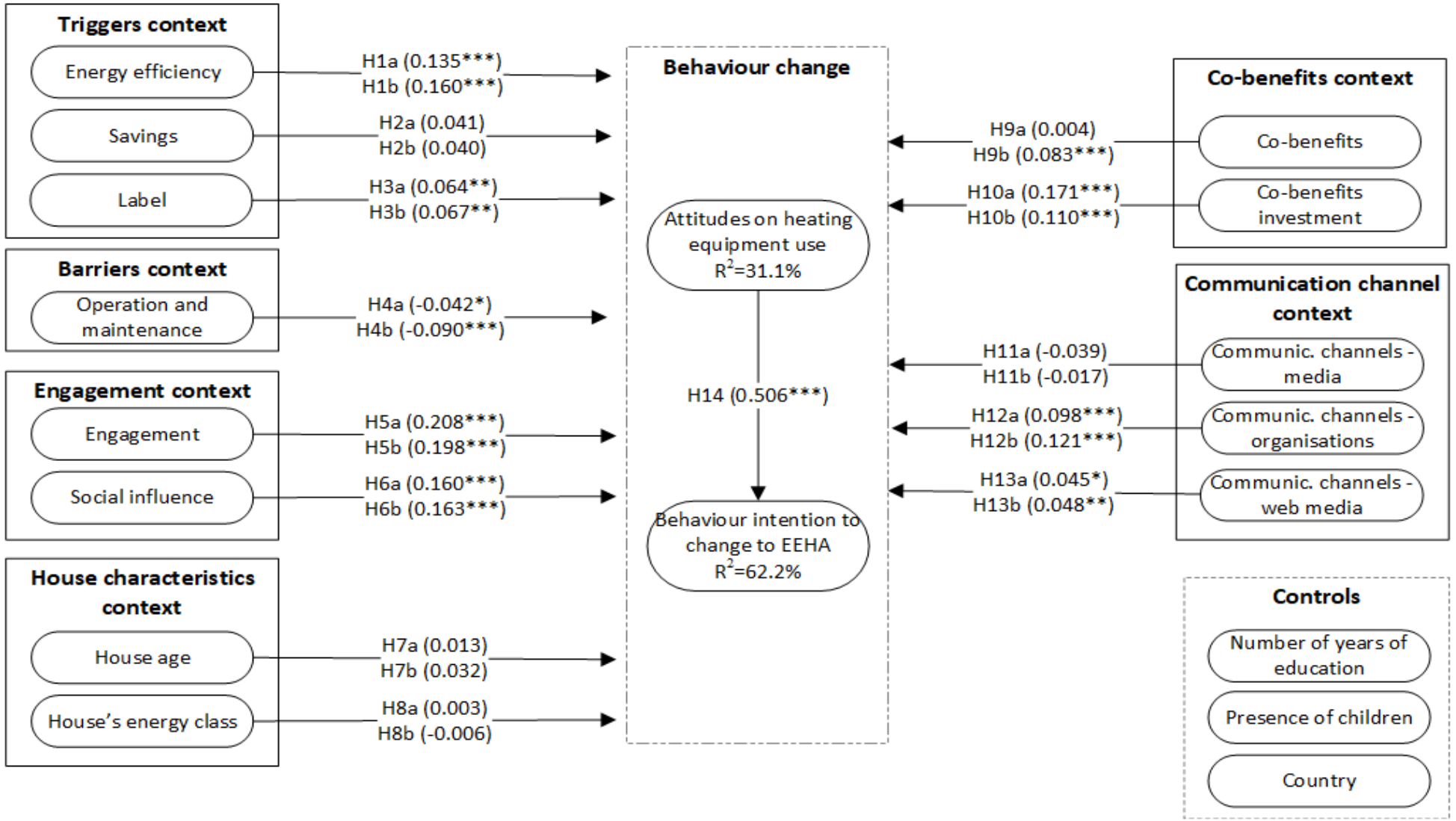
Assess multicolinearity

Consequently, the formative constructs can be used to test the structural model.

Construct	Item	Mean	STD	Weights	Loadings	VIF
Co-benefits	CB1	5.623	1.737	0.274***	0.589***	1.516
	CB2	5.277	1.675	-0.214***	0.227***	1.395
	CB3	5.312	1.696	0.261***	0.591***	1.537
	CB4	5.782	1.476	-0.148*	0.501***	1.819
	CB5	6.081	1.354	0.854***	0.946***	1.634
	CB6	252.943	236.461	0.403***	0.801***	2.674
	CB7	249.765	234.095	-0.089	0.699***	2.897
	CB8	218.981	223.278	0.028	0.658***	3.137
	CB9	209.052	222.694	0.125	0.637***	3.077
Co-benefits investment	CB10	195.953	207.858	-0.150	0.611***	2.681
	CB11	262.967	242.853	-0.042	0.671***	2.356
	CB12	186.082	200.868	0.343***	0.652***	2.238
	CB13	223.899	223.320	-0.230**	0.550***	2.378
	CB14	270.643	236.566	0.134	0.677***	1.982
	CB15	297.098	246.125	0.634***	0.902***	2.268
Communication channels organisations	CC1	4.627	1.894	0.481***	0.768***	1.207
	CC7	5.061	1.814	0.573***	0.854***	1.426
	CC8	4.975	1.653	0.019	0.595***	2.143
	CC9	4.538	1.691	0.226**	0.577***	1.908
Communication channels web media	CC2	4.979	1.575	0.624***	0.868***	1.243
	CC3	3.577	1.802	0.553***	0.829***	1.243
Communication channels media	CC4	3.672	1.762	0.320*	0.848***	2.144
	CC5	3.344	1.784	0.295	0.904***	3.046
	CC6	3.608	1.871	0.498***	0.926***	2.478

