Multilevel Latent Class Analysis with gem: Attitudes toward vaccination at the eve of Covid 19

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„Models are to be used, but not to be believed."
(Henri Theil)

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Outline

- What is my problem ?
- Which strategy of data analysis do I need?
- My empirical example
  - Used data set
  - Measurement instrument
  - Step 1: Estimation of measurement model using LCA (gsem)
  - Step 2a: Prediction of class membership by a fixed-effect multinomial logit model (mlogit)
  - Step 2b: Prediction of class membership by a random-effect multinomial logit model (xtmlogit)
- My Conclusions

What is my problem ?

- **During my whole life as a researcher I have used Likert-type items and explorative or confirmative factor analyis (sem) to develope measurement models for continuous latent variables**
- **Now I have four discrete items to measure the attitude towards vaccinaton at the eve of the Covid19-pandemic**
- **My intention is to develop a multilevel model to explain attitude differences within- and between the EU-countries using exogenous level 1 and level 2 variables**

My choice of strategy for data analysis

- **Step 1: Estimation of a general measurement model using Latent Class Analysis with Stata's gsem (since Stata 15)**
  - **Choose the appropriate distribution family and link function**
  - **Identify the necessary number of latent classes using AIC, BIC or Entropy criteria**
  - **Identify the "senseful groups" by looking at the estimated latent class marginal means of the items**
  - **Calculate the posteriori probabilities of class membership for the respondents**
  - **Assign the respondents to their discrete latent class by the maximum-probability rule (modal rule)**

Choice of strategy for data analysis 2

- **Step 2a: Prediction of the discrete latent group membership by a fixed-effect multinomial logit model (mlogit since Stata 3)**
  - **Using exogenous level 1 variables to predict the class membership within countries**
  - **Using exogenous level 2 dummy variables for the EU-countries assuming fixed-effects**
  - **Assessing the fit of the multinomial model by a separate McKelvey & Zavoina Pseudo R^2 per comparison (my mzr2.ado)**
  - **Graphical presentation of the results by a plus-minus bar chart of the average marginal effects (Ben Jann's coefplot.ado)**

Choice of strategy for data analysis 3

- **Step 2b: Using Multilevel Multinomial Logit model to predict latent class membership using Stata's xtmlogit (since Stata 17)**
  - **Prediction of the latent class membership within the EU-countries by exogenous level 1 variables**
  - **Explaining the variation of the logistic constants - the expected logit of the reference group - between the countries by exogenous level 2 variables**
  - **Assessing the fit of the logistic Intercept-as-Outcome Models by separate Bryk&Raudenbush Level 2 PRE-R^2s**
  - **Graphical presentation of the estimated effects with plus-minus bar charts (average marginal effects)**

My data set

- **Eurobarometer No 91.2 (Special EB 488)**
  - **Topic: Europeans' Attitudes towards vaccination**
  - **Framing: Flu, measles, polio, hepatitis, meningitis, tetanus as potential death causing diseases**
  - **Sampling units: Population of EU-membership states aged 15+**
  - **Survey design**
    - **Multi-stage probability sample with 1,000 in great states and 500 respondents i in small states j**
    - **Realized netto sample: n_{ij} = 27,524 respondents in $n_{.j}$ = 28 Staaten (+1 for BRD-NBL)**
  - **Survey modus: Face-to-Face (CAPI)**
  - **Survey time span: 15. - 29.03.2019 (before Covid19)**
  - **Research institute: Kantar network**

Measurement instrument

QC7	For each of the following statements, could you please tell me whether you think it is true or false.

		True	False	DK
1	Vaccines overload and weaken the immune system	1	2	3
2	Vaccines can cause the disease against which they protect	1	2	3
3	Vaccines can often produce serious side-effects	1	2	3
4	Vaccines are rigorously tested before being authorised for use	1	2	3

?

- **Scientific Knowledge / Current state of research**
  - **True statement: blue; False statement: red; DK: green**
  - **I decide to include the DK-answers because of their sensitivity → analysis of $3^4 = 81$ response patterns!**

Step 1: Estimation of LCA with gsem

- **Specification and estimation of the Latent Class Analysis using Stata's gsem using family multinomial and link logit**
  - **Estimation of models with 1 to 5 latent classes**
  - **Looking at the Latent class statistics (lcstats)**

Latent class statistics

	N	Rank	AIC	BIC	Entropy
class1	27,524	8	197,764.47	197,830.25	
class2	27,524	17	182,094.12	182,233.90	0.6909
class3	27,524	26	173,286.13	173,499.92	0.7548
class4	27,524	35	172,719.41	173,007.21	0.7497
class5	27,524	44	172,442.40	172,804.20	0.6985

AIC is the Akaike information criterion.
BIC is the Bayesian information criterion.
BIC uses N = number of observations.

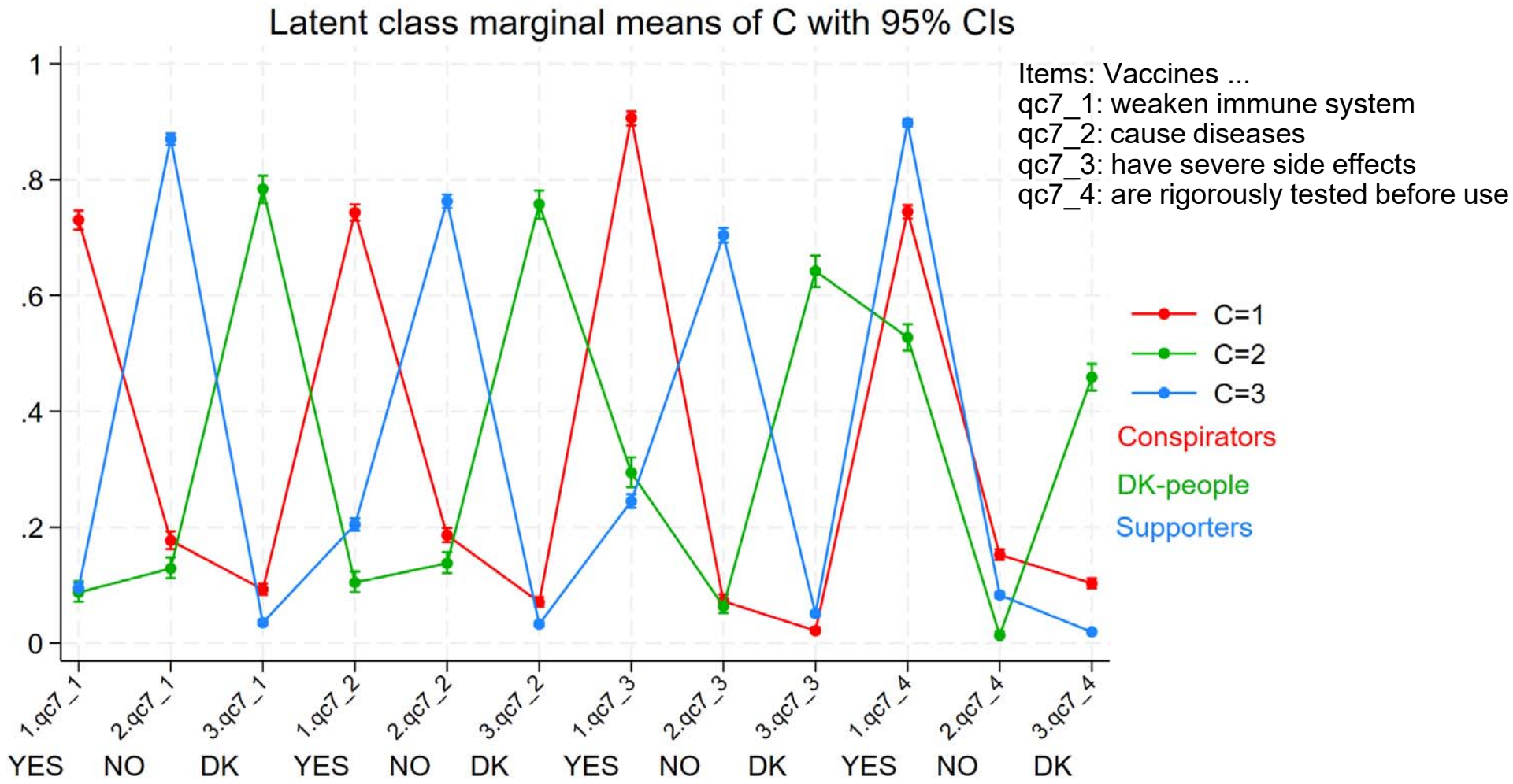
	Classes	ll	df	LMR	P>LMR
class1	1	-98,874.23			
class2	2	-91,030.06	9	15,519.67	0.333
class3	3	-86,617.06	9	8,731.09	<0.001
class4	4	-86,324.71	9	578.43	<0.001
class5	5	-86,177.20	9	291.85	<0.001

LMR is the Lo-Mendell-Rubin-adjusted likelihood-ratio test statistic.
Likelihood-ratio tests compare the given model versus the same model with one less latent class.

