Social Infrastructure and the Alleviation of Loneliness in Europe

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1. Raw Data and Calibration

We have calibrated using the 'direct method,' whereby theoretical anchors are decided for the cut-off, full membership, and full non-membership for each condition (Schneider and Wagemann 2012, p. 29). Then we have applied an s-shaped logistic function to assign values to the raw data based on these anchors. Each of our calibrations is based on a strict set membership, designated by the adjective 'High' (or 'Low' for loneliness). As a result, we do not generally allow the majority of cases to meet this membership fully. Crucially, we have also highlighted theoretically viable alternative anchors, where possible, for each variable. These are used later for robustness checks. For the outcome and each of the conditions below, we provide an ordered list of the raw scores, with lines indicating the selected cut-offs in that list, a plot that maps raw values against calibrated membership scores, and most importantly, a listing of the additional theoretically viable cut-off points.

1.1 Low Loneliness

This outcome condition is built as the country-level aggregate from the post-stratification weighted answers to 2014 ESS data. There is one question about loneliness asked in 2014, 2012, and 2010, worded in the following way:

"I will now read out a list of the ways you might have felt or behaved during the past week. Using this card, please tell me how much of the time during the past week you felt lonely?

None or almost none of the time (4)
Some of the time (3)
Most of the time (2)
All or almost all of the time (1)
(Don't know)"

Five countries (Bulgaria, Cyprus, Iceland, Italy, and Slovakia) had no data from ESS 2014, so we imputed 2014 based on their aggregate (weighted) 2012 loneliness values. A paired T-test for countries sampled in both years shows that the 2012 and 2014 loneliness rates are the same, making a direct substitution of 2012 for 2014 data valid. Similarly, Greece was also not sampled in 2014 (nor in 2012), but a paired T-test shows no significant difference between the loneliness rates of 2010 and 2014. Therefore, Greece's 2010 loneliness rate is used to impute the 2014 value. The set of societies with low loneliness in Europe clearly consists of the Nordics plus Netherlands, Switzerland, and Germany which are all distanced from another group with somewhat higher levels of loneliness, including countries such as the UK, Slovenia, Austria, Ireland, Sweden, and Belgium. Following these, and separated by a significant gap, is a group that is not belonging to the less lonely set, which includes only societies from Southern and Eastern Europe.

This selected calibration is e=1.49, c=1.39, i=1.25, where e indicates full non-membership in the set, c is the cut-off between membership and non-membership and i indicates full membership in the set (see Table 1).

Table 1: Raw data and thresholds for calibrating low loneliness

Country	Loneliness mean
NL	1.22
DK	1.23
FI	1.24
Full Inclusion (1.25)	
CH	1.26
ISL	1.26
DE	1.27
NO	1.27
GB	1.32
SI	1.32
AT	1.35
IE	1.35
SE	1.35
BE	1.36
Maximum fuzziness (1.39)	
PL	1.41
EE	1.42
ES	1.42
CY	1.43
FR	1.47
Full exclusion (1.49)	
PT	1.50
HU	1.52
SK	1.53
LT	1.54
BG	1.54
CZ	1.56
IT	1.58
GR	1.62

Country case legend:

AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

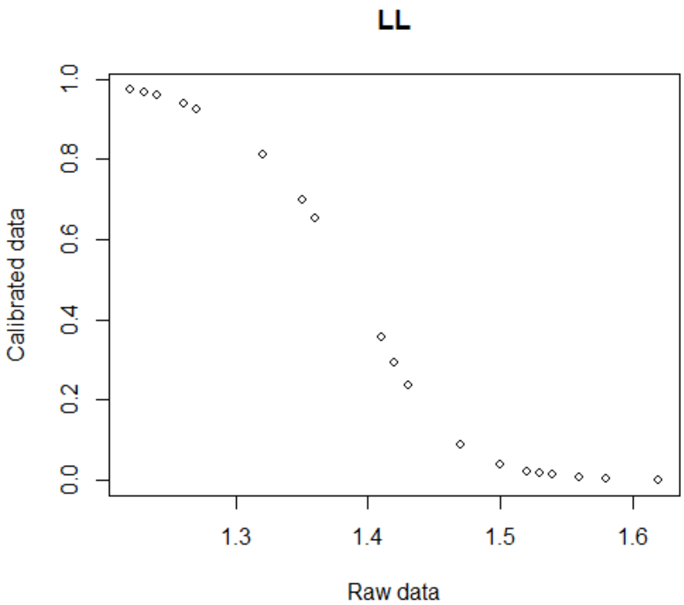
Each conceptual set definition implies only a limited range of plausible thresholds to define that set's boundaries (Schneider and Wagemann 2012, p. 26). Those plausible thresholds are later tested in combination within robustness checks.

The viable theoretical alternatives where thresholds might have been set differently include:

a) Shifting c=1.34, thereby making the less lonely set more restrictive, by excluding Austria, Ireland, Sweden, and Belgium.
b) Shifting i=1.6 thus making it harder to be a full non-member of LL.
c) Shifting c=1.3 and i to 1.21, thereby making the set more strict.

Figure 1 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 1: Plot of calibrated vs raw data for low loneliness



1.2 High commercial social infrastructure

We operationalize commercial social infrastructure by using Eurostat data on total household consumption on restaurants and cafes (classification CP111, "catering services") (Eurostat 2021a). This was combined with PPP data from the OECD (OECD 2021b), January 2015 population data from Eurostat (Eurostat 2021b), and the average Euro to dollar exchange rate from 2014 (Exchange Rates UK 2021).

Swiss data was missing from all years on this indicator. However, we do have the Swiss numbers for a related variable, spending on recreation and culture. We therefore impute the Swiss value for cafes and restaurants by taking the average ratio of recreation & culture spending compared to cafe & restaurant spending. The average ratio calculated from the above data is 1.62, which puts Switzerland on par with France, Belgium, the Netherlands, and Slovenia in terms of this ratio.

Table 2: Raw data and thresholds for calibrating commercial social infrastructure

Country	Restaurants and Cafes per capita (€)
IE	2141.19
AT	1948.64
ES	1878.39
GR	1764.99
Full inclusion (1600)	
GB	1492.76
CY	1354.22
ISL	1280.55
IT	1255.99
PT	1246.14
CH	1144.74
Maximum fuzziness (1100)	
NO	1002.59
NL	946.31
FI	936.64
BE	890.39
SE	870.61
FR	850.94
DK	794.79
CZ	742.89
DE	724.36
SI	701.69
EE	648.43
HU	600.63
Full exclusion (550)	
SK	631.71
BG	456.18

LT	297.40
PL	243.71

Note 1: Data is PPP adjusted

Note 2: CH was imputed based on its spending on recreation and culture, using the average ratio between country spending in that sector and spending on cafes and restaurants

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

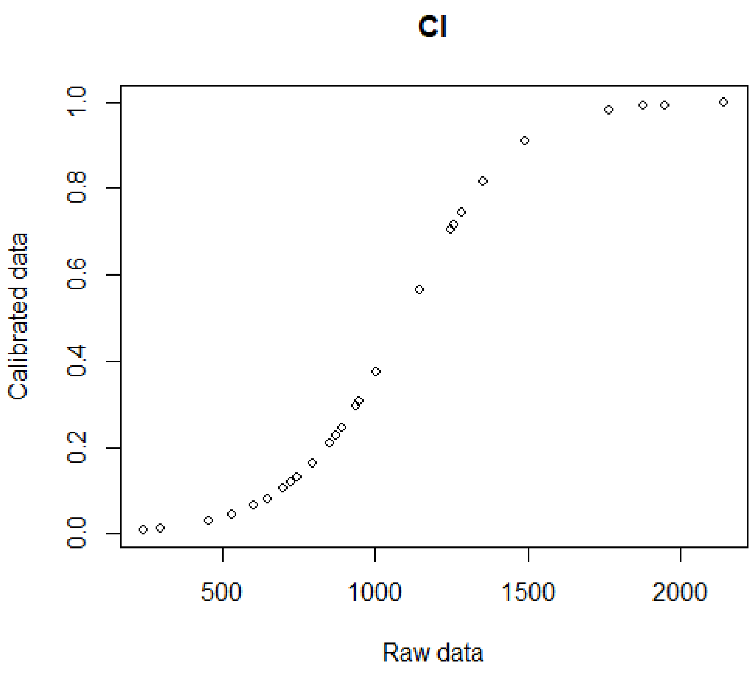
Set membership in high commercial social infrastructure is defined based on a cut-off above the mean (1029) across countries, where there is a noticeable gap between the groups above and below this marker. The inclusion set is led notably by Ireland, Austria, Spain, and Greece, by a sizable gap, followed by Great Britain and a set of other societies. The group of societies not above the cut-off include Northern European societies such as the Netherlands and Norway, as well as some notable ‘underperformers’ in this measure, namely Poland, Lithuania, Bulgaria, and Slovakia (see Table 2).

Viable theoretical alternatives include:

a) Shifting e to 350.

Figure 2 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 2: Plot of calibrated vs raw data for commercial social infrastructure



1.3 High public infrastructure

High public social infrastructure is measured through a combinatorial 'and' index representing the intersection of a set representing the welfare state's social protection functions and its direct provision of public opportunities for social interaction. The former is operationalized as the PPP-adjusted state spending per capita on social protections for vulnerable populations (Eurostat 2021e). The latter is operationalized as the PPP-adjusted state spending per capita on recreation, sports, and culture combined (Eurostat 2021c; Eurostat 2021d).