Notes:*p-value<0.10; **p-value<0.05; ***p-value<0.01*

3.4.1. Results of final conceptual model – All countries

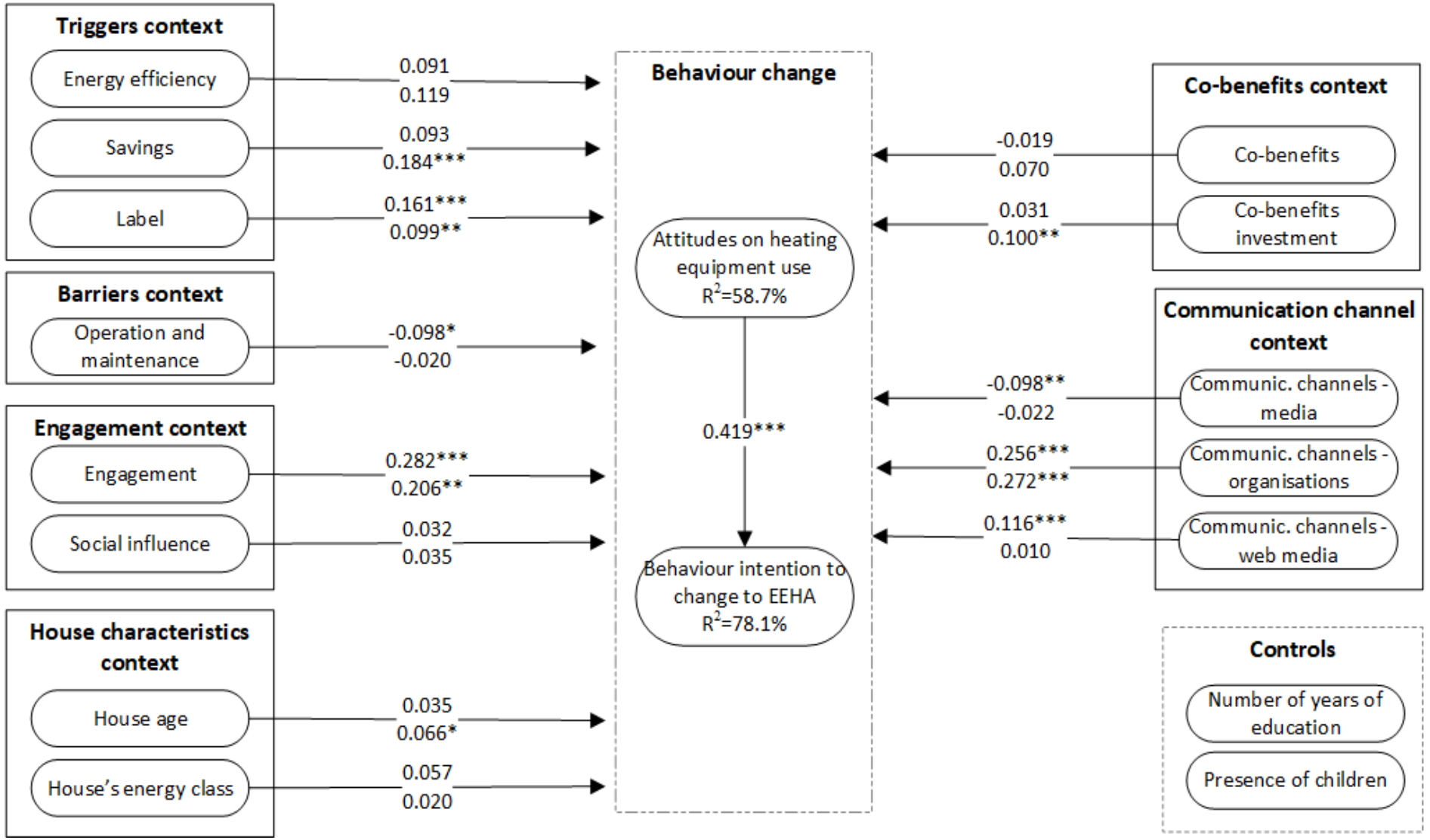


*p-value<0.10; **p-value<0.05; ***p-value<0.01

3.4.1. Other studies

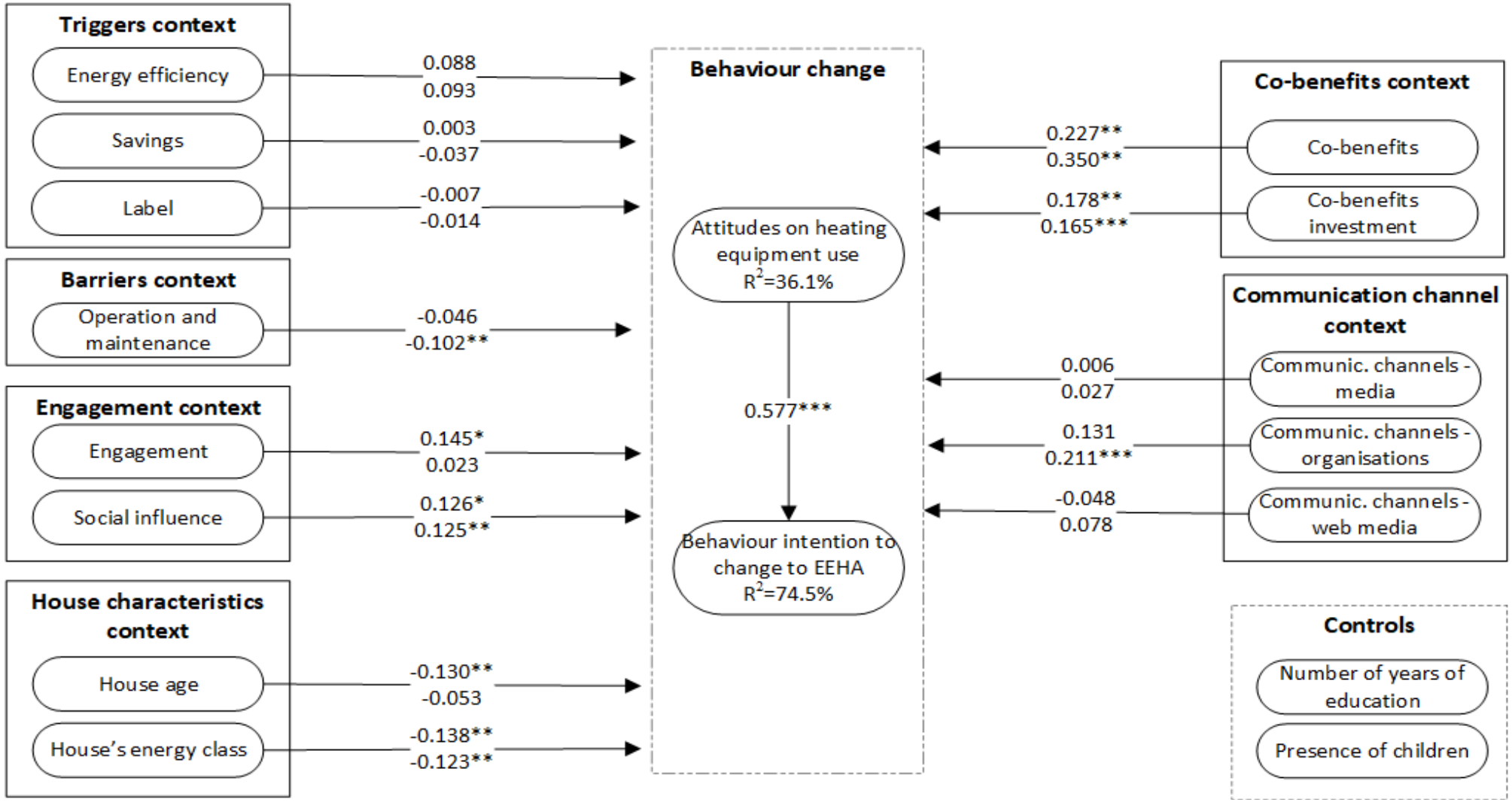
Reference	Dependent Variable	R-Squared
(Yang & Zhao, 2015)	EERE (Domestic energy-efficient and renewable energy equipment) purchase behavioral intention (Structural equation model)	(Adjusted) **R^2= 46.7%**
(Hrovatin & Zoric, 2018)	Decision to undertake EE (energy efficiency) retrofit (Probit model)	(Pseudo R-Squared) **R^2= 9.8%**
(Hrovatin & Zoric, 2018)	Decision on the number of EE (energy efficiency) retrofits (Poisson model)	Pseudo R-Squared) **R^2= 2.7%**
(Banfi, Farsi, Filippini & Jakob, 2006)	Marginal willingness to pay for different energy-saving characteristics in single-family houses (Logit model)	(Pseudo r-Squared) **R^2= 31.8%**
(Banfi, Farsi, Filippini & Jakob, 2006)	Marginal willingness to pay for different energy-saving characteristics in rented apartments (Logit model)	(Pseudo r-Squared) **R^2= 29.8%**
(Sardinou & Genoudi, 2013)	Consumers' willingness to adopt renewable energy sources within their residence (Probit model)	(McFadden's) **R^2= 28.1%**