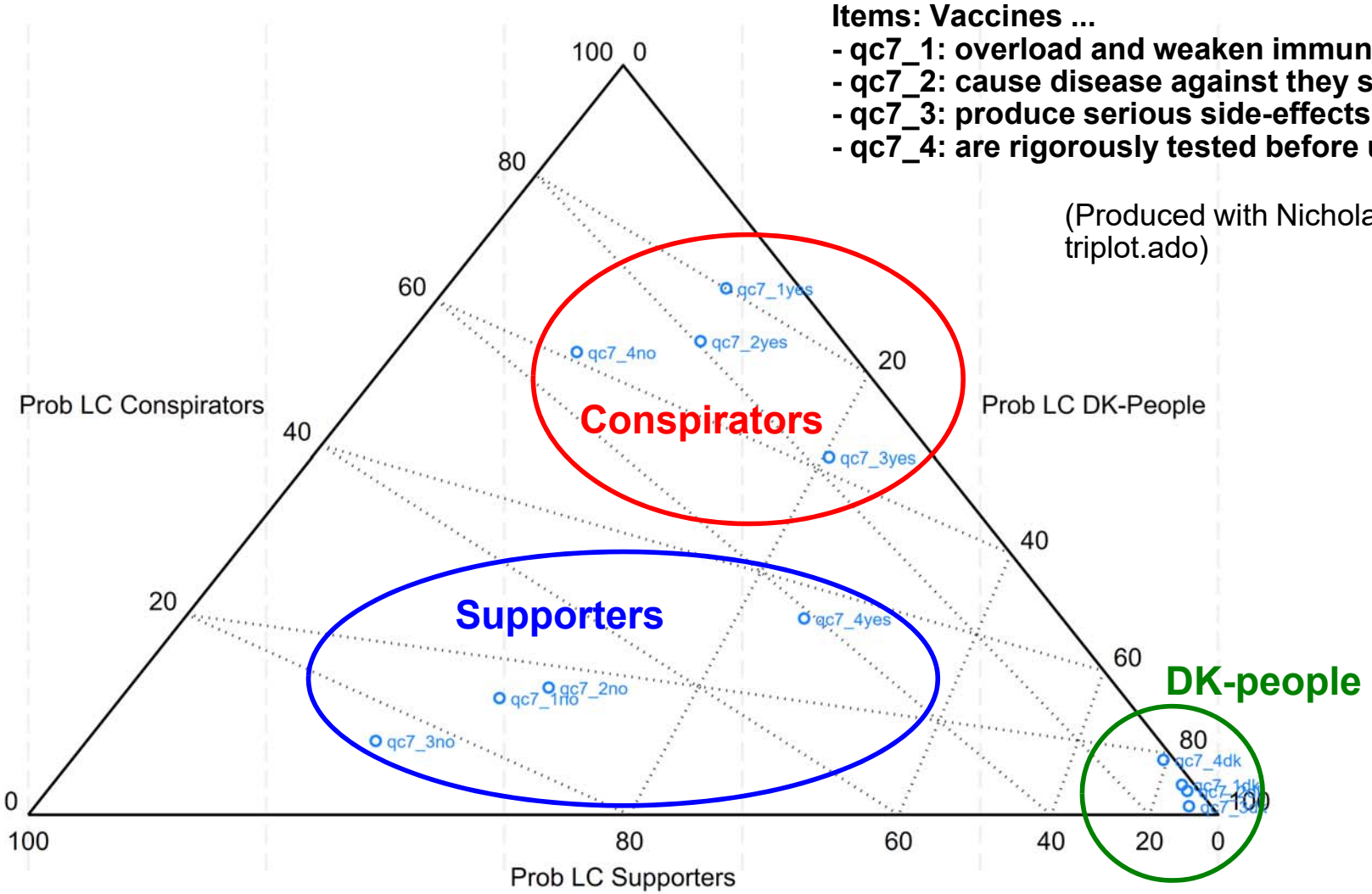
  - **Decision in favour of 3 classes with highest entropy!**

What characterizes the 3 latent classes?

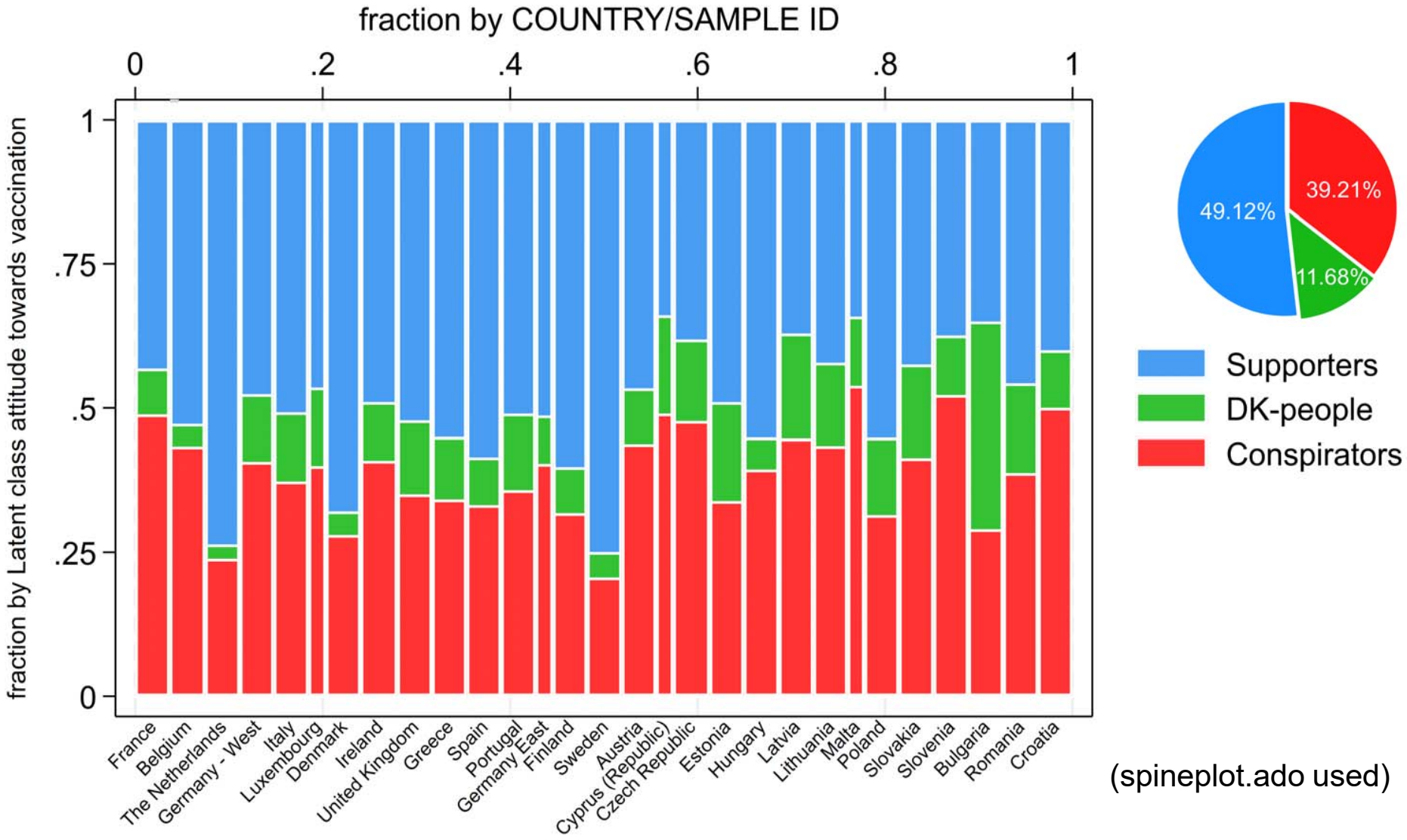
- **Marginsplot of latent class marginal means**



Triplot of the posteriori Class probabilities



Distribution of 3 latent classes in EU 2019



(spineplot.ado used)

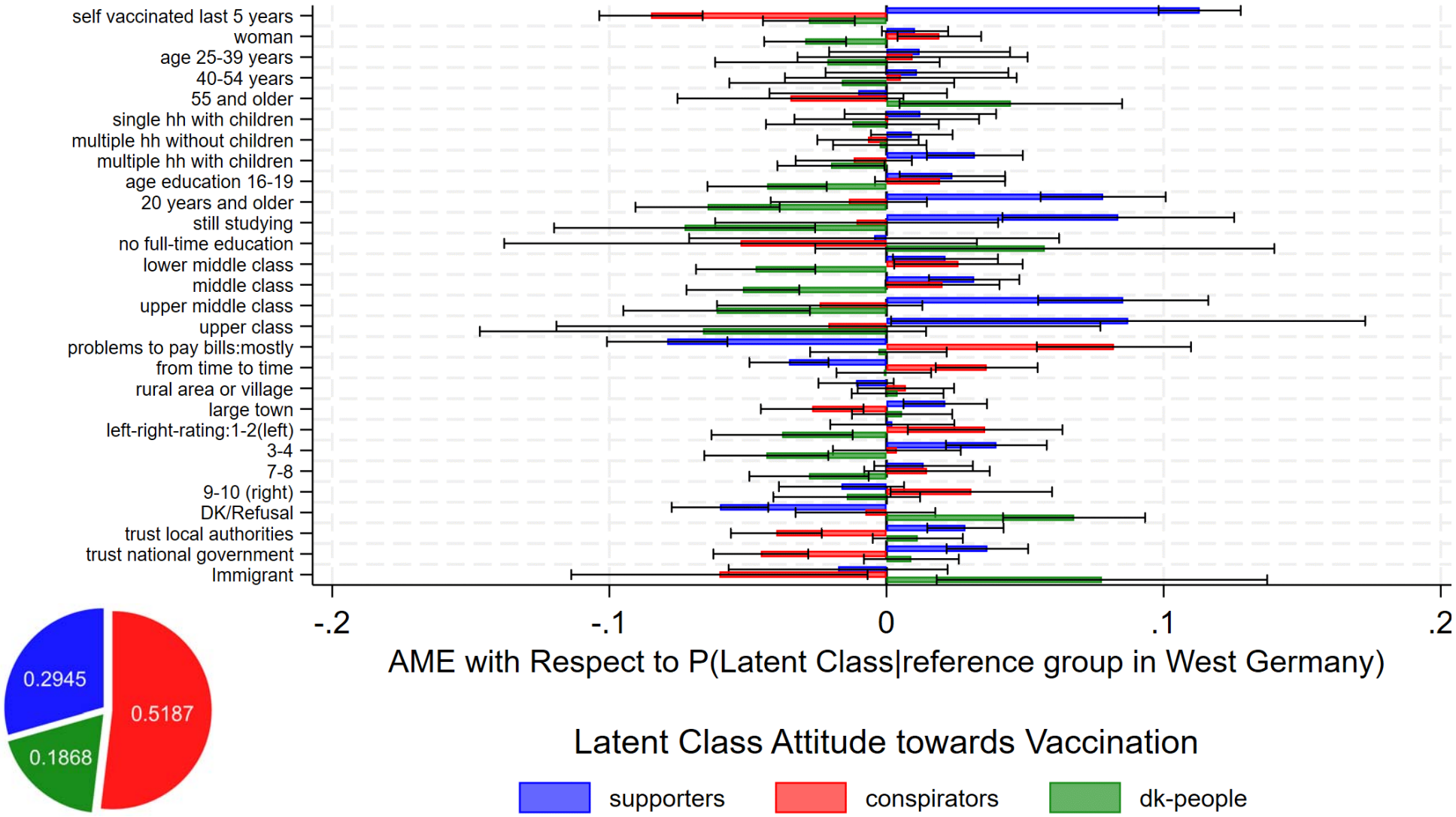
Step 2a: Prediction by Fixed Effect MNL

- **Exogenous level 1 variables (Reference category)**
  - **Self or family member vaccinated last 5 years: yes vs. no**
  - **Age groups: 15-24, 25-39, 40-54, 55 +**
  - **Gender: woman vs. man**
  - **Household type: single, single with children, multiple hh without children, multiple hh with children**
  - **Educational degrees / age stopping full-time education: under 15, 16-19, 20+, still studying**
  - **Subjective social class: working, lower middle, middle, upper middle, upper class**
  - **Problems paying bills: no, mostly, from time to time**