Table 3 Raw data and thresholds for calibrating public social protection

Country	Social Protection per capita (€)
NO	8981
DK	8629
Full inclusion (8300)	
FI	7914
AT	7845
FR	7401
SE	7252
BE	6660
DE	6636
NL	6289
CH	6253
IT	5754
IE	5406
Maximum fuzziness (5200)	
GB	5000
ES	4534
SI	4366
PT	4123
GR	4108
ISL	3421
CZ	3275
SK	3269
CY	3164

PL	3072
HU	2964
Full exclusion (2700)	
EE	2560
LT	2448
BG	1771

Note: Data is PPP adjusted

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

High public social protection is exemplified by the leaders Norway and Denmark, which are 700€ higher than the next country, Finland. Also included above the cut-off are another set of Northern and Western European societies, including Austria, France, Germany, Sweden, Switzerland, and others. These are separated by a gap of 500€ per capita from the group that is 'more out than in' the set of high social protection. That group is led by Italy, Ireland, and the UK, which are within 1000 Euros of the cut-off. Societies that are fully excluded from this set are those that spend less than 2700 Euros per capita on social protection (PPP-adjusted), which includes Estonia, Lithuania, and Bulgaria (see Table 3).

Viable theoretical alternatives for these cut-offs include:

a) c=6000, which would make the main set less inclusive, thereby excluding Italy and Ireland from the set.

Figure 3 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 3: Plot of calibrated vs raw data for public social protection

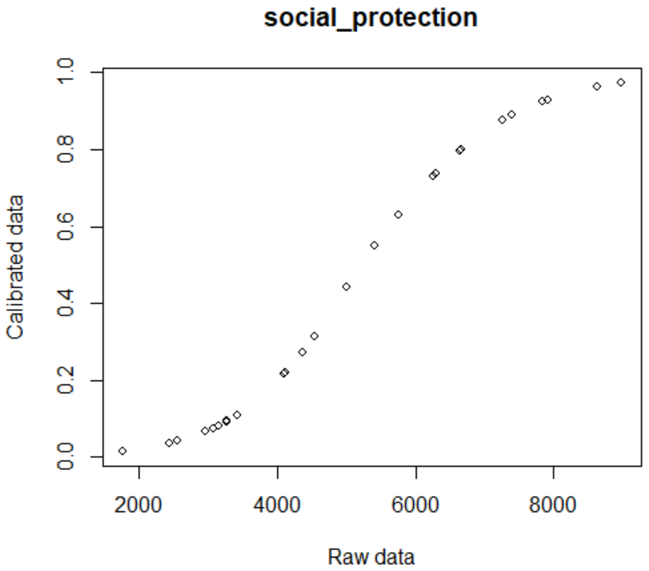


Table 4: Raw data and thresholds for calibrating public spending on recreation, sports, and culture

Country	Public Spending on Recreation, Sports, and Culture (€)
ISL	709
Full inclusion (575)	
NO	450
FR	408
SE	386
DK	372
NL	353
CH	349
EE	319
FI	304
AT	301
BE	290
Maximum Fuzziness (270)	
SI	250
HU	243
CZ	239

DE	229
PL	213
ES	208
IE	180
LT	163
BG	159
GB	157
IT	152
Full Exclusion (145)	
SK	137
CY	127
PT	119
GR	90

Note: Data is PPP adjusted

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

High public spending per capita on culture, recreation, and sport is dominated by Iceland, which leads all societies in this sample by both measures (culture, recreation and sports). Its spending at 709€ per capita per year dwarfs the second-place society, Norway, which spends 450€ per capita. All other societies above the cut-off of 270€ are Western and Northern European societies. Just below the cut-off — a gap in the histogram of 40€ — are Slovenia, Hungary, Czechia, and Germany. Those that are fully excluded from this set include Slovakia, Cyprus, Portugal, and Greece, the last of which spends only 90€ per capita (see Table 4).

Viable theoretical alternatives for these cut-offs include:

a) e= 105, establishing that only Greece is fully excluded from the set.

Figure 4 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 4 Plot of raw vs calibrated data for public spending on recreation, sports, and culture

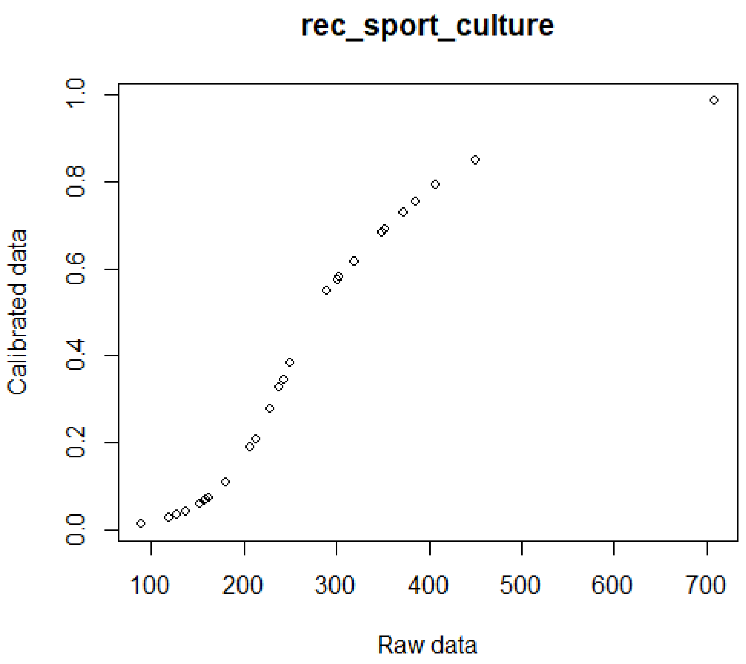


Table 5 displays the final fuzzy scores for the overall combinatorial public social infrastructure index. These are derived by taking the lowest calibrated value for a given case from both ‘social protection’ and ‘public spending on recreation, sports, and culture’ subdimensions.

Table 5: Calibrated public social infrastructure and thresholds

Country	Public Social Infrastructure
NO	0.850
FR	0.791
SE	0.754
DK	0.728
NL	0.591
FI	0.581
CH	0.580
AT	0.574
BE	0.548
(Maximum fuzziness (0.5)	
DE	0.276
SI	0.189

ES	0.188
IE	0.107
ISL	0.091
CZ	0.081
PL	0.068
GB	0.065
HU	0.062
IT	0.058
EE	0.044
SK	0.042
LT	0.040
CY	0.033
PT	0.028
BG	0.022
GR	0.014

Note: PI is a multiplicative Index of high social protection and high recreation, culture, sports, and spending

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

1.4 High internet access

Table 6: Raw data and thresholds for calibrating high internet access

Country	Internet Access
NL	96
ISL	96
Full inclusion (94.5)	
DK	93
NO	93
CH	91
FI	90
GB	90

SE	90
DT	89
BE	83
EE	83
FR	83
IE	82
AT	81
Maximum fuzziness (79)	
SK	78
CZ	78
SI	77
PL	75
ES	74
HU	73
IT	73
Full exclusion (71)	
CY	69
LT	66
GR	66
PT	65
BG	57

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

The high internet access condition is composed of a clear group of two leaders, Iceland, and the Netherlands, above 93%. Other groups having among the highest internet access include other rich societies such as Denmark, Norway, Switzerland, Finland, UK, Sweden, Austria, and Germany. The fuzziness threshold excludes countries in the Eastern and Southern part of the continent, namely countries such as Slovakia, Slovenia or Poland. The fully excluded countries are Cyprus, Lithuania, Greece, and Portugal (see Table 6).

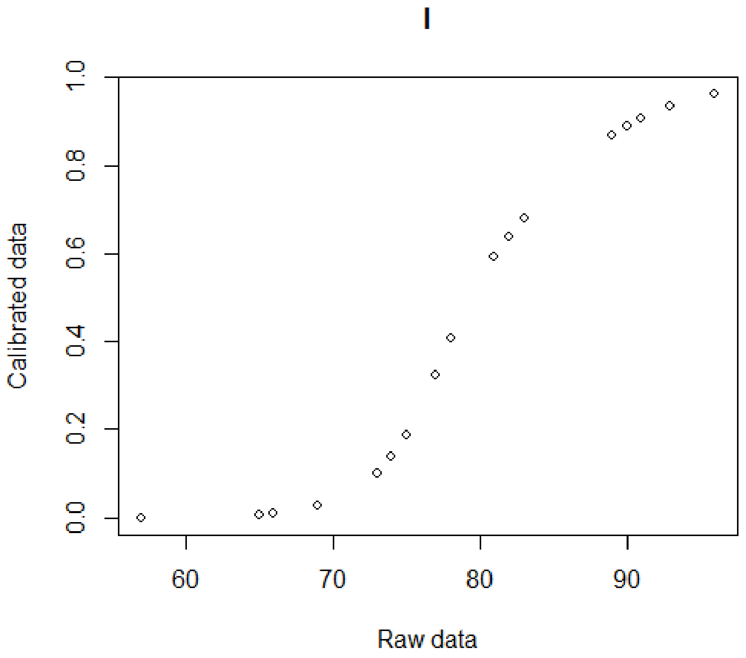
Viable theoretical alternatives include:

a) e to 61, leaving only Bulgaria fully excluded from the set.

b) c to 86, thus encompassing a stricter threshold for inclusion in this wide gap.

Figure 5 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 5 Plot of raw vs calibrated data for high internet access



1.5 High involvement in associations

For this condition we first considered measuring association participation through political participation within the (ESS 2014), but the existing indicators — for example, working with a political party or attending demonstrations — were measuring individuals' political engagement more than their wider civil society engagement. But ESS 2012 included a question to which respondents could answer from the following choices (variable name: "wkvlorg"):

"In the past 12 months, how often did you get involved in work for voluntary or charitable organisations?

At least once a week
At least once a month
At least once every three months
At least once every six months
Less often
Never"

We took the weighted proportion of those that answered either at least once a week or at least once per month.

Data for Austria and Greece were absent, so have taken Austria and Greece's relative positions — compared to the same group of countries as in our ESS sample — in a similar 2015 Gallup World Poll, which asked the question, “*Have you done any of the following in the past month? How about volunteered your time to an organization*?” We then apply those relative positions to the different ESS range of values, thus imputing ESS values for Austria and Greece. For Austria, the resulting value is 15.9 %, which is a fairly high rating among the top half of our sample in Europe, which is substantiated by other data about volunteering in Austria (Angermann and Sittermann 2010). The imputed estimate for Greece’s ESS for those who volunteer at least once per month is 4%, among the lowest rates in Europe, which is substantiated by data from the OECD (2015) as well as a GHK Country Report on volunteering in Greece (2010).