3.4.1. Results of final conceptual model – France



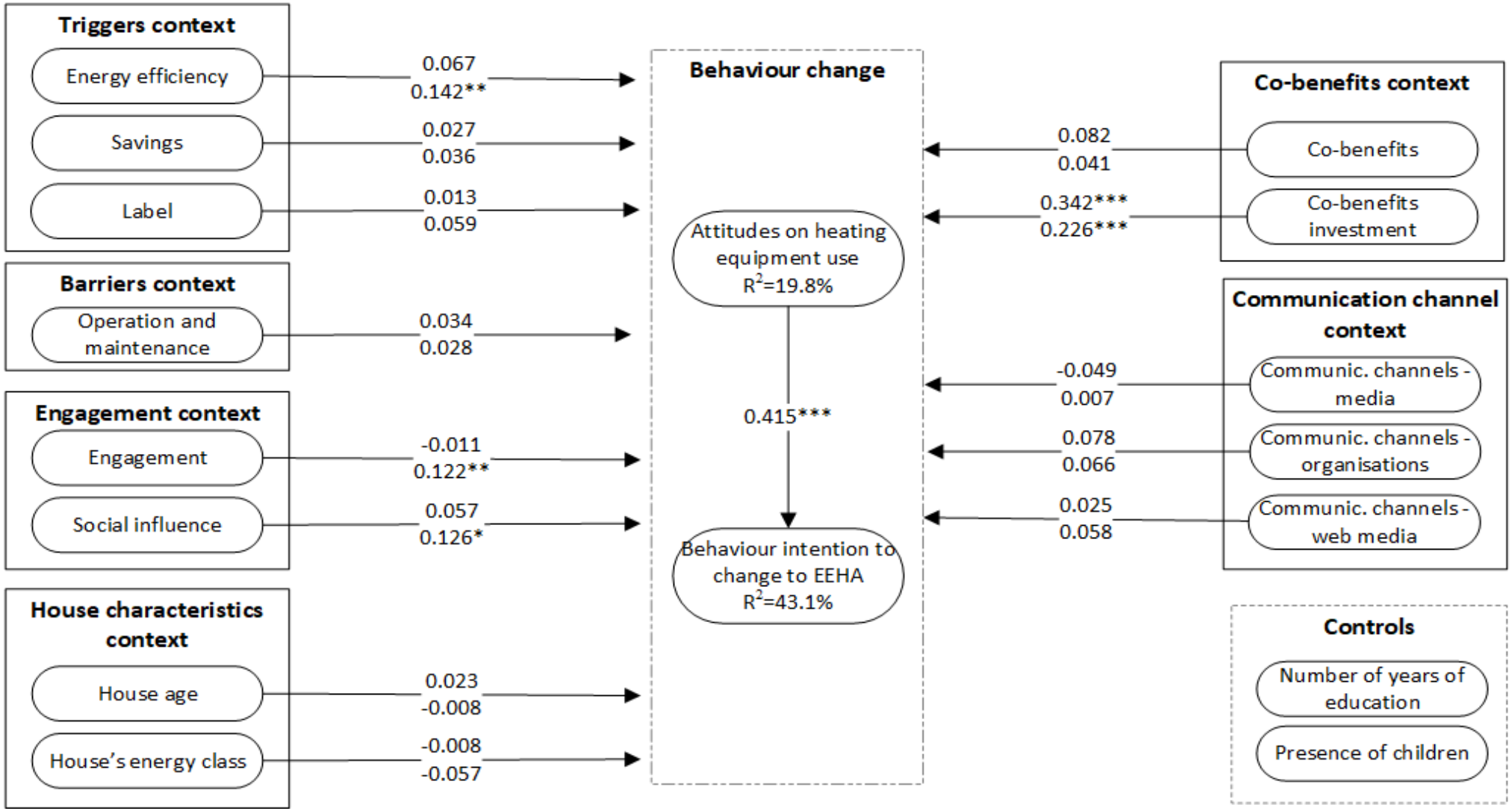
*p-value<0.10; **p-value<0.05; ***p-value<0.01