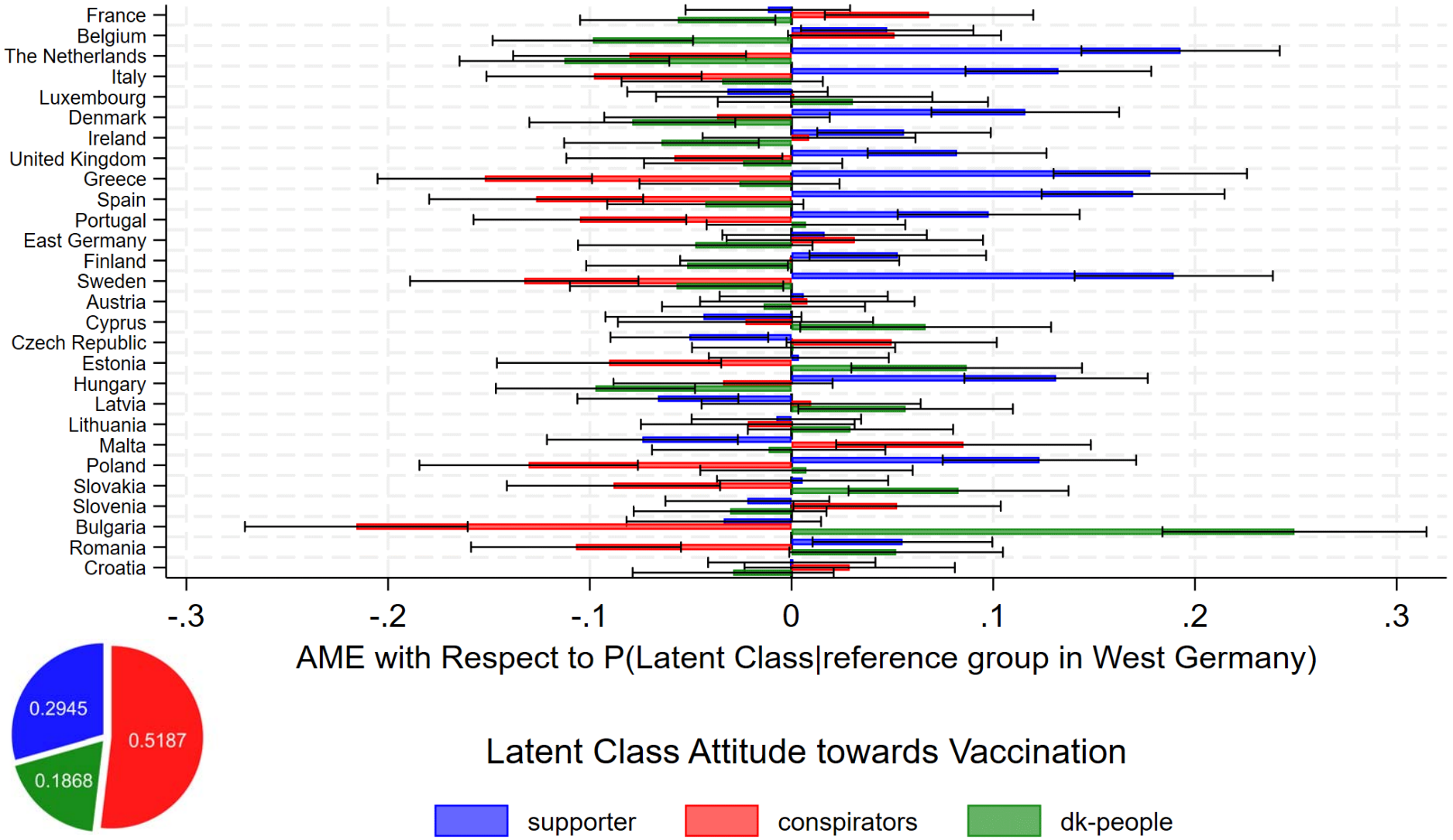
Step 2a: Prediction by Fixed Effect MNL 2

- **Exogenous level 1-Variables**
  - **Geographical area / location: rural area or village, small / middle town, large town**
  - **Political orientation / left-right self rating [1;10] + DK/Refusal: 5-6 reference category (middle)**
  - **Trust in local administration: yes vs. no**
  - **Trust in national government: yes vs. no**
  - **Nationality: immigrants vs. native**
    - **Reference group: single native men, age lower 25, working class, secondary modern school, without vaccination, without confidence in local and national government, middle political orientation, living in a small/middle town**
    - **EU-Memberstate Dummies: West Germany**

Coefplot exogenous level 1 variables



Coefplot exogenous EU-member states



Assessment of model fit

- **Used Ado-Files**
  - **Scott Long's fitstat.ado**

```
. fitstat
                           |      mlogit
---------------------------+-----------
Log-likelihood             |
                     Model |   -20893.144
           Intercept-only  |   -22271.740
---------------------------+-----------
Chi-square                 |
      Deviance(df=23609)   |    41786.289
               LR(df=112)  |     2757.191
                  p-value  |        0.000
---------------------------+-----------
R2                         |
                  McFadden |        0.062
       McFadden(adjusted)  |        0.057
              Cox-Snell/ML |        0.110
  Cragg-Uhler/Nagelkerke   |        0.130
                    Count  |        0.558
          Count(adjusted)  |        0.108
---------------------------+-----------
IC                         |
                       AIC |    42014.289
         AIC divided by N  |        1.771
              BIC(df=114)  |    42934.748
```

  - **W.Langer's mzr2.ado**
    - **Reference category „Supporters"**

```
. mzr2
Separate McKelvey Zavoina R2 for mlogit equations

     Equation |     R2
--------------+--------
   Conspira~s |  0.0926
    DK-people |  0.2074
   Supporters |  0.0000
 ---------------------
```

Results of the MNL

- **Model fit**
  - Comparison „Conspirators" vs. „Supporters": 9.26% of the variation of estimated logits is explained by xvars
  - Comparion „DK-people" vs. „Supporters": 20.74% of the variation of estimated logits is explained by xvars
- **Estimated effecs of exogenous variables**
  - Level 1 - variables: discussion after ML-MNL
  - Level 2 - variables EU-membership states
    - Higher P(„supporters"): The Niederlands, United Kingdom, Irland, Italy, Spain, Portugal, Greece, Denmark, Finland, Sweden, Hungary
    - Higher P(„conspirators"): France, Slovenia
    - Higher P(„DK-people"): Slovakia, Bulgaria compared to BRD(ABL)

Newest development

- **Califano & Fabbricatore (2026) has published their << step3.ado >> which provides two methods to reduce the classification bias of the Latent Class Analysis predicting class membership by the MNL or the distal outcome by a regression model**
  - **Vermunt's ML-approach (2010)**
  - **Bolck, Croon & Hagenaars BCH-approach (2004)**
- **Testing it with my 3 class solution I find out that**
  - **on the average the logit coefficients of the MNL to predict the modal category underestimate around a factor of 0.78 to 0.81 the logistic slopes of the new ML or BCH approach**
  - **It does not support the fitstat.ado and margins**

Step 3: Multilevel MNL - LCA

- **Specification and estimation with xtmlogit (since Stata 17)**
  - **Intercepts-as-Outcome Multinomial Logit Model can be estimated**
    - **Pooled Within-Country Regressions: Explaining the differences between respondents within the EU-membership states by their exogenous level 1-variables**
    - **Between-Country Regression: Explaining the variation of the expected logit of the reference group between EU-membership states by exogenous level 2-variables**
    - **Estimation and test of the covariance of the random-intercepts between level 2 units is possible but not used in this analysis**

Estimation equations of xtmlogit

Level 2: Intercept-as-Outcome-Multinomial-Logit Model:

$$a)\quad \beta_{0j_{21}} = \gamma_{00_{21}} + \gamma_{01_{21}} \times Z_{.j} + u_{0\,j_{21}}$$

$$b)\quad \beta_{0j_{31}} = \gamma_{00_{31}} + \gamma_{01_{31}} \times Z_{.j} + u_{0\,j_{31}}$$

$$\Sigma = \begin{bmatrix} \sigma^2_{u_{0\,j_{21}}} & \\ \sigma_{u_{0\,j_{21}},\,u_{0\,j_{31}}} & \sigma^2_{u_{0\,j_{31}}} \end{bmatrix}$$

Level 1: Within-Context Logistic Regressions

$$a)\quad \ln\left[\frac{P(Y=2)}{P(Y=1)}\right] = \beta_{0\,j_{21}} + \beta_{1j_{21}} \times X_{ij}\ \{+r_{ij_{21}}\}$$

$$b)\quad \ln\left[\frac{P(Y=3)}{P(Y=1)}\right] = \beta_{0\,j_{31}} + \beta_{1j_{31}} \times X_{ij}\ \{+r_{ij_{31}}\}$$

Single equation notation: 2) in 1)

$$a)\quad \ln\left[\frac{P(Y=2)}{P(Y=1)}\right] = \left(\gamma_{00_{21}} + \gamma_{01_{21}} \times Z_{.j} + u_{0\,j_{21}}\right) + \left(\gamma_{10_{21}} \times X_{ij}\right)\{+r_{ij_{21}}\}$$

$$b)\quad \ln\left[\frac{P(Y=3)}{P(Y=1)}\right] = \left(\gamma_{00_{31}} + \gamma_{01_{31}} \times Z_{.j} + u_{0\,j_{31}}\right) + \left(\gamma_{10_{31}} \times X_{ij}\right)\{+r_{ij_{31}}\}$$