Table 7: Raw data and thresholds for calibrating high involvement in associations

Country	Volunteering
NL	0.3221
CH	0.3081
DE	0.2942
Full inclusion (0.28)	
NO	0.2350
DK	0.2051
GB	0.1922
ISL	0.1866
ES	0.1849
IE	0.1827
FR	0.1775
AT	0.1590
IT	0.1415
BE	0.1328
SE	0.1285
SI	0.1244
FI	0.1063
Maximum fuzziness (0.09)	
CY	0.0737
EE	0.0682
SK	0.0531
PT	0.0526
PL	0.0522
CZ	0.0465
GR	0.0400
HU	0.0385

Full exclusion (0.03)	
LT	0.0225
BG	0.0171

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

The clear leaders in the set defined as ‘high involvement in associations’ are the Netherlands and Switzerland, which have at least 29% volunteering rates of at least once per month. This is followed by a large group that passes the maximum fuzziness threshold, containing countries from all over Europe. The countries that fall below the threshold are mostly Eastern- and Southern Europeans, followed by ‘underperformers’ (Lithuania and Bulgaria) that are fully excluded from the set with a participation rate of around 2% (see Table 7).

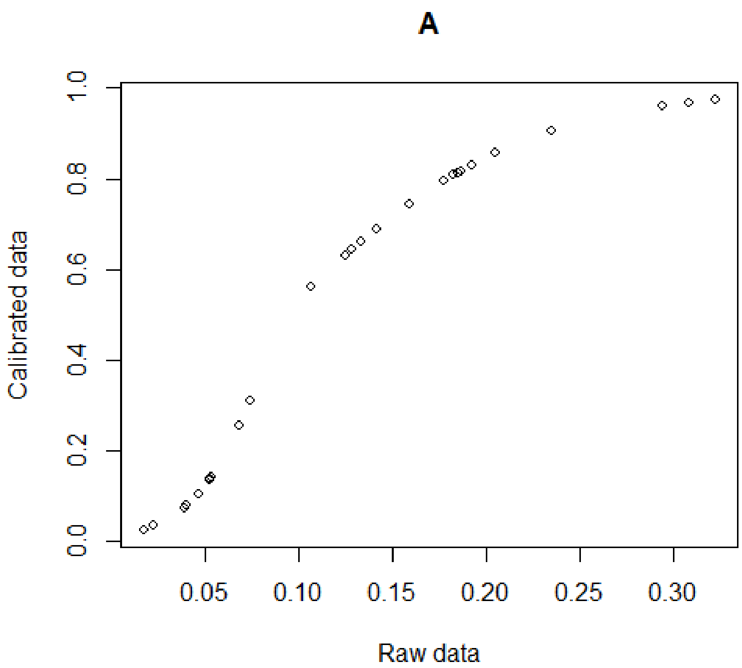
Viable theoretical alternatives include:

a) c=0.165, making the set less inclusive.

b) c=0.15, thus making the set somewhat less inclusive.

Figure 6 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 6 Plot of raw vs calibrated data for high involvement in associations



1.6 High cultural preference

Cultural preferences are measured according to the Schwartz indicator for the value of ‘universalism’, taken especially from the 2014 ESS. ‘Universalism’ has a defining goal of “u*nderstanding, appreciation, tolerance, and protection for the welfare of all people and for nature*” (Schwartz 2012). It is operationalized through the indicator, “*It is important to her/him to listen to people who are different from her/him. Even when she/he disagrees with them, her/him still wants to understand them*,” with a footnote specifying also the meaning of “different” as “‘*Different’ in almost any way. The key idea is that he sees difference/diversity positively and as something worth learning about*” (ESS 2014). Individuals could answer on a six-point scale ranging from “*very much like me*” to “*not like me at all*.” This indicates thus the respondent’s orientation toward especially those who are in an outgroup, indicating the modern pluralism embedded within individualist values.

Five societies — Bulgaria, Cyprus, Slovakia, Italy, and Iceland — had no data available for 2014, so their values were taken from 2012, after a T-test confirmed no significant differences between 2012 and 2014. The Greek value was taken from 2010 ESS because of missing data in later years. A T-test shows 2014 to be more universalist (tolerant) than 2010 to a slight degree (a 0.07 difference), so the Greek value was adjusted by this amount.

Table 8: Calibration and thresholds for high cultural preference for universalism

Country	Universalism
Full inclusion (2.0)	
CH	2.04
ES	2.06
IT	2.07
DE	2.08
GR	2.10
FI	2.12
SI	2.16
SE	2.18
AT	2.24
CY	2.26
DK	2.29

ISL	2.29
PL	2.30
GB	2.32
BE	2.34
Maximum fuzziness (2.35)	
NO	2.39
IE	2.39
EE	2.39
FR	2.40
NL	2.48
BG	2.48
Full exclusion (2.52)	
HU	2.57
SK	2.67
PT	2.69
CZ	2.79
LT	3.31

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

Fifteen societies have ratings of universalism within about 1 standard deviation better than the mean (2.35). The top societies in universalism, Switzerland, Spain, Italy, and Germany, have an average near 2.0, which represents someone 'like me' in terms of universalism. In contrast, a value of 3 represents somewhat only '*somewhat* like me'. Societies just below the threshold include a wide range from Norway, Iceland, Estonia, and France. Further from the cutoff, removed from it by one standard deviation or more, and fully excluded from the set because they on average closer to being only *somewhat* represented by universalism, are societies such as Hungary, Slovakia, Portugal, Czechia, and the bottom-performer, by far, in this measure, Lithuania (see Table 8).

Viable theoretical alternatives to these cut-offs include:

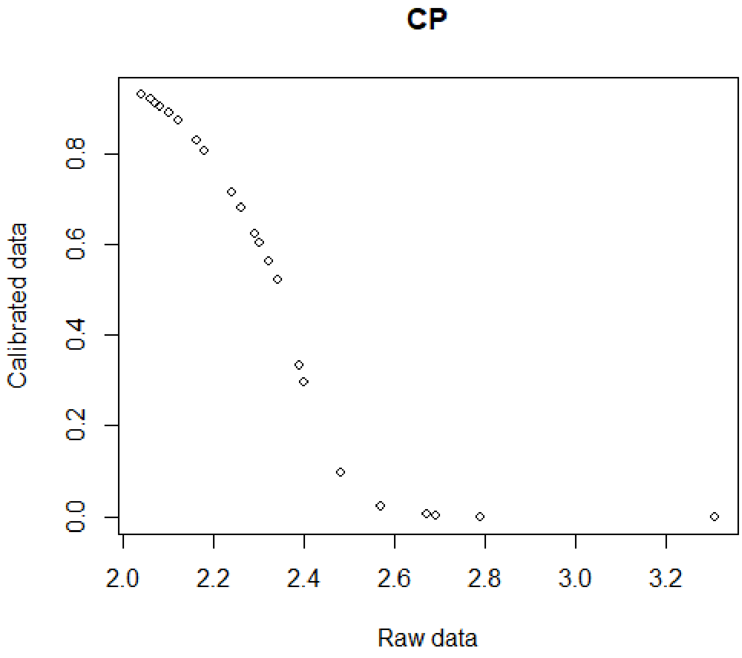
a) c=2.21, constituting a much stricter set membership threshold.

b) c=2.28, constituting a less strict set membership threshold, which also includes Austria and Cyprus.

c) e=2.75, making it somewhat harder to be a complete non-member of the set

Figure 7 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 7: Plot of raw vs calibrated data for high cultural preference for universalism



1.7 Strong personal relationships

This is a form of objective micro-level social integration, represented by an additive index (taking the mean of the z-scores of both items) between the quality and quantity of personal social relationships. For the quality of relationships, we use the country-level aggregate (post-stratification weighted) of the question:

"How many people, if any, are there with whom you can discuss intimate and personal matters? Choose your answer from this card."

Respondents could answer "*1*", "*2*", "*3*", "*4-6*", "*7-9*," or "*10 or more*". For the quantity of personal relationships, we use the weighted average of the question

"Using this card, how often do you meet socially with friends, relatives or work colleagues?

Never
Less than once a month
Once a month
Several times a month
Once a week
Several times a week
Every day"

"socially", in this case, is refined in a footnote for the interviewers as such: "'*Meet socially' implies meet by choice rather than for reasons of either work or pure duty*."

Six countries had missing data for the 2014 wave of ESS. For five of them — Bulgaria, Cyprus, Slovakia, Italy, and Iceland, we instead use 2012 data, which we found to be equivalent (using paired T-test analyses) with 2014. Greece's value in this item is imputed from 2010 data. For the intimate discussions question, an earlier dichotomous version was used in 2010. This variable was converted from 2-1 coding to 0-1. Greece's relative position to other societies in 2010, which was also measured in 2014, was used to impute its 2014 value. An additive index was then constructed based on the average of the standardized scores of the frequency of social meetings and the number of intimate conversation partners.

Table 9: Calibration and thresholds for high degree of personal relationships

Country	socialZ	intimateZ	Personal relationships
SE	1.20	1.69	1.445
NL	1.15	1.45	1.300
Full inclusion (1.0)			
CH	0.58	1.37	0.975
DK	0.88	1.02	0.950
NO	0.93	0.69	0.810
ISL	0.98	0.57	0.775
ES	0.73	0.72	0.725
DE	-0.09	1.141	0.660
BE	0.55	0.49	0.520
PT	1.71	-0.69	0.510
FI	0.40	0.51	0.455
GB	0.04	0.61	0.325
AT	0.20	0.45	0.325
Maximum fuzziness (0.25)			
FR	0.53	-0.14	0.195
IT	0.29	-0.77	-0.240
IE	-0.34	-0.16	-0.250
SI	-0.36	-0.26	-0.310
PL	-1.18	0.16	-0.510
CY	-0.76	-0.67	-0.715
BG	-0.14	-1.35	-0.745

SK	-0.01	-1.53	-0.770
CZ	-0.60	-1.08	-0.840
Full exclusion (-0.9)			
EE	-1.07	-1.10	-1.085
GR	-2.09	-0.63	-1.360
LT	-1.25	-1.78	-1.515
HU	-2.30	-0.98	-1.640

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

Sweden and the Netherlands are the clear leaders in belonging to the set with strong personal relationships, with scores well over 1 standard deviation above the mean. Other members of this set include other rich, Northern- and Central-European societies, including Switzerland, Denmark, Norway, Iceland, Germany, and others, including also the Southern European societies of Spain and Portugal. The weakest personal relationships by this measure are found at the aggregate level in Hungary, Lithuania, Greece, and Estonia. Other Southern and Eastern European societies are also non-members of this ‘strong personal relationship set’, as well as some richer societies such as Ireland, France, and Italy just below the cut-off (see Table 9).