3.4.1. Results of final conceptual model – Germany



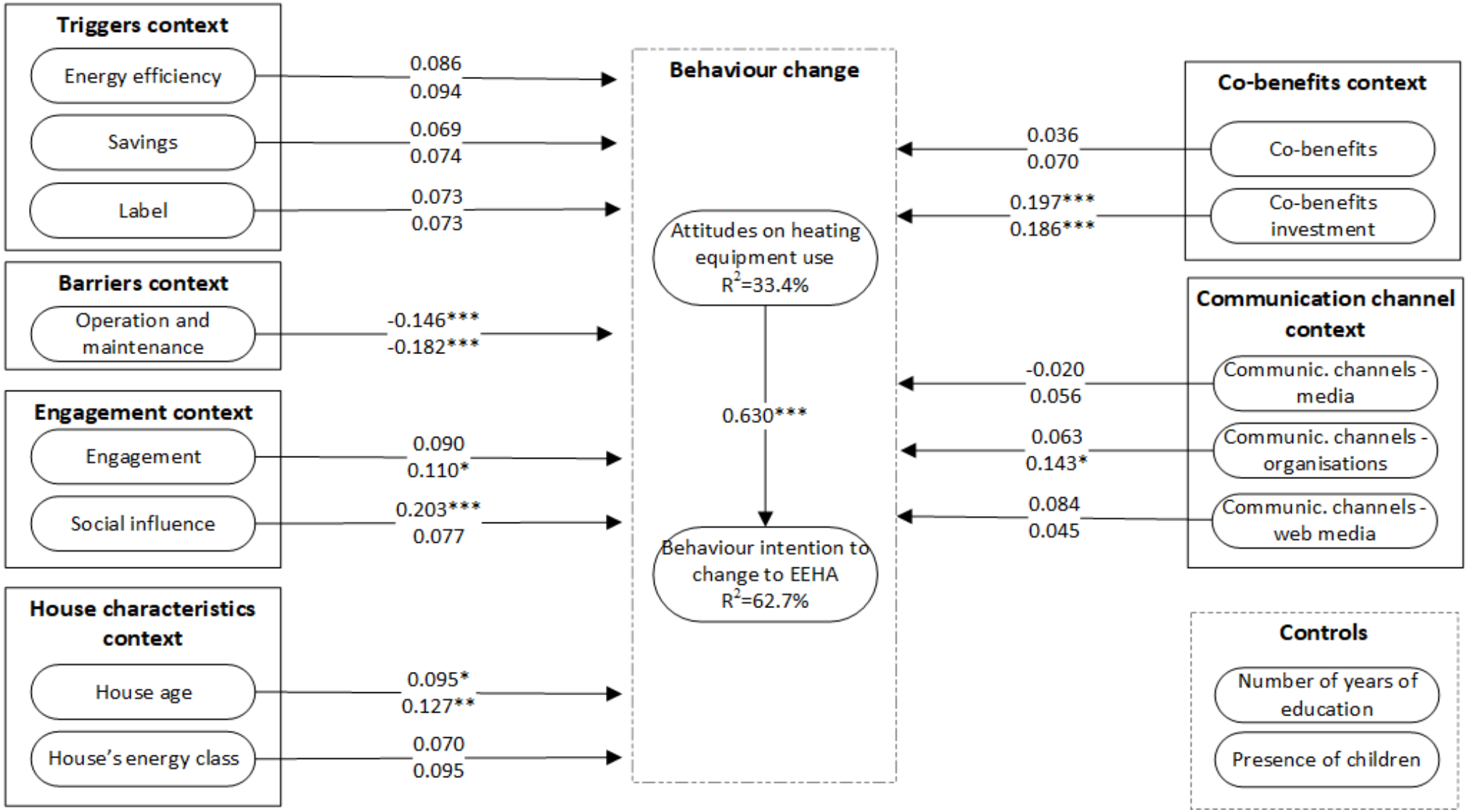
*p-value<0.10; **p-value<0.05; ***p-value<0.01