Step 3: Exogenous level 2 variables

- **Exogene Level 2-Variablen der EU Staaten**

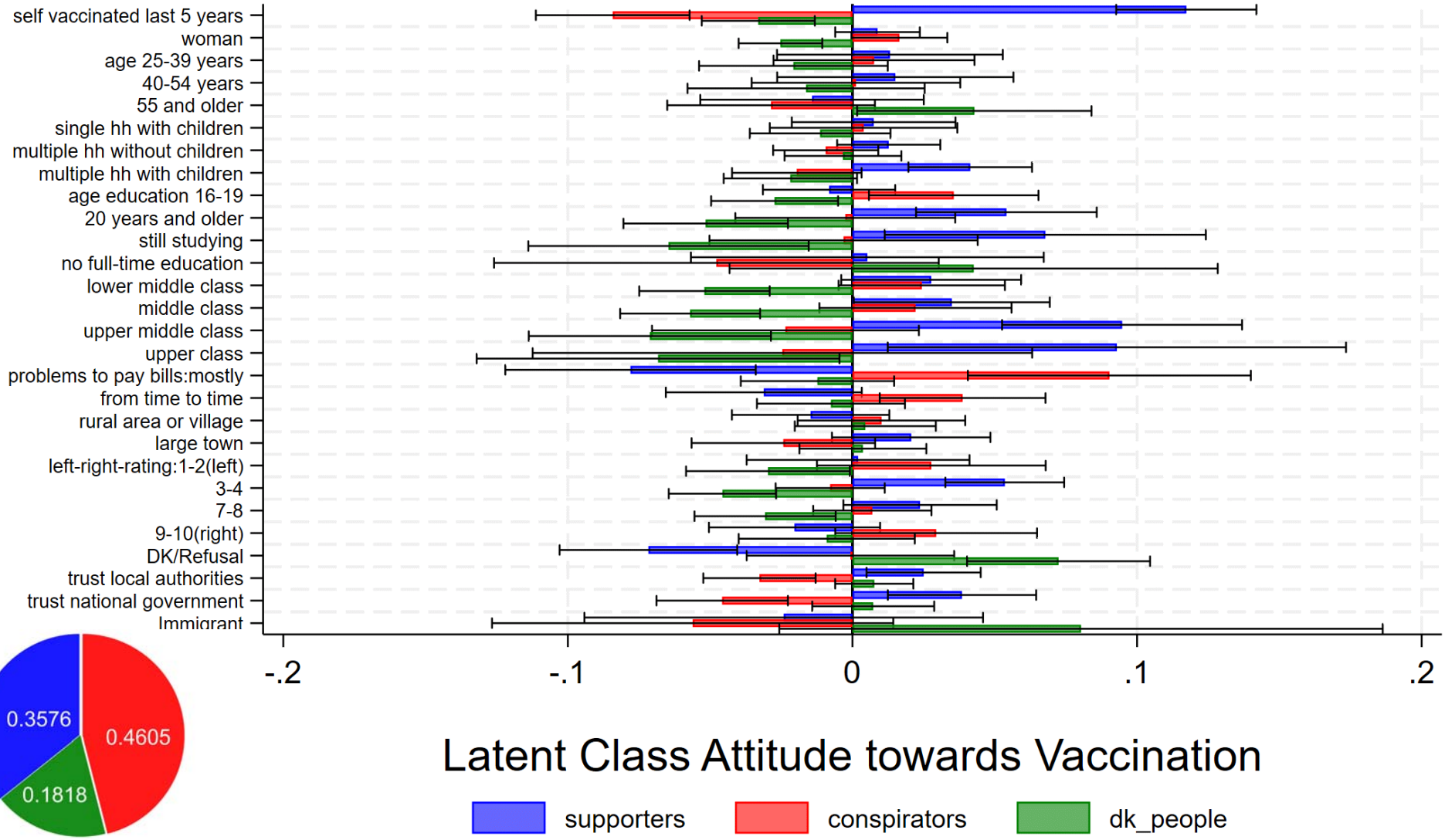
  - **Collective level of trust in national government**
  - **National vaccination rate**
  - **Economic weath measured by GDP per Capita 2019**
  - **National Poverty Rate 2019**
  - **Global Health Security Index 2019**

    - **All indicators are z-standardized: average EU-membership country is the reference context**
    - **Robust standard errors are used because of analysing clustered subsamples**

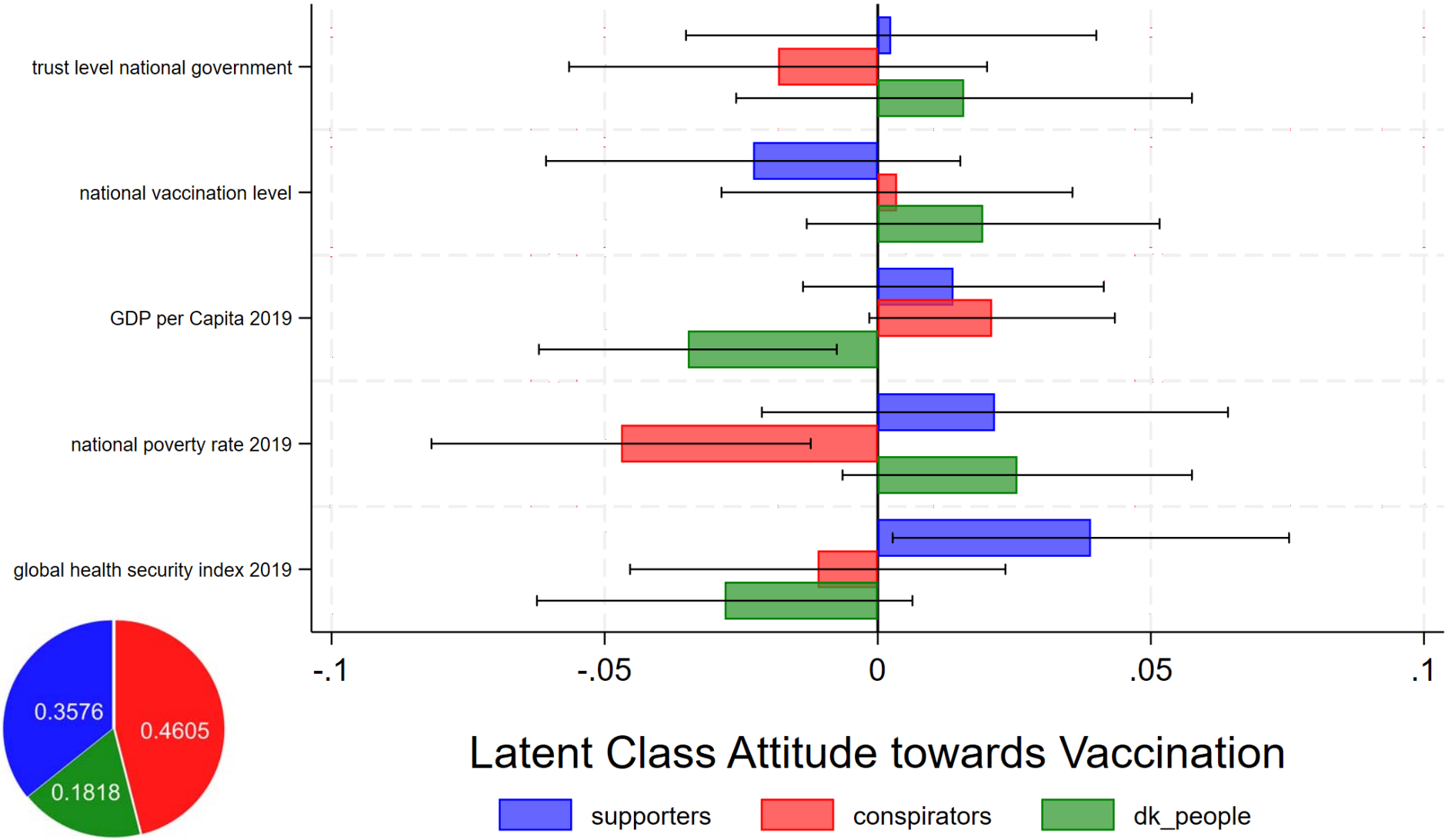
Anchoring the Multilevel LC MNL Model

- **Reference group**
  - **Single native men, under 25 years old, belonging to the working class, certificate of secondary education, without vaccination, without trust in local authorities and national government, political liberal orientation, living in a small / middle town**
- **Reference context**
  - **EU-State with average economic performance, poverty rate, trust in national government, vaccination rate and pandemic medical prevention (GHSI)**

Within-Countries MNL-regression



Between-Countries MNL-Regression



Goodness of fit

- **Global fit of the Multilevel-Multinomial-Logit model (n_{ij} = 23,723; $n_{.j}$ = 29)**
  - **Wald chi² = 536.37 D.F. = 28 p = 0.00**
  - **McKelvey & Zavoina Pseudo R² for each equation**
    - **Conspirators vs. Supporters: M&Z-R² = 0.0676**
    - **Ignorants vs. Supporters: M&Z-R² = 0.1539**
- **Fit of Between EU-Countries Regressions**
  - **Bryk & Raudenbush Level 2 PRE-R² per equation**
    - **Conspirators vs. Supporters: B&R-PRE-R² = 0.7227**
    - **DK-people vs. Supporters: B&R-PRE-R² = 0.7606**

(modification of my mzr2.ado for xtmlogit)

Results of Within-Context Regressions 1

- **Average Marginal Effects exogenous Level 1 Vars**
  - **Significant in- or decrease of ΔP(„vacc-supporters”)**
    - **Being him-/herself vaccinated last 5 years: Yes: +11.73%**
    - **Multiple household with children vs. Single: + 4.14%**
    - **End of education in age 20: +5.41 , still studying: +6.78%**
    - **Middle to higher social class: +3.49% to 9.29%**
    - **Precarious financial state (most of time): -7.80%**
    - **Location: village, large town: no effect**
    - **Political orientation: moderate left: +5.35%**
      DK Refusal: -7.17%
    - **Trust in local administration: Yes : +2.50%**
    - **Trust in national government Yes : +3.85%**
    - **Immigrants vs. Natives: no effect**

Results of Within-Context Regressions 2

- **Average Marginal Effects exogenous Level 1 Vars**
  - **Significant in- or decrease of ΔP(„conspirators")**
    - **Being him-/herself vaccinated last 5 years: - 8.42%**
    - **Women vs. men: no effect**
    - **End of education in age of 16-19 Jahren: +3.56%**
    - **Social Class: no effects**
    - **Precarious financial state most of time: +9.03%, from time to time: +3.87%**
    - **Location: no effects**
    - **Political orientation: no effects**
    - **Trust in local administration yes vs. no: - 3.27%**
    - **Trust in national government yes vs. no: - 4.58%**
    - **Immigrants vs. Natives: no effect**