Viable theoretical alternatives include:

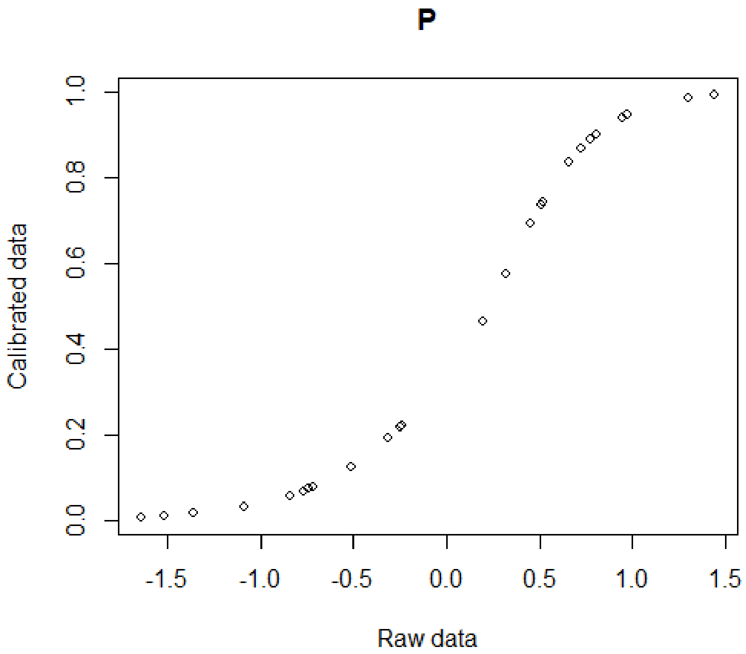
a) c =0, thus making the set much more inclusive.

b) c =0.61, thus making the set somewhat less inclusive.

c) c =0.39, thus making the set somewhat more inclusive, including also Belgium, Portugal, and Finland.

Figure 8 displays a scatterplot of the original raw data values plotted against the newly calibrated values.

Figure 8: Plot of raw vs calibrated data for high degree of personal relationships



1.8 Raw Data Correlations

Our analysis is based on arguments that the conditions we analyze have a relationship both with loneliness as well as with individualism. Evidence is found within the relevant literatures, but here we also provide a simple bivariate correlation table (see Table 10) of the country-level bivariate relationships (with individualism operationalized as the 2014 ESS societal average, post-stratification weighted, of the extent to which individuals think it is important to "make their own decisions and be free").

Table 10: Pearson correlations between raw data (before calibration)

	Loneliness	Commercial Infrastructure	SP	RSC	Internet Access	Volunteering	~Universalism	PR	SP*RSC	~Individualism
Loneliness	1.000									
Commercial Infrastructure	-0.103	1.000								
SP	-0.614***	0.261	1.000							
RSC	-0.607***	-0.063	0.397*	1.000						
Internet Access	-0.839***	0.076	0.659***	0.727***	1.000					
Volunteering	-0.764***	0.298	0.662***	0.474*	0.767***	1.000				
~Universalism	0.409*	-0.430*	-0.436*	-0.175	-0.333	-0.462*	1.000			
PR	-0.758***	0.248	0.729***	0.542**	0.708***	0.776***	-0.456*	1.000		
SP*RSC	-0.684***	0.047	0.853***	0.782***	0.768***	0.631***	-0.295	0.727***	1.000	
~Individualism	0.324	-0.274	-0.059	0.109	-0.110	-0.301	0.628***	-0.142	0.107	1.000

Note: p<0.001***; p<0.01**; p<0.05*
Note: RSC= Recreation, Sport, Culture; SP= Social Protection; PR= Personal Relationships
~: The Universalism and Individualism values are inverted

2. Main Analysis Details

2.1 Factors that do not make it into the final analysis

As described below, other potential conditions were considered at earlier stages of the analysis and subsequently rejected.

Public Spaces

Public spaces, such as parks, public squares, libraries, and pedestrian zones also serve as resources for those who may be feeling lonely. Public spaces are highlighted for their role in generating social cohesion. For instance, parks (Kaźmierczak 2013), coastline and beaches (Bell et al. 2015), and public libraries (Aabo 2005; Klinenberg 2018) may foster social ties. We note that public spaces are usually accessible with no direct financial cost, except possibly transportation. In addition, parks and beaches are only able to fulfill this free social function in good weather, and this potential may be lost during the winter, at night, and in bad weather. Public libraries are among the few no-cost public spaces that can be visited during the wintertime or in bad weather. However, public space might not explain the difference between individualist and collectivist societies because Eastern and Southern European societies, have at least as much public space as Western and Northern European societies but higher degrees of loneliness.

We have tested and confirmed this expectation. Thus, public space — at least when operationalized as green space within cities — is unable to explain why particular European societies are less lonely. To construct the variable, we used maps ranging from 2007-2010 provided by Eurostat's European Environmental Agency (2017). Using MATLAB we then calculated the percentage of green pixels for the three largest cities (as of 2014, using different national censuses as sources).

Housing ownership

Housing was considered in relation to different states of the housing market in specific countries, presuming that people may live with family in particular countries because of high costs or housing unavailability. Previous research has discussed living arrangements and home ownership as possible gateways to understanding the mechanisms of loneliness (de Jong Gierveld and Tilburg 1999). While the condition of home ownership had shown correlations with both individualism and loneliness, we dropped it because there was no clear theoretical mechanism that might lead to loneliness in contrast to our other conditions. Moreover, QCA works best with fewer conditions, and this one was also cut for the purpose of parsimony. The original operationalization of the concept was with an OECD measure of the percentage of people that own housing outright from 2019 (OECD 2021a).

2.2 Necessity Analysis

The first step in conducting the analysis is determining which of the conditions (if any) are necessary for the outcome by looking for high consistency scores as well as a non-trivial ‘relevance of necessity’ score. Table 11 represents the outcome of that analysis, whereas we determine that there are two necessary conditions for low loneliness, both I and A. Both are somewhat below the nominal threshold of 0.9 cited in most necessity literature, but the Relevance of Necessity of both is high, and each presents only one logical contradiction out of 26 cases. Both are also consistently found in nearly all solution pathways, and they make more theoretical sense as necessary rather than as scope conditions (Rutten 2020).

Table 11: Necessity test for low loneliness

	inclN	RoN	covN
A	0.907	0.816	0.805
I	0.884	0.848	0.827
I*A	0.828	0.937	0.911
P	0.790	0.849	0.800
I*P	0.766	0.951	0.922
A*P	0.763	0.918	0.874
CP	0.753	0.784	0.722
A*CP	0.688	0.908	0.842
CI+~CP	0.657	0.415	0.437
I*CP	0.656	0.974	0.946
~PI	0.632	0.425	0.428
~CI	0.625	0.593	0.510
CP*P	0.609	0.936	0.864
A*~PI	0.597	0.891	0.785
CI+~I	0.596	0.479	0.432
CI+~A	0.594	0.457	0.421
~CP+~P	0.576	0.463	0.413
~CI*A	0.574	0.925	0.833
~I+~CP	0.558	0.449	0.396
~CI*I	0.555	0.892	0.769
~A+~CP	0.548	0.527	0.427

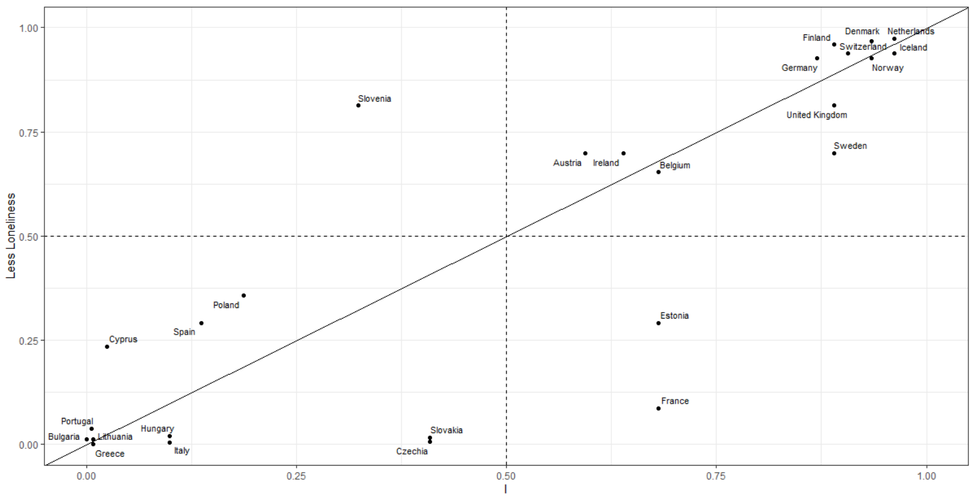
I*~PI	0.547	0.919	0.813
PI	0.542	0.947	0.868
CP*~PI	0.538	0.832	0.671
A*PI	0.536	0.951	0.874
I*PI	0.534	0.955	0.884
P*PI	0.533	0.970	0.919
~CI*P	0.521	0.939	0.843
~CI*CP	0.520	0.950	0.869

Condition legend:

PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations (volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure.

Figure 9 involves a QCA necessity scatterplot, where cases supporting the logical claim that particular conditions or combinations are necessary for the outcome are located in the lower right triangular half of the plot. Logical contradictions to this claim are in the upper left square of the plot.