3.4.1. Results of final conceptual model – Italy



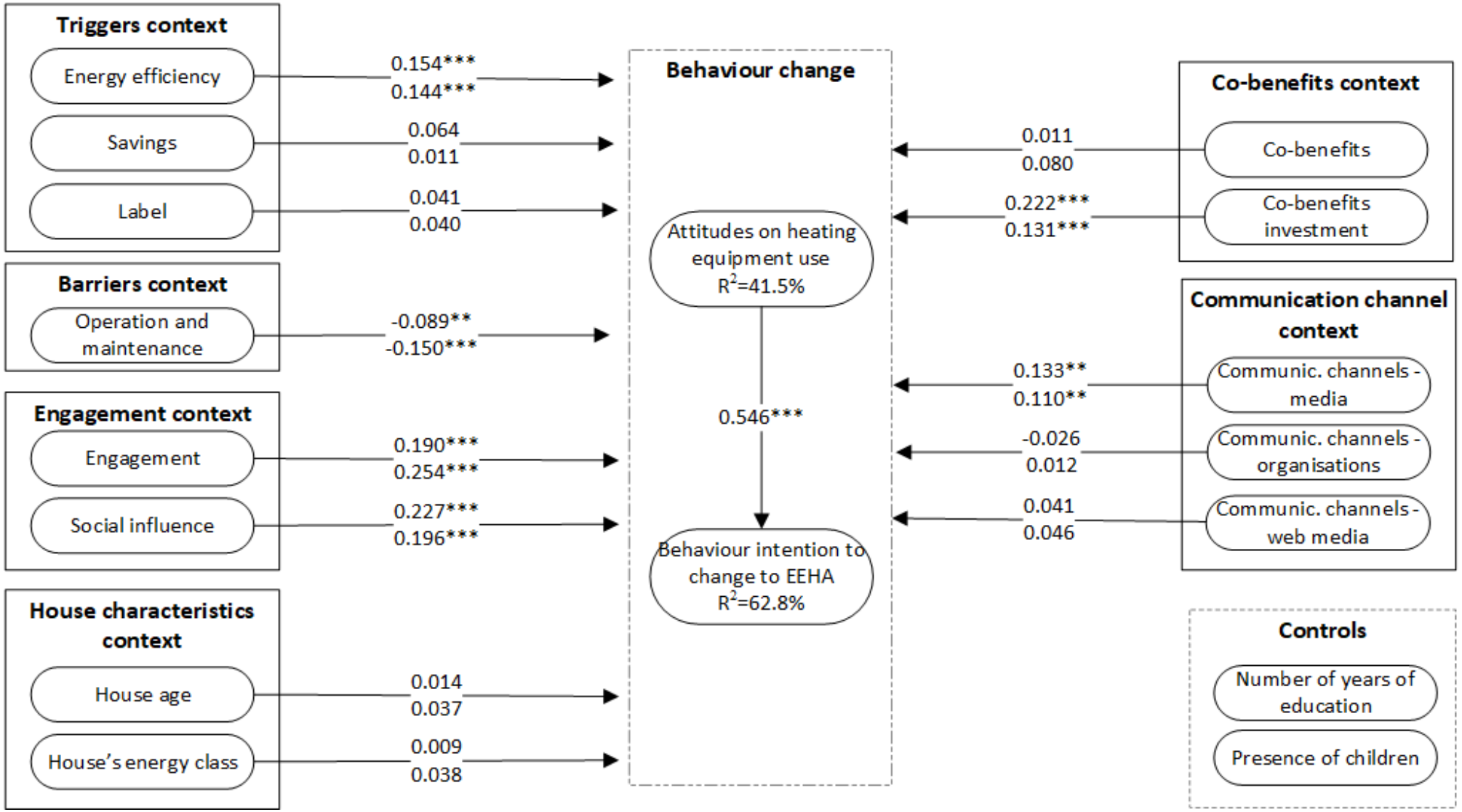
*p-value<0.10; **p-value<0.05; ***p-value<0.01

3.4.1. Results of final conceptual model – Portugal



**p-value<0.10; **p-value<0.05; ***p-value<0.01*

3.4.1. Results of final conceptual model – Spain



**p-value<0.10; **p-value<0.05; ***p-value<0.01*

3.4.2. Results of final conceptual model – Total Effects

FRANCE

- **Official campaigns** from national authorities and energy agencies
- Appliance with a **positive energy label** (above C)
- Receiving **information** about heating appliances options
- Energy and monetary **savings**
- Willingness to pay for **house and consumer wellbeing**

GERMANY

- **House and consumer wellbeing**
- **Official campaigns** from national authorities and energy agencies
- Willingness to pay for **house and consumer wellbeing**
- Change **low energy performance** of the house
- **Inner social circle opinion**
- Easy **maintenance and operation**

ITALY

- Willingness to pay for **house and consumer wellbeing**
- Increase **house energy efficiency**
- **Inner social circle opinion**
- Receiving **information** about heating appliances options

PORTUGAL

- Willingness to pay for **house and consumer wellbeing**
- Easy **maintenance and operation**
- **Official campaigns** from national authorities and energy agencies
- Receiving **information** about heating appliances options