Results of Within-Context Regressions 3

- **Average Marginal Effects exogenous Level 1 Vars**
  - **Significant increase or decrease of ΔP(„DK-people / Ignorants")**
    - **Being him-/herself vaccinated last 5 years yes: - 3.31%**
    - **Women vs. men: - 2.53%**
    - **Age group 55 years and older vs. lower 25: + 4.28%**
    - **End of education in age 16-19: - 2.74%, 20+: - 5.16%, still studying: - 6.46%**
    - **Social Class: lower middle: - 5.20%, middle: - 5.70%, upper middle: - 7.12%, higher class: - 6.83%**
    - **Location: no effects**
    - **Political orientation: exterme left to moderate right: - 2.97% to - 3.07%; DK/Refusal: + 7.24%**
    - **Immigrants vs. natives: no effect**

Results of Between-Context Regressions

- **Average Marginal Effects of exogenous Level 2 Variables: + 1 sd: Significant increase or decrease**
  - **Collective trust in national government**
    - **no effects**
  - **Collective vaccination rate:**
    - **no effects**
  - **Economic weath measured by GDP per Capita 2019**
    - **DK-people/Ignorants: - 3.48%**
  - **National poverty rate 2019:**
    - **Conspirators: - 4.70%**
  - **Global Health Security Index 2019**
    - **Supporters: + 3.90%**

My conclusions

- **With regard to content**
  - **Empirical proven effects of exogenous level 1 variables**
    - **On experience of vaccination**
    - **Social class and degress of education**
    - **Precarious financial state**
    - **Trust in institutions**
  - **Empirical proven effects of exogenous level 2 variables**
    - **Economic weath**
    - **National poverty rate**
    - **Quality of pandemic health prevention (GHSI)**
  - **But because of the low model fit further research is necessary!**

My conclusions 2

- **With regard to statistics and technique**
  - **Advantages of xtmlogit in Stata 19 compared to gllamm.ado written by Rabe-Hesketh et. al. (2004/22)**
    - **Estimation runs more quickly and more stable**
    - **Stata MP-Version uses more than one processor core**
    - **Even more parameters can be estimated**
    - **Estimation and test of random-effects is possible**
    - **Use of margins und coefplot.ado is supported**
  - **Disadvantage**
    - **Only Intercepts-as-Outcome Model can be estimated**
  - **Validation of results with Latent Gold 6 or MPLUS 8 is necessary**
  - **The recently published step3.ado should support fitstat, margins and coefplot.ado in a future release**

Closing words

- **Thank you for your attention**
- **Do you have some questions?**

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Appendix

Exogenous Level 2 Variables

- **Global Health Security Index (GHSI) developed by Center of Health Security, Johns Hopkins Univesity, Bloomberg School of Public Health, Baltimore**

  - **Range: [0 ; 100] for all 195 UNO-membership states**
  - **Subdimensions**
    - **Prevention of the Emergence or Release of Pathogens**
    - **Early Detection & Reporting for Epidemics of Potential International Concern**
    - **Rapid Response to and Mitigation of the Spread on an Epidemic**
    - **Sufficient & Robust Health System to Treat the Sick & Protect Health Workers**
    - **Commitments to Improving National Capacity, Financing and Adherence to Norms**
    - **Overall Risk, Environment and Country Vulernability to Biological Threats**

Multinomial Logit Model: Estimates for Modal Latent Class: Comparison
- Conspirators vs. Supporters
- DK-people vs. Supporters

Multinomial Logit model of attitude types towards vaccination (modal assignment of LC)

	Logits			
	Conspirators		DK_people	
vaccination: yes	-0.5037***	(-16.34)	-0.4873***	(-9.36)
Woman	0.0018	(0.06)	-0.2053***	(-4.25)
25 - 39 years	-0.0218	(-0.27)	-0.1610	(-1.12)
40 - 54 years	-0.0267	(-0.32)	-0.1270	(-0.89)
55 years and older	-0.0339	(-0.42)	0.2506	(1.83)
Single hh with children (10,12,14 in d7)	-0.0405	(-0.60)	-0.1088	(-0.95)
Multiple hh without children (1, 5 in d7)	-0.0435	(-1.16)	-0.0436	(-0.73)
Multiple hh with children (2-4, 6-8 in d7)	-0.1258**	(-3.03)	-0.2163**	(-3.08)
16-19	-0.0411	(-0.86)	-0.3399***	(-4.89)
20 years and older	-0.2620***	(-5.01)	-0.6597***	(-8.08)
Still Studying	-0.2710**	(-2.70)	-0.7445***	(-4.17)
No full-time education	-0.0918	(-0.52)	0.2821	(1.17)
The lower middle class of society	-0.0209	(-0.46)	-0.3612***	(-4.95)
The middle class of society	-0.0638	(-1.66)	-0.4271***	(-7.10)
The upper middle class of society	-0.3022***	(-4.41)	-0.6525***	(-4.93)
The higher class of society	-0.3006	(-1.55)	-0.6973	(-1.83)
Most of the time	0.4598***	(7.84)	0.2972***	(3.35)
From time to time	0.1946***	(5.26)	0.1220*	(2.03)
Rural area or village	0.0514	(1.47)	0.0592	(1.03)
Large town	-0.1226***	(-3.33)	-0.0398	(-0.64)
(1-2) Left	0.0593	(1.06)	-0.2324*	(-2.40)
(3-4)	-0.1191**	(-2.82)	-0.3906***	(-4.99)
(7-8)	-0.0166	(-0.38)	-0.2066**	(-2.64)
(9-10) Right	0.1140	(1.92)	-0.0233	(-0.24)
DK/Refusal	0.2134***	(4.80)	0.5375***	(8.25)
Tend to trust	-0.1720***	(-5.22)	-0.0336	(-0.61)
Tend to trust	-0.2080***	(-6.12)	-0.0697	(-1.22)
immigant	-0.0625	(-0.61)	0.4091**	(2.59)
FR - France	0.1642	(1.58)	-0.3190	(-1.70)
BE - Belgium	-0.0554	(-0.55)	-0.8988***	(-4.25)
NL - The Netherlands	-0.6718***	(-6.21)	-1.4270***	(-5.83)
IT - Italy	-0.5802***	(-5.44)	-0.5744**	(-3.11)
LU - Luxembourg	0.1166	(0.87)	0.2650	(1.24)
DK - Denmark	-0.4056***	(-3.80)	-0.8810***	(-4.14)
IE - Ireland	-0.1568	(-1.51)	-0.5969**	(-3.18)
GB-UKM - United Kingdom	-0.3646***	(-3.40)	-0.3833*	(-2.16)
GR - Greece	-0.8193***	(-7.48)	-0.6210***	(-3.45)
ES -Spain	-0.7339***	(-6.91)	-0.7140***	(-3.98)
PT - Portugal	-0.5125***	(-4.73)	-0.2490	(-1.47)
DE-E Germany East	0.0046	(0.04)	-0.3493	(-1.51)
FI - Finland	-0.1663	(-1.57)	-0.4892*	(-2.53)
SE - Sweden	-0.7916***	(-7.11)	-0.8607***	(-4.13)
AT - Austria	-0.0053	(-0.05)	-0.0975	(-0.54)
CY - Cyprus (Republic)	0.1155	(0.87)	0.4650*	(2.40)
CZ - Czech Republic	0.2801**	(2.70)	0.1942	(1.10)
EE - Estonia	-0.2038	(-1.79)	0.3696*	(2.18)
HU - Hungary	-0.4359***	(-4.19)	-1.1032***	(-5.41)
LV - Latvia	0.2734*	(2.50)	0.5195**	(3.07)
LT - Lithuania	-0.0169	(-0.16)	0.1712	(1.01)
MT - Malta	0.4412**	(3.28)	0.2264	(1.06)
PL - Poland	-0.6381***	(-5.72)	-0.3099	(-1.73)
SK - Slovakia	-0.2050	(-1.92)	0.3485*	(2.11)
SI - Slovenia	0.1734	(1.65)	-0.1008	(-0.57)
BG - Bulgaria	-0.4166***	(-3.46)	0.9691***	(5.87)
RO - Romania	-0.4018***	(-3.75)	0.0738	(0.44)
HR - Croatia	0.0537	(0.51)	-0.1687	(-0.91)
Constant	0.5660***	(4.52)	-0.4556*	(-2.22)
Wald-chi2	2757.19			
D.F.	112			
Prob	0.0000			
McFadden R2	0.0619			
adj.McF.R2	0.0568			
Observations	23723			

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Average Marginal Effects (AME) of NML

Average Marginal Effects of Multinomial Logit model of attitude types towards vaccination