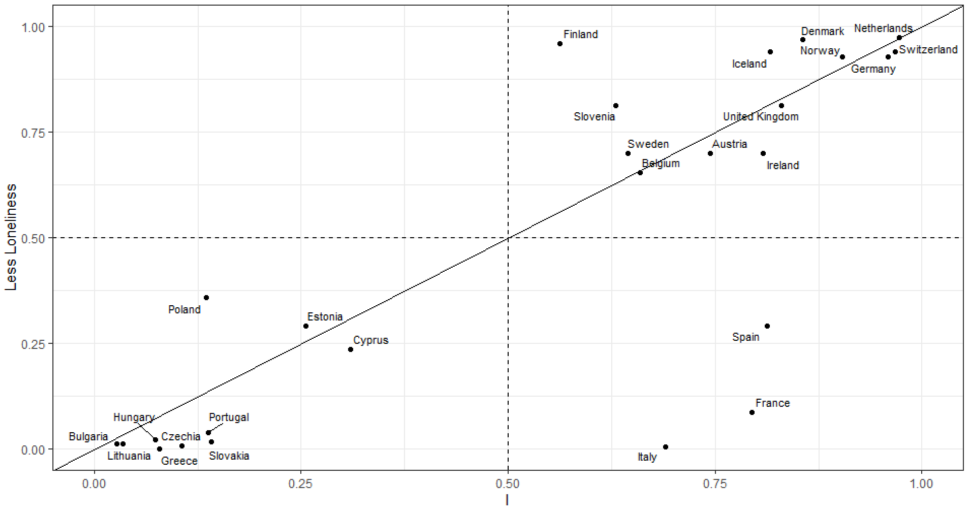
Figure 9: Necessity XY plot of high internet access (I)



Slovenia is the only ‘true logical contradiction’ to the claim that I is necessary for LL. Therefore, Slovenia is left unexplained (uncovered) as a result of declaring I as necessary.

Figure 10 involves a QCA necessity scatterplot, where cases supporting the logical claim that particular conditions or combinations are necessary for the outcome are located in the lower right triangular half of the plot. Logical contradictions to this claim are in the upper left square of the plot.

Figure 10: Necessity XY plot of high association participation (A)



There are no 'true logical contradictions' to the claim that A is necessary for LL

I, A, and their combination were the most common of all conditions found in necessity robustness testing. Table 12 illustrates that their appearance was not rare (see Table 22 for comparative information).

Table 12: Robustness check combination

How often did x occur within all pathways within at least one of the solution models for robustness combinations?	Frequency	True	False
I	54%	9267	8013
A	38%	6628	10652
I *A	24%	4070	13210

Condition legend:
*I: high internet accessibility. A: high involvement in associations (volunteering). I*A: the combination of these two conditions.*

2.3 Sufficiency Analysis

We have chosen a consistency cut-off of 0.8 when declaring a truth table row to be considered sufficient for LL (see Table 1 in main text). The reason for this is that each of these included rows contains only cases where the outcome of low loneliness is present, and these rows also each have adequate PRI statistics above 0.5. There are no 'contradictory rows' of sufficient combinations that are included in the above selection, but which have cases that are not part of the 'less lonely' set.

2.3.1 Enhanced Standard Analysis (ESA) procedure

Before the logical minimization procedure, which will aggregate the sufficient truth table rows into a smaller group of pathways, it is needed to decide which logical remainder rows — possible combinations of conditions that have no observed cases — are 'untenable' as counterfactual assumptions and therefore should be excluded from solution formation process.

There are three types of untenable assumptions: "Assumptions can be untenable because they are *implausible* (i.e., they contradict common sense), are *incoherent* with findings for necessity, or because they are *contradictory* assumptions" (Schneider and Wagemann 2012, p. 211)."

First, we do not have logically *implausible* condition configurations that violate common sense. For example, it is possible to have a society that is less lonely that lacks high internet access, with simultaneously high commercial infrastructure and public infrastructure, but that lacks high cultural preferences, association participation, and social integration. While this is not the most common configuration, nothing logically prohibits it. *Any* combination of our conditions is logically possible, so none of our truth table rows is excluded as a result of being implausible.

Second, because we have two necessary conditions of I and A, any rows which lack either of these are *incoherent* counterfactuals that would violate these necessity assumptions, and they are thereby excluded from the following analysis.

Third, *contradictory* counterfactuals are truth table rows that cannot be simultaneously used to indicate sufficiency both for the outcome and for its negation (Schneider and Wagemann 2013, p. 213). Using the *findRows* function in the *QCA* package in *R,* we have found 4 additional contradictory rows and none indicating simultaneous subset relations. These 4 are excluded from the logical minimization procedure.

2.3.2 Parsimonious and Conservative Solutions

A standard analysis produces a 'parsimonious solution' by assuming all remaining logical remainder rows (those not deemed as untenable by ESA) as relevant counterfactuals, which for our analysis can be seen in Table 13. We find that the necessary conditions of high internet accessibility and high association participation combine with (a) high quality of personal relationships or (b) high commercial infrastructure and a lack of high public infrastructure in order to be sufficient for low loneliness.

In contrast, by making the opposite assumption about logical remainder rows, that they are each not sufficient for the outcome, we have also a 'conservative solution' that is more complex. Instead, we will present and interpret, as is standard in fsQCA, the following 'intermediate solution.'

The following two tables (Table 13 and Table 14) represent the parsimonious and conservative solutions that are a prelude to the intermediate solution presented in the text, also visible in Table 15.

Table 13: Parsimonious solution

	inclS	PRI	covS	covU	Cases
I*A*P	0.939	0.920	0.739	0.398	NL, NO, DE, DK, FI, SE, BE, IS, GB, CH, AT
CI*I*A*~PI	0.923	0.872	0.400	0.058	IE, IS, GB
M1	0.934	0.913	0.798		
M1: I*A*P+CI*I*A*~PI □ LL					

Table 14 Conservative solution

	inclS	PRI	covS	covU	cases
I*A*CP*P	0.958	0.939	0.575	0.167	DE, DK, FI, SE, BE, IS, GB, CH, AT
~CI*I*A*P*PI	0.909	0.875	0.417	0.082	NL, NO, DK, FI, SE, BE
CI*I*A*~CP*~P*~PI	0.872	0.672	0.212	0.039	IE
M1: I*A*CP*P + ~CI*I*A*P*PI + CI*I*A*~CP*~P*~PI □ LL					

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

Condition legend:
PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations

(volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure.

2.3.3 Intermediate Solution

The main solution (the 'intermediate solution'; see Table 2 in main text) is between the conservative and parsimonious solutions in terms of complexity and employs the most care in its counterfactual assumptions (Schneider and Wagemann, p. 151-177). This involves keeping all solution conditions that are found in the parsimonious solution and adding to them those from the conservative solution which follow our directional expectations. As a reminder, our directional expectations are that each of our conditions independently is expected to be theoretically sufficient for LL.

The main intermediate solution (see Table 15) has a consistency threshold at 0.932 and a very high coverage of .909. It results in one uncovered case (out of 26), because Slovenia is ejected due to its row failing to satisfy the necessary condition of I. The Slovenian truth table row anyways had a PRI that was rather low, and leaving it 'uncovered' allows us to more confidently explain the remaining 25 cases.

In addition to the two necessary conditions, the first *'Welfare Support'* pathway involves both high public social infrastructure and strong interpersonal relationships. The second pathway, *'Cultural Support,'* adds a strong cultural preference for relational pluralism (universalism) as well as strong interpersonal relationships to the necessary conditions. The third and final pathway of *'Commercial Provision'* is mutually exclusive to the first path because it involves the *negation* of public infrastructure in combination with high commercial infrastructure, as well as the two necessary conditions. 25 European societies are explained by these three pathways, and only Slovenia remains unexplained. fsQCA 'XY Plots' show that none of these three paths have true logical contradictions, thus strengthening our confidence in this solution (See Appendix 2.3.4, Figures 11-13).

Table 15: Three solution pathways toward low loneliness and their members: the intermediate solution

	pathway 1 CI*I*A* ~PI **Commercial Provision**	**pathway 2** I*A*CP*P **Cultural Support and Micro-Social Composition**	**pathway 3** I*A*P*PI **Welfare Support and Micro-Social Composition**
Raw coverage	0.400	0.575	0.520
Unique coverage	0.069	0.067	0.083
Consistency	0.923	0.958	0.926
Covered Cases	IE, ISL, GB	DE, DK, FI, SE, BE, ISL, GB, CH, AT	NL, NO, DK, FI, SE, BE, CH, AT
M1: CI*I*A*~PI + I*A*CP*P + I*A*P*PI → LL			
Solution Consistency	0.932		
Solution Coverage	0.747		

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

Condition legend:

PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations (volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure.

2.3.4 Sufficiency Plots

Visualization is one of the most helpful tools in determining sufficiency/necessity and spotting outlying cases. QCA XY Plots should not be read as normal scatterplots; they rather are interpreted through the logic of set membership. In the case of Sufficiency, cases that are in the bottom right quadrant are the 'true logical contradictions' that violate the set relation. At the same time, we look for the clearest cases of sufficiency in the large upper-left triangle of the plot, with the most typical cases in the upper right triangle of that larger triangle. There are no true logical contradictions to any of our three pathways.

Figures 11, 12, and 13 involve a QCA sufficiency scatterplots, where cases supporting the logical claim that particular conditions or combinations are sufficient for the outcome are located in the upper left triangular half of the plot. Logical contradictions to this claim are in the lower right square of the plot.