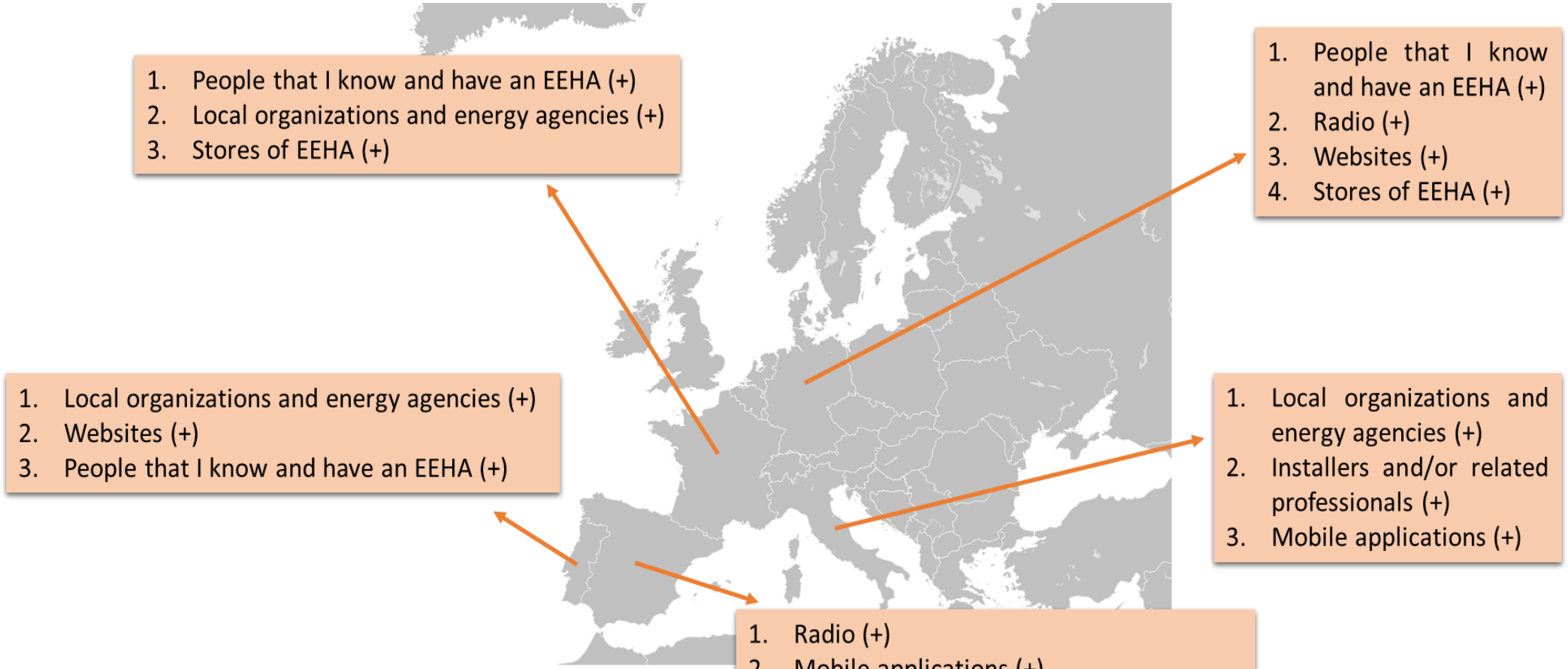
SPAIN

- Receiving **information** about heating appliances options
- **Inner social circle opinion**
- Easy **maintenance and operation**
- Increase **house energy efficiency**
- Willingness to pay for **house and consumer wellbeing**

3.4.2. Main Findings

Co-benefits	In a general way, consumers are more likely to replace equipment's in exchange of the benefits that it can bring to their and house's health, comfort, etc.
Influencers	As the **social circle and connections** becomes more and more important in consumers life, in the change of heating equipment is not different. Consumers value their friends and relative's opinion when changing to an efficient heating equipment
Local organizations and energy agencies	Not only public opinion from social connections is important, but also specialized organizations play an important role. Investing in an efficient heating equipment brings more details and specifications then usual shopping, so **specialized opinions and advices are still very relevant**

3.4.3. Communication Channels



1. People that I know and have an EEHA (+)
2. Local organizations and energy agencies (+)
3. Stores of EEHA (+)

1. People that I know and have an EEHA (+)
2. Radio (+)
3. Websites (+)
4. Stores of EEHA (+)

1. Local organizations and energy agencies (+)
2. Websites (+)
3. People that I know and have an EEHA (+)

1. Local organizations and energy agencies (+)
2. Installers and/or related professionals (+)
3. Mobile applications (+)

1. Radio (+)
2. Mobile applications (+)
3. People that I know and have an EEHA (+)

Thank you for your attention!