	conspirators		dk-people		supporters	
vaccination: yes	-0.0850***	(-8.93)	-0.0280***	(-3.31)	0.1130***	(14.95)
Woman	0.0191*	(2.48)	-0.0294***	(-3.89)	0.0103	(1.69)
25 - 39 years	0.0094	(0.44)	-0.0213	(-1.03)	0.0119	(0.72)
40 - 54 years	0.0052	(0.24)	-0.0161	(-0.78)	0.0110	(0.65)
55 years and older	-0.0347	(-1.67)	0.0449*	(2.19)	-0.0102	(-0.62)
Single hh with children (10,12,14 in d7)	0.0001	(0.01)	-0.0123	(-0.77)	0.0122	(0.88)
Multiple hh without children (1, 5 in d7)	-0.0067	(-0.72)	-0.0024	(-0.28)	0.0091	(1.21)
Multiple hh with children (2-4, 6-8 in d7)	-0.0118	(-1.10)	-0.0201*	(-2.04)	0.0319***	(3.61)
16-19	0.0193	(1.61)	-0.0431***	(-3.92)	0.0238*	(2.45)
20 years and older	-0.0136	(-0.95)	-0.0646***	(-4.86)	0.0782***	(6.79)
Still Studying	-0.0108	(-0.41)	-0.0729**	(-3.03)	0.0836***	(3.92)
No full-time education	-0.0527	(-1.21)	0.0571	(1.35)	-0.0045	(-0.13)
The lower middle class of society	0.0260*	(2.20)	-0.0472***	(-4.30)	0.0213*	(2.20)
The middle class of society	0.0202	(1.92)	-0.0518***	(-4.99)	0.0316***	(3.80)
The upper middle class of society	-0.0241	(-1.28)	-0.0613***	(-3.57)	0.0854***	(5.45)
The higher class of society	-0.0210	(-0.42)	-0.0662	(-1.61)	0.0872*	(2.00)
Most of the time	0.0821***	(5.78)	-0.0029	(-0.23)	-0.0791***	(-7.14)
From time to time	0.0362***	(3.85)	-0.0010	(-0.11)	-0.0352***	(-4.83)
Rural area or village	0.0070	(0.79)	0.0040	(0.47)	-0.0110	(-1.58)
Large town	-0.0268**	(-2.84)	0.0056	(0.61)	0.0212**	(2.76)
(1-2) Left	0.0356*	(2.50)	-0.0377**	(-2.90)	0.0021	(0.18)
(3-4)	0.0037	(0.32)	-0.0434***	(-3.80)	0.0396***	(4.27)
(7-8)	0.0146	(1.26)	-0.0280*	(-2.55)	0.0134	(1.47)
(9-10) Right	0.0306*	(2.06)	-0.0144	(-1.06)	-0.0162	(-1.41)
DK/Refusal	-0.0076	(-0.59)	0.0677***	(5.17)	-0.0601***	(-6.76)
Tend to trust	-0.0398***	(-4.75)	0.0113	(1.36)	0.0285***	(4.05)
Tend to trust	-0.0454***	(-5.20)	0.0090	(1.03)	0.0364***	(4.85)
immigant	-0.0603*	(-2.21)	0.0777*	(2.56)	-0.0174	(-0.87)
FR - France	0.0682**	(2.59)	-0.0564*	(-2.28)	-0.0117	(-0.56)
BE - Belgium	0.0511	(1.90)	-0.0985***	(-3.89)	0.0474*	(2.18)
NL - The Netherlands	-0.0803**	(-2.73)	-0.1126***	(-4.24)	0.1929***	(7.69)
IT - Italy	-0.0979***	(-3.60)	-0.0344	(-1.35)	0.1323***	(5.63)
LU - Luxembourg	0.0013	(0.04)	0.0304	(0.89)	-0.0318	(-1.25)
DK - Denmark	-0.0369	(-1.30)	-0.0789**	(-3.03)	0.1159***	(4.88)
IE - Ireland	0.0087	(0.32)	-0.0645**	(-2.62)	0.0558*	(2.54)
GB-UKM - United Kingdom	-0.0581*	(-2.13)	-0.0240	(-0.96)	0.0821***	(3.63)
GR - Greece	-0.1521***	(-5.61)	-0.0258	(-1.02)	0.1778***	(7.27)
ES -Spain	-0.1266***	(-4.68)	-0.0427	(-1.72)	0.1693***	(7.32)
PT - Portugal	-0.1049***	(-3.90)	0.0072	(0.29)	0.0977***	(4.25)
DE-E Germany East	0.0313	(0.97)	-0.0477	(-1.61)	0.0164	(0.63)
FI - Finland	-0.0009	(-0.03)	-0.0518*	(-2.03)	0.0527*	(2.36)
SE - Sweden	-0.1325***	(-4.59)	-0.0570*	(-2.11)	0.1895***	(7.56)
AT - Austria	0.0078	(0.29)	-0.0139	(-0.54)	0.0060	(0.28)
CY - Cyprus (Republic)	-0.0228	(-0.71)	0.0665*	(2.10)	-0.0437	(-1.76)
CZ - Czech Republic	0.0496	(1.87)	0.0010	(0.04)	-0.0507*	(-2.54)
EE - Estonia	-0.0905**	(-3.19)	0.0868**	(2.98)	0.0036	(0.16)
HU - Hungary	-0.0339	(-1.22)	-0.0972***	(-3.86)	0.1311***	(5.65)
LV - Latvia	0.0097	(0.35)	0.0566*	(2.08)	-0.0663**	(-3.26)
LT - Lithuania	-0.0217	(-0.80)	0.0292	(1.13)	-0.0075	(-0.35)
MT - Malta	0.0853**	(2.65)	-0.0113	(-0.38)	-0.0739**	(-3.06)
PL - Poland	-0.1303***	(-4.72)	0.0074	(0.28)	0.1229***	(5.02)
SK - Slovakia	-0.0883**	(-3.27)	0.0828**	(2.98)	0.0055	(0.25)
SI - Slovenia	0.0523*	(2.00)	-0.0305	(-1.25)	-0.0219	(-1.06)
BG - Bulgaria	-0.2157***	(-7.66)	0.2493***	(7.47)	-0.0336	(-1.37)
RO - Romania	-0.1068***	(-4.02)	0.0518	(1.92)	0.0550*	(2.42)
HR - Croatia	0.0288	(1.08)	-0.0289	(-1.14)	0.0001	(0.01)
Observations	23723		23723		23723	

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Step 3 ML Logit estimates of MNL of attitude types towards vaccination

	1.mlclass		2.mlclass	
vaccination: yes	-0.6427***	(-16.04)	-0.5719***	(-9.47)
Woman	0.0075	(0.20)	-0.2447***	(-4.33)
25 - 39 years	-0.0332	(-0.31)	-0.1701	(-1.04)
40 - 54 years	-0.0403	(-0.37)	-0.1399	(-0.86)
55 years and older	-0.0533	(-0.51)	0.2917	(1.86)
Single hh with children (10,12,14 i	-0.0487	(-0.56)	-0.1053	(-0.79)
Multiple hh without children (1, 5	-0.0548	(-1.13)	-0.0433	(-0.63)
Multiple hh with children (2-4, 6-8	-0.1575**	(-2.94)	-0.2420**	(-2.97)
16-19	-0.0448	(-0.72)	-0.3812***	(-4.91)
20 years and older	-0.3222***	(-4.63)	-0.7610***	(-8.33)
Still Studying	-0.3482**	(-2.62)	-0.8245***	(-4.13)
No full-time education	-0.1310	(-0.52)	0.3486	(1.25)
The lower middle class of society	-0.0157	(-0.27)	-0.4038***	(-4.77)
The middle class of society	-0.0648	(-1.30)	-0.4812***	(-6.93)
The upper middle class of society	-0.3952***	(-4.20)	-0.7500***	(-4.57)
The higher class of society	-0.3520	(-1.38)	-0.7535	(-1.71)
Most of the time	0.5941***	(7.83)	0.3592***	(3.54)
From time to time	0.2445***	(5.15)	0.1457*	(2.08)
Rural area or village	0.0660	(1.47)	0.0740	(1.11)
Large town	-0.1566**	(-3.25)	-0.0420	(-0.59)
(1-2) Left	0.0879	(1.24)	-0.2764*	(-2.46)
(3-4)	-0.1356*	(-2.49)	-0.4595***	(-4.91)
(7-8)	-0.0238	(-0.41)	-0.2345*	(-2.55)
(9-10) Right	0.1522*	(1.97)	-0.0260	(-0.23)
DK/Refusal	0.2662***	(4.67)	0.6067***	(8.09)
Tend to trust	-0.2153***	(-5.07)	-0.0366	(-0.58)
Tend to trust	-0.2716***	(-6.16)	-0.0789	(-1.19)
immigant	-0.0951	(-0.70)	0.4511*	(2.41)
FR - France	0.1996	(1.57)	-0.3694	(-1.69)
BE - Belgium	-0.0602	(-0.47)	-1.0749***	(-4.01)
NL - The Netherlands	-0.8522***	(-5.94)	-1.8017***	(-4.96)
IT - Italy	-0.7471***	(-5.42)	-0.6553**	(-3.13)
LU - Luxembourg	0.1422	(0.81)	0.3030	(1.18)
DK - Denmark	-0.5404***	(-3.77)	-1.0714***	(-3.86)
IE - Ireland	-0.1969	(-1.48)	-0.7001**	(-3.16)
GB-UKM - United Kingdom	-0.4634***	(-3.36)	-0.4403*	(-2.15)
GR - Greece	-1.0565***	(-7.43)	-0.7302***	(-3.55)
ES -Spain	-0.9484***	(-6.79)	-0.8170***	(-3.99)
PT - Portugal	-0.6796***	(-4.67)	-0.3022	(-1.56)
DE-E Germany East	0.0026	(0.02)	-0.3842	(-1.43)
FI - Finland	-0.2151	(-1.56)	-0.6060*	(-2.55)
SE - Sweden	-1.0460***	(-6.71)	-1.0010***	(-3.87)
AT - Austria	-0.0059	(-0.04)	-0.1397	(-0.65)
CY - Cyprus (Republic)	0.1177	(0.69)	0.5307*	(2.40)
CZ - Czech Republic	0.3448**	(2.60)	0.2329	(1.13)
EE - Estonia	-0.2778	(-1.95)	0.4015*	(2.07)
HU - Hungary	-0.5390***	(-4.14)	-1.3205***	(-5.18)
LV - Latvia	0.3319*	(2.40)	0.6075**	(3.13)
LT - Lithuania	-0.0340	(-0.25)	0.1938	(0.98)
MT - Malta	0.5380**	(3.11)	0.2860	(1.19)
PL - Poland	-0.8345***	(-5.66)	-0.3781	(-1.82)
SK - Slovakia	-0.2786*	(-2.04)	0.3799*	(2.02)
SI - Slovenia	0.2168	(1.66)	-0.1027	(-0.49)
BG - Bulgaria	-0.5824***	(-3.64)	1.0424***	(5.46)
RO - Romania	-0.5324***	(-3.89)	0.0642	(0.33)
HR - Croatia	0.0374	(0.28)	-0.1896	(-0.88)
Constant	0.6476***	(3.97)	-0.2829	(-1.21)
Wald-chi2				
D.F.				
Prob				
McFadden R2				
adj.McF.R2				
Observations	23723			

t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001

Step3 ML approach: Logit-estimates

Class composition (%) before and after Step 3

Class	Step 1	Step 3	Change
1	36.14	36.93	0.79
2	12.69	10.37	-2.32
3	51.17	52.70	1.53

Observations in Step 1 class moved to a different class in Step 3

n	%
2264	8

Note: results might be inconsistent for % > 20

- **Using step3.ado (2026), default option <<ml>>**
- **No support of**
  - **Stata margins and marginsplot**
  - **Scott Long's fitstat.ado**
  - **Ben Jann's coefplot.ado**