Figure 11: Sufficiency XY plot for the 'Commercial Provision' path

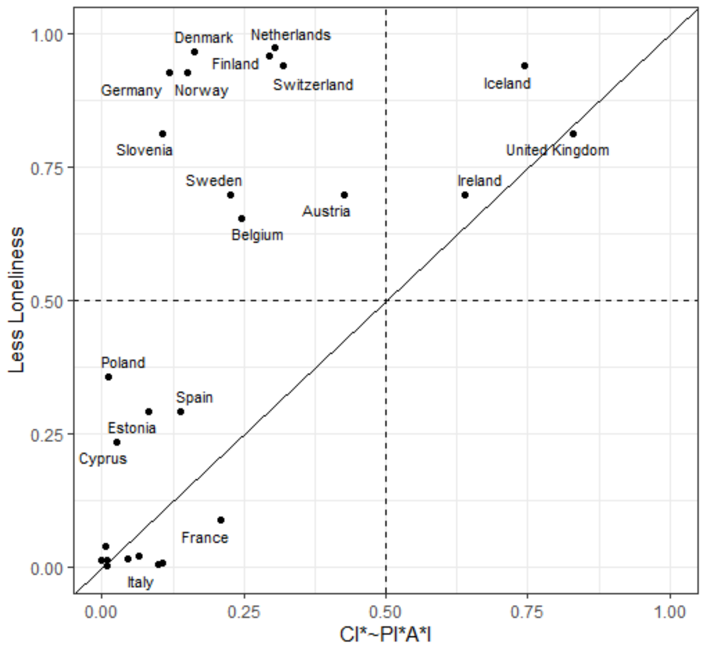


Figure 12: Sufficiency XY plot for the 'Cultural Support and Micro-Social-Composition' path

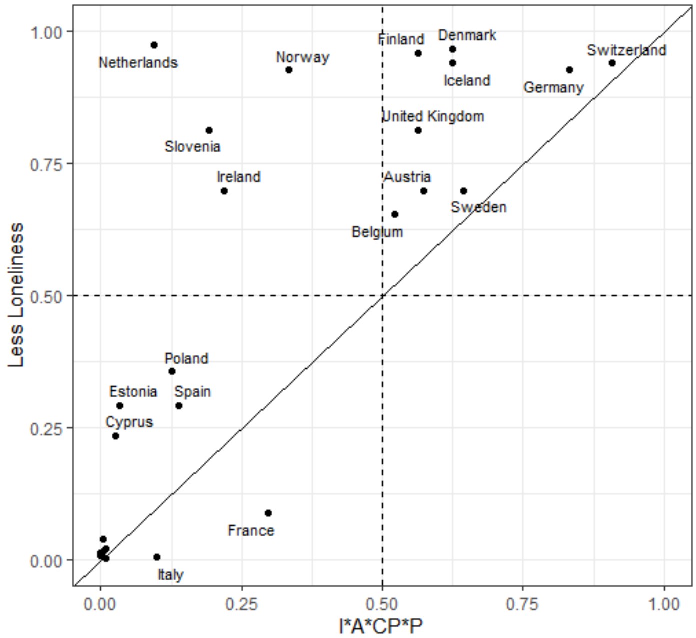
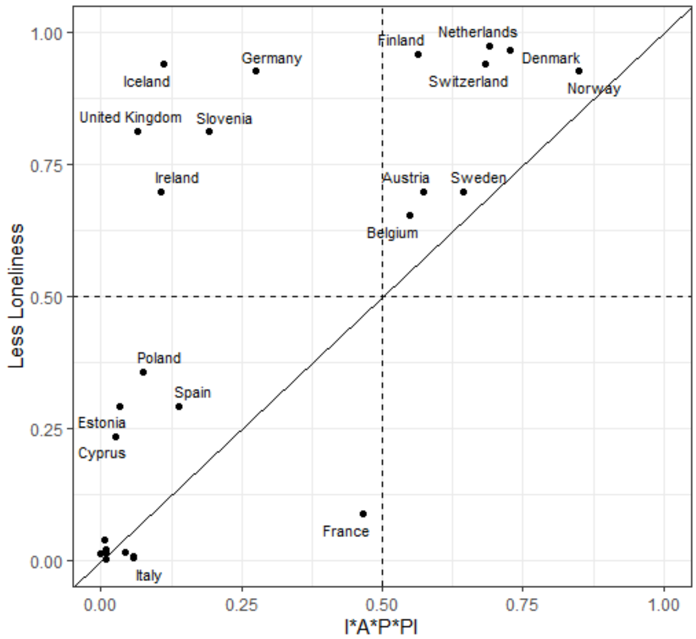


Figure 13: Sufficiency XY plot for the 'Welfare Support and Micro-Social Composition' path



2.4 Negated Outcome Analysis

2.4.1 Necessity Analysis (Negated Outcome)

We have one necessary condition for the lack of low loneliness. The lack of high public social infrastructure (see Table 16) has a consistency score above 0.9 and a moderately sized RoN, and its

XY Plot shows only one true logical contradiction (France) out of 26 to the statement that a lack of PI is necessary for the lack of LL.

Table 16 Necessity Test for negated low loneliness

	inclN	RoN	covN
~PI	0.925	0.577	0.690
~CI	0.678	0.636	0.590

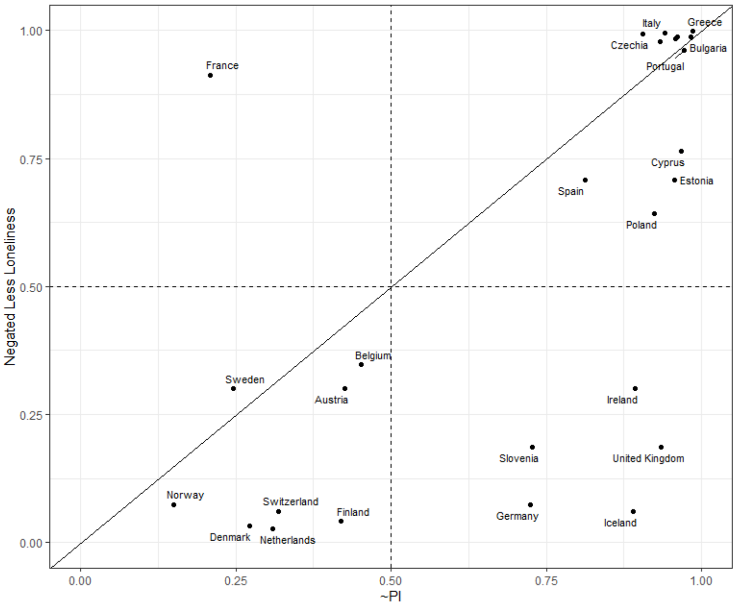
Note: only single conditions with consistency scores above 0.5 are present

Condition legend:

~PI: the lack of a public social infrastructure. ~CI: the lack of commercial social infrastructure.

Figure 14 involves a QCA necessity scatterplot, where cases supporting the logical claim that particular conditions or combinations are necessary for the outcome are located in the lower right triangular half of the plot. Logical contradictions to this claim are in the upper left square of the plot.

Figure 14: Necessity XY plot for negated high Public Infrastructure (~PI)



Note: in a necessity XY Plot for QCA, cases consistent with the necessity relation are in the bottom right-hand half of the plot beneath the diagonal, typical cases are in the upper right triangle of that larger triangle, and true logical contradictions are located in the upper left square quadrant of the plot.

2.4.2 Sufficiency Analysis (Negated Outcome)

In the base truth table (visible in Table 17) for the negated outcome, we establish a cut-off of 0.85. The PRI in these included rows is 0.66 or higher. The French row (row 26) is set to zero in order to account for the fact that it lacks ~PI, leaving France uncovered in this set of pathways.

Table 17: Truth Table for negated low loneliness

Row	CI	I	A	CP	P	PI	OUT	n	Incl	PRI	Cases
1	0	0	0	0	0	0	1	5	0.985	0.979	HU, SK, BG, LT, CZ
37	1	0	0	1	0	0	1	2	0.974	0.949	CY, EL
35	1	0	0	0	1	0	1	1	0.963	0.907	PT
17	0	1	0	0	0	0	1	1	0.941	0.887	EE
45	1	0	1	1	0	0	1	1	0.915	0.779	IT
5	0	0	0	1	0	0	1	1	0.902	0.736	PL
26	0	1	1	0	0	1	0	1	0.899	0.763	FR
47	1	0	1	1	1	0	1	1	0.874	0.664	ES
13	0	0	1	1	0	0	0	1	0.773	0.424	SI
57	1	1	1	0	0	0	0	1	0.738	0.328	IE
64	1	1	1	1	1	1	0	2	0.548	0.104	CH, AT
63	1	1	1	1	1	0	0	2	0.537	0.106	ISL, GB
28	0	1	1	0	1	1	0	2	0.512	0.218	NL, NO
31	0	1	1	1	1	0	0	1	0.473	0.102	DE
32	0	1	1	1	1	1	0	4	0.410	0.094	DK, FI, SE, BE

Table 18: Parsimonious solution for negated low loneliness

	inclS	PRI	covS	covU	cases
~A	0.905	0.873	0.800	0.456	HU, SK, BG, LT, CZ, PT, EE, PT, CY, EL

CI*~I	0.914	0.867	0.438	0.094	PT, CY, EL, IT, ES
M1	0.883	0.846	0.894		
M1: ~A +CI* ~I ~LL					

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

Condition legend:
PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations (volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure.