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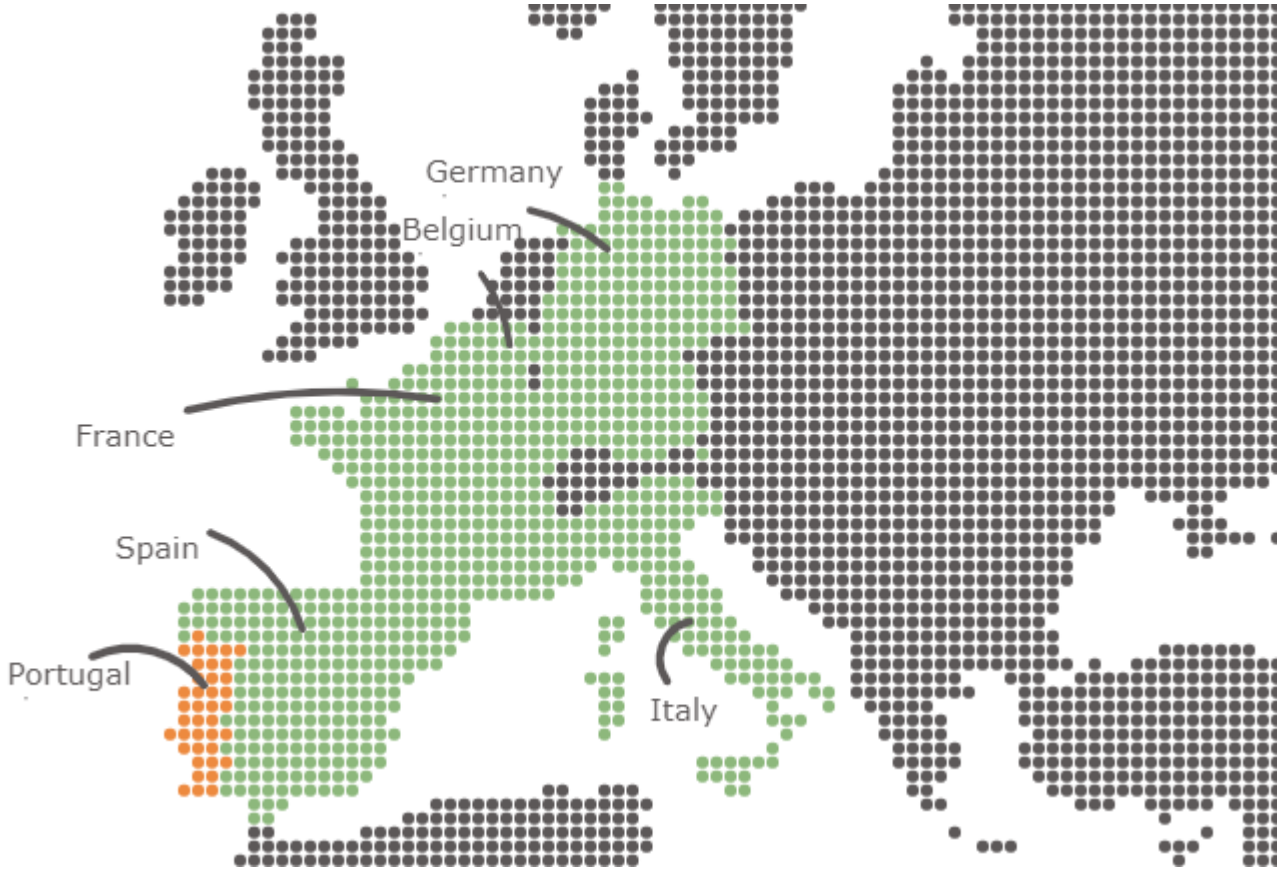

Constructs and items

Construct	Items
Energetic efficiency (EE)	It will increase my house's energy efficiency
Savings (Sav)	I receive a subsidy to finance the replacement
	I am aware of the total energy savings over EEHA lifetime
	I am aware of the total monetary savings over the EEHS lifetime
Label (Lab)	The energy label is important in the decision of buying a heating appliance
	When I buy a heating appliance, I pay attention to the energy label
	I am more willing to buy a heating appliance with an efficient energy class (above C, i.e., A or B)
Operation and Maintenance (OM)	I believe that the operation of an EEHA is more complicated than my current heating solution
	I believe that an EEHA needs the user to perform the maintenance work by himself
	I believe that the maintenance of na EEHA requires too much work
Engagement (EG)	I pay a lot of attention to anything about EEHA
	I keep up with things related to EEHA
Social influence (SI)	People who are important to me think that I should adopt EEHA
	People who influence my behaviour think that I should adopt EEHA
	People wose opinions that I value prefer that I adopt EEHA
House age (HA)	How old is your dwelling since your last renovation (in years)? If it was not renovated, answer with the years since its construction.
House energetic label (HEL)	If you know, what is the energy class of your house (based on the Energy Performance of Building Certificate)?

Constructs and items

Construct	Items
Co-benefits (CB)	Condensation, humidity and mould related problems are avoided
	It will not reduce my house's useful floor area
	It values the dwelling in the real-estate market (I will sell the house for a higher price if it is equipped with an EEHA)
	It allows me to be independent from energy price fluctuations
	It allows me to have a reduced environmental impact
Co-benefits investment (CB Inv)	Achieve a comfortable indoor temperature during the heating season more easily
	Have better indoor air quality
	Lower indoor noise level
	Lower external noise level
	Operate the EEHA more easily
	Be more independent to energy prices
	Have a more aesthetically pleasing EEHA
	Have more useful living area
	Value the dwelling in the real-estate market
	Have a reduced environmental impact

Constructs and items

Construct	Items
Communication channels media (CCM)	Websites
	Mobile Applications
	Newspaper
	Radio
	TV
Communication channels organizational (CCO)	People that I know and have an EEHA
	Organizations (local associations, energy agencies)
	Installers and/or related professionals
	Stores of EEHA
Attitude (Att)	I am willing to change my heating appliance(s)
	I am planning to buy an EEHA
Behaviour intention (BI)	I intend to change to EEHA in the future
	I will try to change to EEHA in my future
	I am ready to change to EEHA