Step 3 BCH Logit estimates of MNL of attitude types towards vaccination

	1.bchclass		2.bchclass	
vaccination: yes	-0.6467***	(-16.06)	-0.5699***	(-9.43)
Woman	0.0060	(0.16)	-0.2389***	(-4.23)
25 - 39 years	-0.0259	(-0.24)	-0.1911	(-1.17)
40 - 54 years	-0.0335	(-0.31)	-0.1511	(-0.93)
55 years and older	-0.0485	(-0.46)	0.2846	(1.83)
Single hh with children (10,12,14 i	-0.0536	(-0.61)	-0.1273	(-0.95)
Multiple hh without children (1, 5	-0.0565	(-1.17)	-0.0521	(-0.76)
Multiple hh with children (2-4, 6-8	-0.1603**	(-2.99)	-0.2552**	(-3.13)
16-19	-0.0462	(-0.75)	-0.3826***	(-4.92)
20 years and older	-0.3269***	(-4.76)	-0.7586***	(-8.30)
Still Studying	-0.3355*	(-2.55)	-0.8628***	(-4.25)
No full-time education	-0.1244	(-0.52)	0.3286	(1.18)
The lower middle class of society	-0.0186	(-0.32)	-0.4071***	(-4.84)
The middle class of society	-0.0721	(-1.45)	-0.4847***	(-7.01)
The upper middle class of society	-0.4051***	(-4.28)	-0.7682***	(-4.67)
The higher class of society	-0.3995	(-1.49)	-0.8142	(-1.77)
Most of the time	0.5823***	(7.72)	0.3587***	(3.53)
From time to time	0.2459***	(5.20)	0.1452*	(2.08)
Rural area or village	0.0657	(1.46)	0.0699	(1.05)
Large town	-0.1592***	(-3.30)	-0.0483	(-0.68)
(1-2) Left	0.0817	(1.14)	-0.2723*	(-2.42)
(3-4)	-0.1516**	(-2.74)	-0.4656***	(-4.97)
(7-8)	-0.0166	(-0.29)	-0.2396**	(-2.60)
(9-10) Right	0.1502	(1.96)	-0.0231	(-0.20)
DK/Refusal	0.2609***	(4.58)	0.6098***	(8.16)
Tend to trust	-0.2217***	(-5.22)	-0.0445	(-0.70)
Tend to trust	-0.2722***	(-6.14)	-0.0874	(-1.32)
immigant	-0.0901	(-0.67)	0.4687*	(2.54)
FR - France	0.2034	(1.58)	-0.3751	(-1.71)
BE - Belgium	-0.0662	(-0.52)	-1.1165***	(-4.08)
NL - The Netherlands	-0.8876***	(-6.01)	-1.8164***	(-4.99)
IT - Italy	-0.7436***	(-5.39)	-0.6778**	(-3.20)
LU - Luxembourg	0.1497	(0.86)	0.3058	(1.22)
DK - Denmark	-0.5203***	(-3.66)	-1.0641***	(-3.91)
IE - Ireland	-0.1971	(-1.49)	-0.7010**	(-3.19)
GB-UKM - United Kingdom	-0.4676***	(-3.38)	-0.4499*	(-2.21)
GR - Greece	-1.0549***	(-7.38)	-0.7395***	(-3.59)
ES -Spain	-0.9453***	(-6.77)	-0.8367***	(-4.07)
PT - Portugal	-0.6634***	(-4.64)	-0.3058	(-1.59)
DE-E Germany East	0.0104	(0.06)	-0.4072	(-1.50)
FI - Finland	-0.2064	(-1.50)	-0.5729*	(-2.49)
SE - Sweden	-1.1127***	(-6.80)	-1.0186***	(-3.96)
AT - Austria	-0.0084	(-0.06)	-0.1164	(-0.55)
CY - Cyprus (Republic)	0.1266	(0.75)	0.5227*	(2.36)
CZ - Czech Republic	0.3417**	(2.59)	0.2298	(1.12)
EE - Estonia	-0.2815	(-1.94)	0.3961*	(2.05)
HU - Hungary	-0.5495***	(-4.18)	-1.3205***	(-5.22)
LV - Latvia	0.3309*	(2.38)	0.5971**	(3.08)
LT - Lithuania	-0.0362	(-0.26)	0.1854	(0.95)
MT - Malta	0.5488**	(3.20)	0.2754	(1.13)
PL - Poland	-0.8259***	(-5.65)	-0.3765	(-1.82)
SK - Slovakia	-0.2806*	(-2.05)	0.3753*	(2.00)
SI - Slovenia	0.2063	(1.56)	-0.1099	(-0.53)
BG - Bulgaria	-0.5884***	(-3.69)	1.0396***	(5.47)
RO - Romania	-0.5278***	(-3.85)	0.0610	(0.31)
HR - Croatia	0.0482	(0.36)	-0.2013	(-0.93)
Constant	0.6601***	(4.09)	-0.2474	(-1.07)
Wald-chi2				
D.F.				
Prob				
McFadden R2				
adj.McF.R2				
Observations	23723			

t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001

Step3 BCH approach: Logit-estimates

- **Using step3.ado (2026) , option <<bch>>**
- **No support of**
  - **Stata margins and marginsplot**
  - **Scott Long's fitstat.ado**
  - **Stata margins command**
  - **Ben Jann's coefplot.ado**

Multilevel Multinomial Logit Model: xtmlogit

Logit coefficients of XTMLOGIT Multilevel Logit model of latent classes towards vaccination

	Latent class Conspirators		DK_people		/R .E.	
self vaccinated yes	-0.4944***	(-8.01)	-0.4923***	(-6.45)		
Woman	0.0125	(0.35)	-0.1798**	(-3.13)		
25 - 39 years	-0.0191	(-0.22)	-0.1620	(-1.19)		
40 - 54 years	-0.0385	(-0.45)	-0.1388	(-0.84)		
55 years and older	-0.0263	(-0.31)	0.2614	(1.67)		
Single hh with children (10,12,14 in d7)	-0.0118	(-0.16)	-0.0876	(-0.94)		
Multiple hh without children (1, 5 in d7)	-0.0566	(-1.47)	-0.0543	(-0.70)		
Multiple hh with children (2-4, 6-8 in d7)	-0.1549***	(-3.39)	-0.2423**	(-2.65)		
16-19	0.1013	(1.63)	-0.1458*	(-1.98)		
20 years and older	-0.1467	(-1.82)	-0.4861***	(-4.46)		
Still Studying	-0.1808	(-1.59)	-0.6275**	(-2.77)		
No full-time education	-0.1289	(-0.88)	0.2052	(0.79)		
The lower middle class of society	-0.0207	(-0.30)	-0.4232***	(-4.22)		
The middle class of society	-0.0441	(-0.57)	-0.4824***	(-5.54)		
The upper middle class of society	-0.2901**	(-3.10)	-0.7481***	(-4.30)		
The higher class of society	-0.2886	(-1.57)	-0.7175*	(-2.24)		
Most of the time	0.4342***	(3.60)	0.1735	(1.58)		
From time to time	0.1758*	(2.29)	0.0471	(0.42)		
Rural area or village	0.0649	(0.96)	0.0676	(0.72)		
Large town	-0.1128	(-1.60)	-0.0355	(-0.44)		
(1-2) Left	0.0557	(0.60)	-0.1904	(-1.51)		
(3-4)	-0.1575***	(-3.78)	-0.4393***	(-5.10)		
(7-8)	-0.0486	(-0.92)	-0.2562*	(-2.26)		
(9-10) Right	0.1235	(1.66)	0.0057	(0.05)		
DK/Refusal	0.2224**	(2.60)	0.5751***	(5.69)		
Tend to trust	-0.1446**	(-3.04)	-0.0247	(-0.46)		
Tend to trust	-0.2116***	(-3.54)	-0.0614	(-0.73)		
immigant	-0.0656	(-0.48)	0.4533	(1.53)		
(mean) trustngov (standardized)	-0.0483	(-0.60)	0.0836	(0.54)		
(mean) vaccination (standardized)	0.0719	(0.90)	0.1742	(1.25)		
GDP per capita in PPS 2019 (standardized)	0.0088	(0.16)	-0.2377*	(-2.17)		
severe material deprivation rate 2019 (standardize	-0.1668	(-1.82)	0.0861	(0.63)		
Global Health Security Index 2019 (standardized)	-0.1342	(-1.72)	-0.2696*	(-1.99)		
var(u1)					0.1042	(1.38)
var(u2)					0.2197	(1.10)
Constant	0.2491*	(1.99)	-0.7434***	(-3.75)		
N_g	29					
Observations	23723					