Table 19: Conservative solution for negated low loneliness

	inclS	PRI	covS	covU	cases
~CI*~A*~CP*~P*~PI	0.975	0.966	0.528	0.343	HU, SK, BG, LT, CZ, EE
CI*~I*A*CP*~PI	0.895	0.765	0.268	0.086	IT, ES
~I*~A*CP*~P*~PI	0.942	0.884	0.334	0.104	PL, CY, EL
CI*~I*~A*~CP*P*~PI	0.963	0.907	0.196	0.032	PT
M1	0.942	0.922	0.831		
M1: ~CI*~A*~CP*~P*~PI + CI*~I*A*CP*~PI + ~I*~A*CP*~P*~PI + CI*~I*~A*~CP*P*~PI ~LL					

Table 20: Intermediate solution for negated low loneliness

	inclS	PRI	covS	covU	(M1)	(M2)	cases
CI* ~I*CP*~PI	0.919	0.859	0.357	0.084	0.186	0.084	CY, EL, IT, ES
~CI*~A*~CP*~P*~PI	0.975	0.966	0.528	0.070	0.070	0.343	HU, SK, BG, LT, CZ, EE

CI*~I*~A*P*~PI	0.966	0.917	0.213	0.032	0.032	0.032	PT
~CI*~I*~A*~P*~PI	0.937	0.915	0.493	0.004	0.021		HU, SK, BG, LT, CZ, PL
~I*~A*CP*~P*~PI	0.942	0.884	0.334	0.000		0.017	PL, CY, EL
M1	0.929	0.906	0.837				
M2	0.942	0.922	0.832				

M1: CI*~I*CP*~PI + ~CI*~A*~CP*~P*~PI + CI*~I*~A*P*~PI + (~CI*~I*~A*~P*~PI) → ~LL

M2: CI*~I*CP*~PI + ~CI*~A*~CP*~P*~PI + CI*~I*~A*P*~PI + (~I*~A*CP*~P*~PI) → ~LL

Note: Factorized solution: ~A~P*~PI*(~CI*~CP + CP*~I) + CI*~I*~PI*(CP + ~A*P)*

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

Condition legend:
PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations (volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure.

There are many sufficient pathways toward the lack of low loneliness in European societies (Table 20, the intermediate solution, which is at a midrange complexity between Tables 18 and 19, the parsimonious and conservative solutions), but they all share the lack of high public social infrastructure. These can be differentiated into Central/Eastern European and Southern European branches. The Central and Eastern European branch of sufficient pathways results in a lack of low loneliness with *both* commercial and public social infrastructure negated (Hungary, Slovakia, Bulgaria, Lithuania, Czechia, Estonia, and Poland), in combination with other conditions. Another branch of Southern European Societies (Cyprus, Greece, Italy, Spain, and Portugal) requires the presence of CI but still the *negation* of PI. France is the only country unexplained by our solution pathways, because it has a high public social infrastructure but nonetheless it lacks 'low loneliness.'

Robustness checks

3.1 QCA Robustness State-of-the-Art

Before describing our procedure, we present briefly the state-of-the-art in QCA robustness testing. We then relate our procedure to this state-of-the-art to show its advantages.

Four types of robustness checks are recommended in relation to fsQCA: robustness to calibration, to the consistency threshold within the truth table, to case selection (Schneider and Wagemann 2012, p. 316), and robustness to frequency thresholds for truth table rows (Oana and Schneider 2021).

The definition of robustness in QCA is that "solution terms ... involve similar necessary and sufficient conditions and ... consistency and coverage are roughly the same across different model specifications" (Schneider and Wagemann 2012, p. 285; see also Thomann and Maggetti 2020). This means that the impacts of the above factors should be looked at in terms of the final solution terms.

The state-of-the art in QCA robustness tests sensitivity ranges of three of the four parameters (Oana and Schneider 2021) and addresses the fourth, case robustness, through other means (addressing deviant and typical cases). Sensitivity range testing changes one parameter at a time in order to find the range at which the main solution stays intact. A test set of possible valid alternative solutions is produced, it is compared to the initial parsimonious solution for which robustness is checked, and the stable part of the solution is labeled as the 'robust core.'

The above authors explain two main shortcomings of their method: first that the sensitivity ranges are tested only one at a time, and second, that the sensitivity range testing is not conceptually guided. Our method resolves both critiques first by testing all conceptually valid choices in combination with one another.

Our relation to the state-of-the-art (Oana and Schneider 2021):

- Regarding the four types of robustness checks, we implement three (robustness to calibration, consistency thresholds, and case selection) and ignore the fourth, frequency thresholds, because we already use the strictest threshold possible, of 100%. However, we recognize that our technique could be easily extended to test multiple frequency thresholds.

- In contrast to taking the initial parsimonious solution as the core of our robustness tests, we instead test the combination pathways produced by the intermediate solution after the esa procedure.

- We replace one-at-a-time sensitivity range testing with a configurational (combinatorial) approach that tests all possible combinations of all conceptually valid choices. We agree that "if only this single parameter is changed *and everything else in the analysis is left unaltered*" (Oana and Schneider 2021, p. 3) is a shortcoming, since it is the combination of decisions in QCA that leads to specific outcomes, and the above approach is thus highly dependent upon the initial settings. Our configurational technique avoids this problem.

- We test only choices that we consider to be conceptually/theoretically valid.

- We also check whether our specific IS paths, or subsets of those paths, occur within the solution models that are produced.

- Our method also takes model ambiguity into account by checking the IS's relation to all models produced as output.

- We also use a TS (testset) against which our solution is tested, but there are two types. One corresponds to each configuration of choices (n=17280), where multiple models are organized and tested under each combination of choices they represent, and one corresponds to every unique solution produced, including those which are resulting from model ambiguity (n=67788). Thus, the first TS is used to represent how the IS appears within different analytical decision configurations, while the second represents how often the IS appears within any produced solution model, regardless of which configuration of decisions produced that model.

- We handle case robustness differently from Oana and Schneider (2021). Rather than figuring out which cases become typical or deviant for different choices, we randomly drop cases from different analysis combinations and observe these impacts on the solutions.

- We soften the notion of a 'robust core' because of the sheer number of configurations and solutions presented. It is made probabilistic but should not be interpreted in a rote way. Exact pathways are less likely to be repeated if they are more complex. Likewise individual conditions nearly always appear. We recommend the use of the exact intermediate solution pathways, their subsets, as well as theoretically valid combinations of conditions, such as pairs or triads, to determine if 'they are not rare' within the set of possible analytic choices that could have been combined.

- Finally, we also extend the protocol to check for necessary conditions. This is done as the first step for each unique configuration of robustness decisions. Any unique or conjunctural necessary conditions surpassing the .89 threshold are saved for further analysis.

3.2 A Brief Introduction to Configurational Robustness Testing

Our robustness tests, encompassing statistics gathered from 17280 simulations and individual solutions (including model ambiguity), demonstrate that our results are not arbitrarily linked to choices that are somehow atypical. We check for robustness to (a) case selection, (b) theoretically viable calibration decisions and (c) truth table row inclusion score cutoffs (Schneider and Wagemann 2012). Thus, we incorporate standard fsQCA robustness checks for case selection, calibration based, and inclusion thresholds, but we do so simultaneously and combinatorially, considering that different combinations of these choices may yield different results. We take this approach while maintaining theoretical relevance and justifications at the forefront, for instance, by only including theoretically valid thresholds and condition combinations into our calculations. Our procedures synchronize well with the state of the art in robustness testing (Oana and Schneider 2021), but we add an important combinatorial approach. Instead of testing robustness decisions independently, we test all possible combinations of valid robustness decisions.

We test the combination of three types of robustness choices. In terms of case selection, we have removed one random case in 50 % of the simulations. In the other 50%, the full set of cases is used.

In terms of calibration anchors, we have used only those possibilities identified as theoretically valid in line with the set definitions and knowledge about the cases. Combinations of multiple calibration anchors were analyzed for the outcome and for all conditions. These cut-offs are listed in Appendix 1 (‘Raw Data and Calibration’).

In terms of inclusion thresholds for truth table rows, we have tested the lowest possible threshold of .75 in addition to the largest empirical gap in the inclusion score between truth table rows. For any given threshold, we have further removed all rows where the outcome is coded as 1 but which contain inconsistent cases that lack that outcome.

For every possible combination of the above three types, a QCA analysis is performed, and all the data are stored. For necessity analysis, a consistency cutoff of .89 or higher is used. For the truth table analysis, the minimization procedure is conducted only on TT rows higher than the inclusion threshold, with a PRI greater than .5, and that have only consistent cases. Further, the necessary conditions are entered into the ‘esa’ function (Oana and Schneider 2018) in order to remove untenable associated rows.

Accounting for model ambiguity (all solutions are collected), we then gather statistics on how often our solution terms of interest were included in the necessity outcomes, QCA intermediate results for sufficiency (while adjusting for contradictory cases), and we also report the consistency, coverage, and PRI statistics of these terms.

We have checked whether the exact combination pathways were found, whether more specific pathways that include those pathways are found, theoretically relevant combination pairs found in our solution pathways, as well as atomic results of individual conditions. We have calculated robustness information only for the outcome of low loneliness but not for its negation.

Thus, our reported robustness results include case removal statistics (see Table 21), necessity findings (see Table 22), distributions of the statistics for exact intermediate solution paths (see Figures 15, 16, and 17), frequencies of pathways within all robustness configurations (see Table 24) and the solutions (see Table 23) resulting from those decisions, and frequencies of theoretically relevant supersets of the sufficient pathways, such as dyads (see Table 25).

Robustness testing confirms the stability of the statistics of the three sufficient pathways and that the prevalence of these exact combinations as well as key pairs within them are not rare (although the first and second pathways occur more often than the third).

3.3 Case selection Robustness

Table 21: Case selection robustness

Country	Frequency of removal
AT	342
BE	284
BG	282
CY	324
CZ	326
DK	352
EE	320
FI	330
FR	340
DE	294
GR	368
HU	320
ISL	356
IE	326
IT	354
LT	318
NL	384
NO	320
PL	356
PT	352

SK	314
SI	298
ES	330
SE	332
CH	376
GB	290
None	8692

Note: Summary of frequency cases excluded in robustness simulations

Country case legend:
AT=Austria, BE=Belgium, BG=Bulgaria, CH=Switzerland, CY=Cyprus, CZ=Czechia, DE=Germany, DK=Denmark, EE=Estonia, EL=Greece, ES=Spain, FI=Finland, FR=France, GB=Great Britain, HU=Hungary, IE=Ireland, ISL=Iceland, IT=Italy, LT=Lithuania, NL=The Netherlands, NO=Norway, PL=Poland, PT=Portugal, SE= Sweden, SI=Slovenia, SK=Slovakia

3.4 Robustness to Necessity

Table 22: Robustness of Necessity findings in each unique combination of Robustness choices

Conditions	Frequency	Percent
None	3552	41.1
I	2722	31.5
I*A	1194	13.8
A	1156	13.4
I*P	5	0.1
I*A*P	4	0
I*A*CP	3	0
I*CP	2	0
A*CP	1	0
A*P	1	0

Note: The above table reports the frequency of exact necessity results occurring (with an inclusion score above .89) within each relevant robustness combination (robustness to inclusion thresholds is ignored, as it is only relevant for sufficiency testing).

Condition legend:
PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations (volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure.

3.5 Configurational Robustness results

Figure 15: Configurational Robustness for CI*I*A*~PI (*Commercial Provision* pathway)

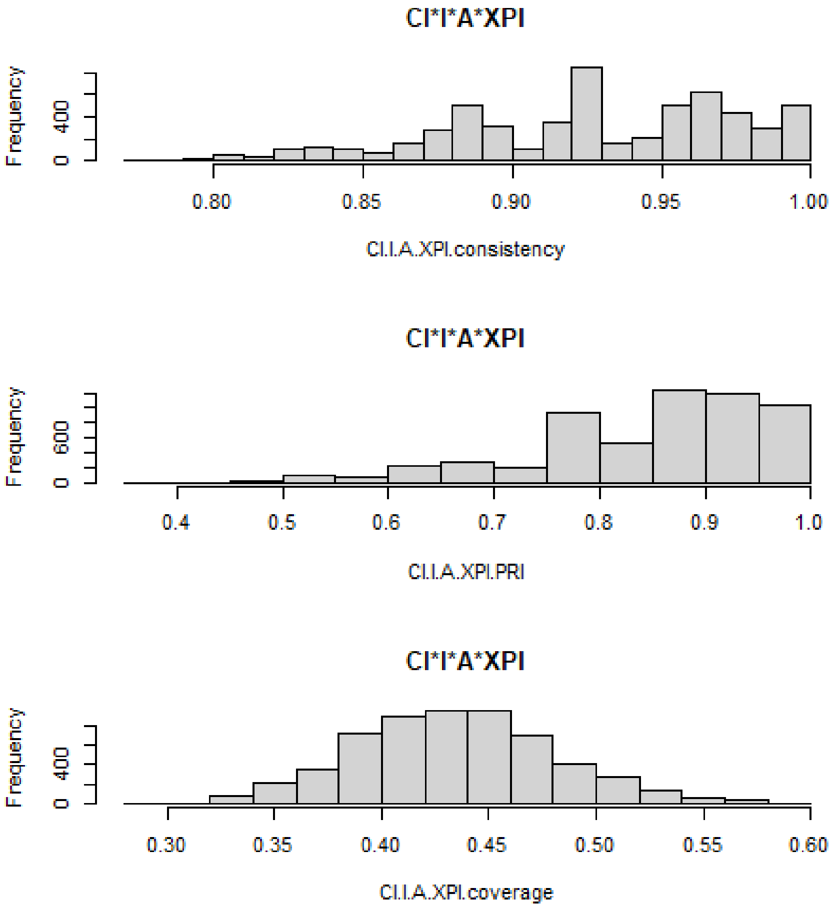


Figure 16: Configurational Robustness for I*A*CP*P (*Cultural Support* pathway)

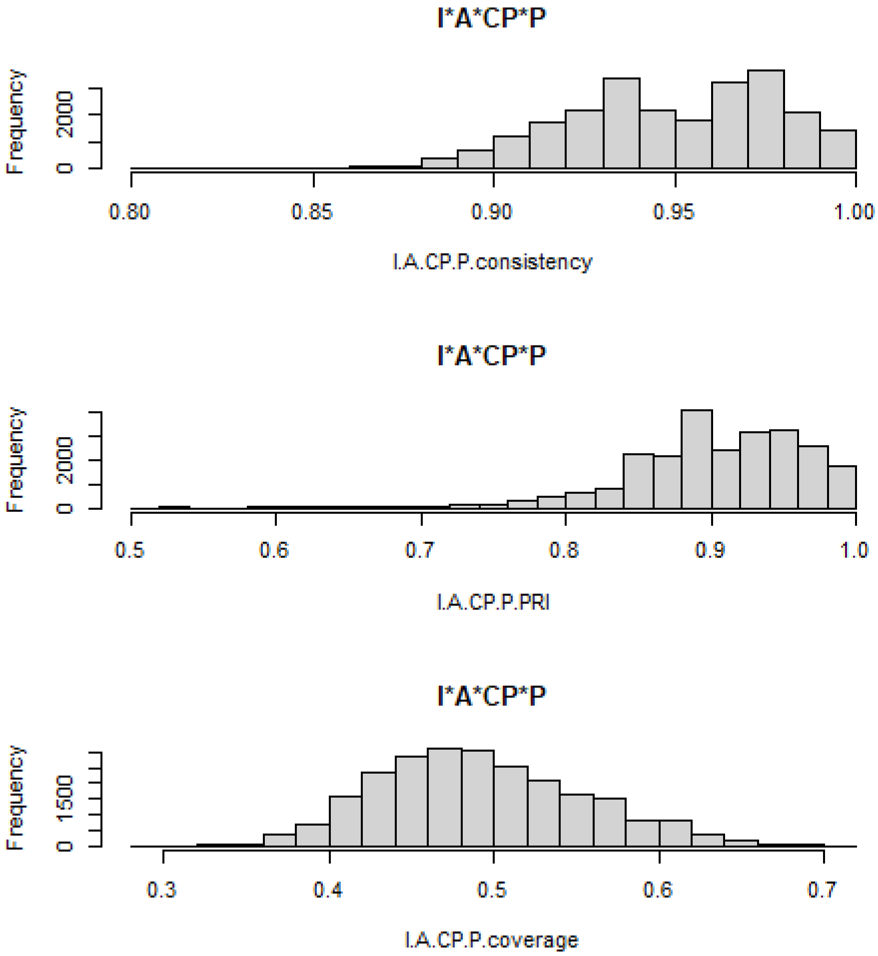


Figure 17: Configurational Robustness for I*A*P*PI (*Welfare Support* pathway)

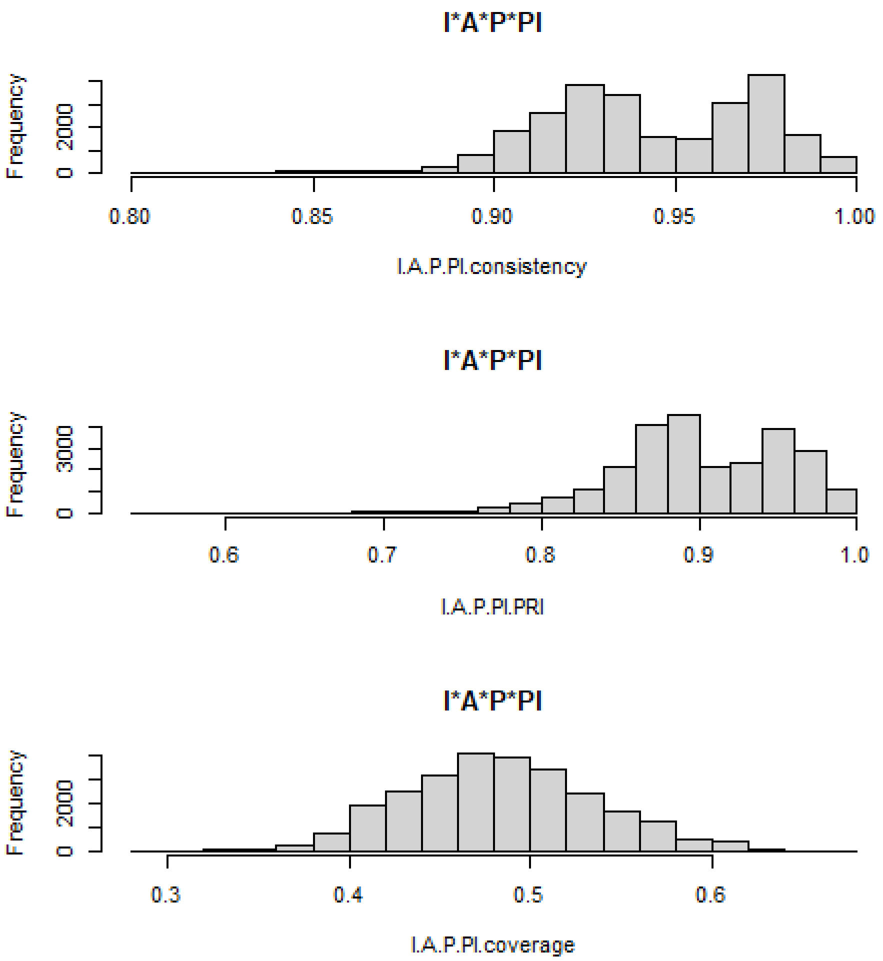


Table 23: Presence of each sufficient configuration in all solutions

	True	False	Percentage
CI*I*A* ~PI (commercial provision)	10271	58011	15
I*A*CP*P (cultural support)	32586	35696	47.7
I*A*P*PI (welfare support)	37289	30993	54.6

Note: including the additional solutions involving model ambiguity, which means that multiple solutions are sometimes produced for every combination of robustness parameters.

Condition legend:
PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations (volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure

Table 24: Presence of each sufficient configuration in each unique combination of robustness parameters

	True	False	Percentage
CI*I*A* ~PI (commercial provision)	4701	12579	27
I*A*CP*P (cultural support)	12741	4539	74
I*A*P*PI (welfare support)	10676	6604	62

Table 25: Robustness of theoretically relevant pairs of conditions found in main solution combinations

	True	False	Percentage
CI*~PI	30713	37569	45
CI*PI	12316	55966	18
~CI*PI	19780	48502	29
I*A	59523	8759	87.2
P*PI	54738	13544	80.2
CP*P	43429	24853	63.6

Notes: N=68k, includes model ambiguity

Condition legend:
PI: high public infrastructure. P: strong personal relationships. I: high internet accessibility. CP: high cultural preferences for universalism (relational pluralism). A: high involvement in associations (volunteering). CI: high commercial infrastructure (service sector). ~PI: the lack of a condition, in this case high public infrastructure.

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