t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001

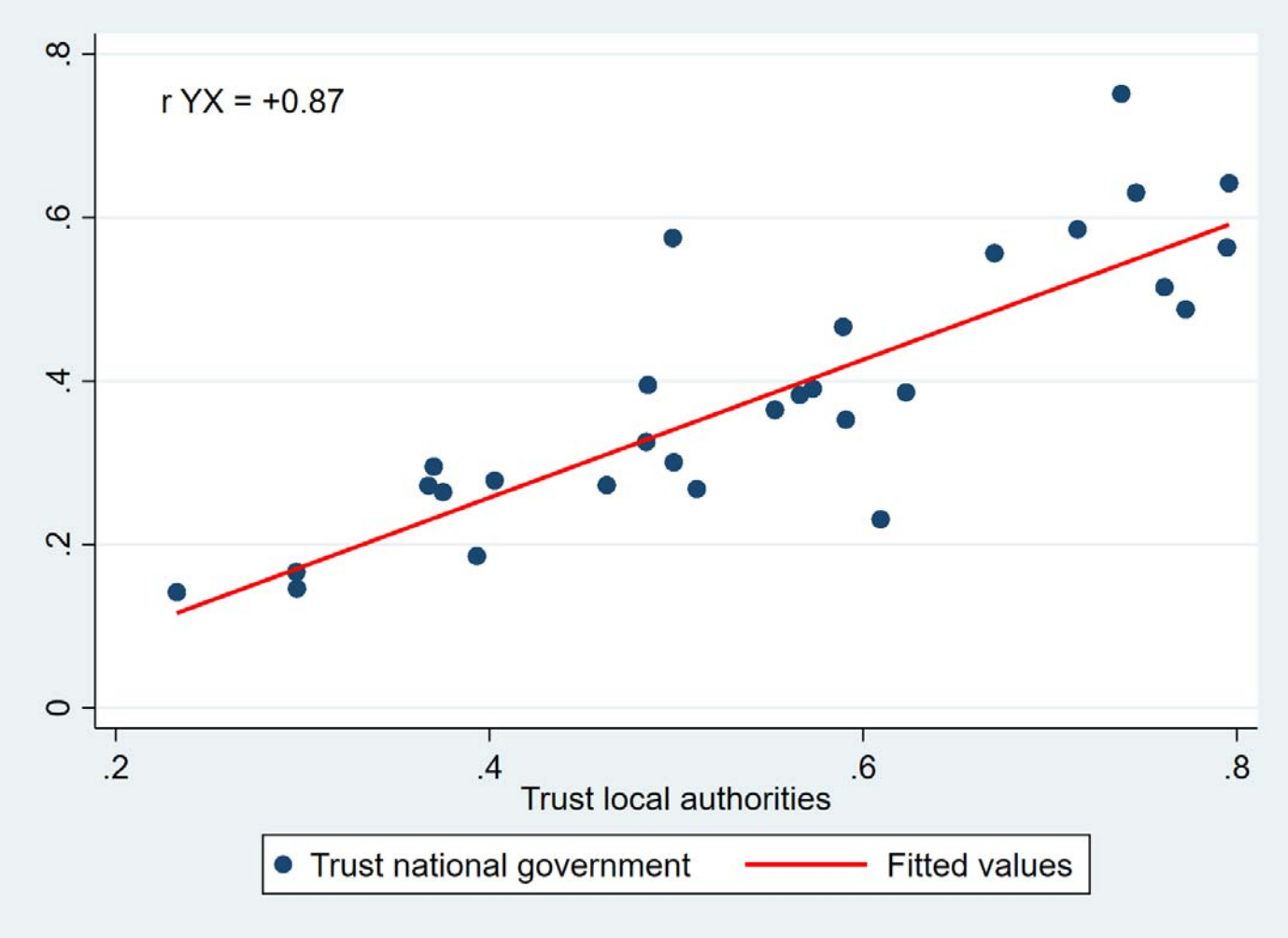
Average Marginal Effects (AME) des Multilevel MNL xtmlogit

Average Marginal Effects of XTMLOGIT Multilevel Logit model of attitude groups towards vaccination

	conspirators		dk_people		supporters	
self vaccinated yes	-0.0842***	(-6.11)	-0.0331**	(-3.26)	0.1173***	(9.34)
Woman	0.0165	(1.92)	-0.0253***	(-3.37)	0.0088	(1.16)
Age 25 - 39 years	0.0076	(0.42)	-0.0207	(-1.23)	0.0132	(0.65)
40 - 54 years	0.0012	(0.07)	-0.0163	(-0.77)	0.0151	(0.71)
55 years and older	-0.0286	(-1.54)	0.0428*	(2.04)	-0.0142	(-0.71)
Single hh with children (10,12,14 in d7)	0.0039	(0.23)	-0.0114	(-0.90)	0.0074	(0.51)
Multiple hh without children (1, 5 in d7)	-0.0094	(-1.00)	-0.0033	(-0.32)	0.0127	(1.38)
Multiple hh with children (2-4, 6-8 in d7)	-0.0196	(-1.68)	-0.0218	(-1.83)	0.0414***	(3.73)
End of education at age 16-19	0.0356*	(2.34)	-0.0274*	(-2.40)	-0.0082	(-0.69)
20 years and older	-0.0025	(-0.13)	-0.0516***	(-3.50)	0.0541***	(3.34)
Still Studying	-0.0031	(-0.13)	-0.0646*	(-2.57)	0.0678*	(2.35)
No full-time education	-0.0478	(-1.20)	0.0426	(0.97)	0.0052	(0.17)
The lower middle class of society	0.0243	(1.63)	-0.0520***	(-4.45)	0.0277	(1.72)
The middle class of society	0.0221	(1.28)	-0.0570***	(-4.55)	0.0349*	(1.99)
The upper middle class of society	-0.0235	(-0.98)	-0.0712**	(-3.28)	0.0947***	(4.40)
The higher class of society	-0.0246	(-0.55)	-0.0683*	(-2.10)	0.0929*	(2.26)
Most of the time	0.0903***	(3.56)	-0.0123	(-0.89)	-0.0780***	(-3.47)
From time to time	0.0387**	(2.60)	-0.0076	(-0.57)	-0.0312	(-1.77)
Rural area or village	0.0102	(0.68)	0.0045	(0.36)	-0.0147	(-1.04)
Large town	-0.0243	(-1.48)	0.0037	(0.32)	0.0206	(1.45)
Left-right-Self rating (1-2) Left	0.0277	(1.35)	-0.0297*	(-2.02)	0.0020	(0.10)
(3-4)	-0.0078	(-0.80)	-0.0457***	(-4.75)	0.0535***	(5.03)
(7-8)	0.0070	(0.66)	-0.0307*	(-2.43)	0.0237	(1.73)
(9-10) Right	0.0294	(1.63)	-0.0090	(-0.57)	-0.0204	(-1.33)
DK/Refusal	-0.0007	(-0.04)	0.0724***	(4.41)	-0.0717***	(-4.50)
Tend to trust local administration	-0.0327**	(-3.25)	0.0077	(1.09)	0.0250*	(2.45)
Tend to trust national government	-0.0458***	(-3.89)	0.0073	(0.67)	0.0385**	(2.89)
immigant vs. native	-0.0561	(-1.56)	0.0803	(1.48)	-0.0242	(-0.68)
(mean) trustngov (standardized)	-0.0182	(-0.93)	0.0158	(0.74)	0.0024	(0.13)
(mean) vaccination (standardized)	0.0035	(0.21)	0.0193	(1.17)	-0.0228	(-1.18)
GDP per capita in PPS 2019 (standardized)	0.0209	(1.82)	-0.0348*	(-2.50)	0.0138	(0.99)
severe material deprivation rate 2019 (standardized)	-0.0470**	(-2.65)	0.0255	(1.57)	0.0215	(0.99)
Global Health Security Index 2019 (standardized)	-0.0110	(-0.63)	-0.0280	(-1.60)	0.0390*	(2.11)
N_g						
Observations	23723		23723		23723	

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Scatterplot Trust in local authorities and national government for EU-states 2019



Step 1 and 2: Graphical representation

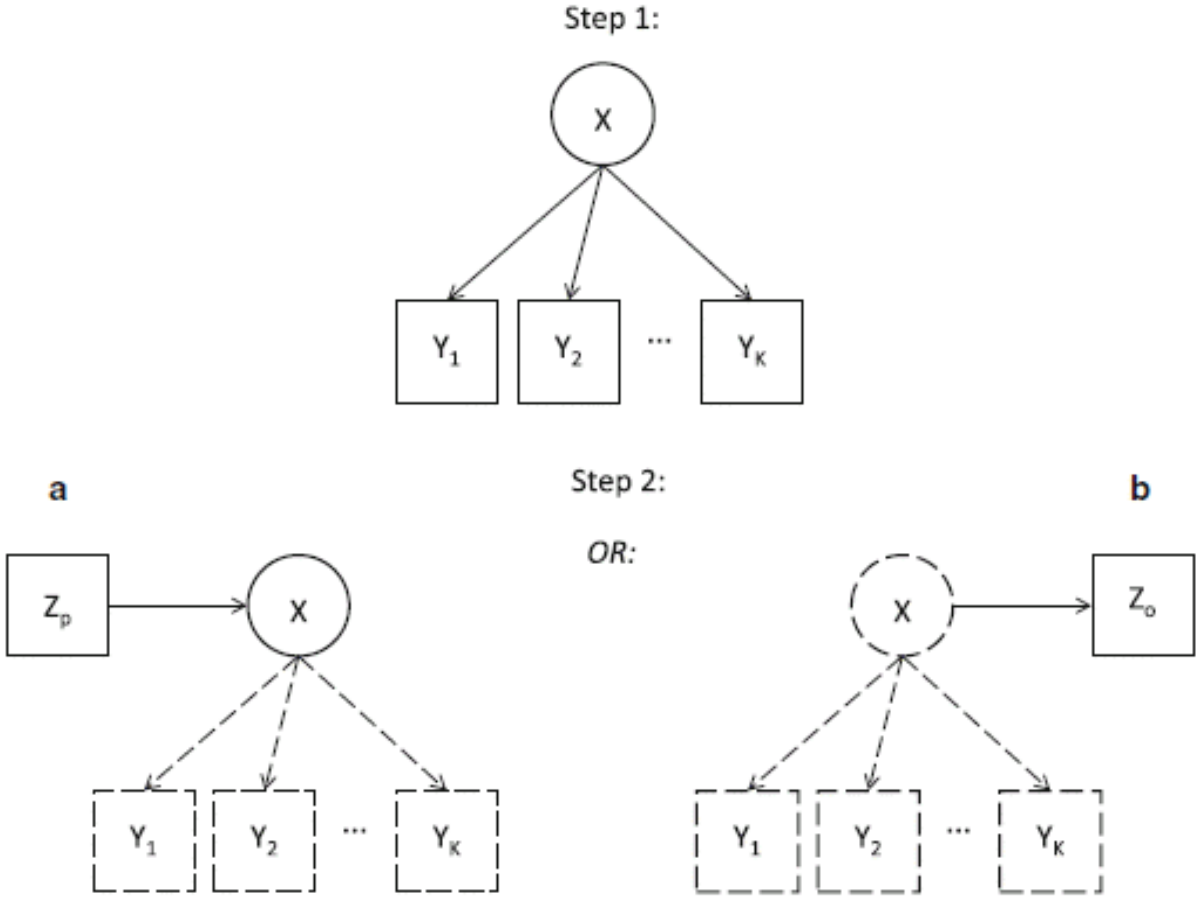


FIGURE 1.

Graphical representation of the two-step method of latent class analysis with latent class variable X measured by indicators $Y_1, Y_2, \ldots, Y_K$. Two specific structural models are represented, **a** with only covariates Z_p for X and **b** with only response variables Z_o for it. In step 2, the dashed lines represent those parts of the model which are held fixed at their estimates from step 1.

X: latent class
Y_k: discrete indikator
Z_p: exogenous covariate (predictor)
Z_o: endogenous variable (distal outcome)

(Bakk & Kuha 2018, p.877)