Spatially weighted context data with the R package spacom:
Studying the indirect impact of war on well being of young adults in ex-Yugoslavia

Sandra Penic

The team

- Coordinated by Guy Elcheroth

- Rachel Fasel
- Francesco Giudici
- Stephanie Glaeser
- Dominique Joye
- Jean-Marie Le Goff
- Davide Morselli
- Dario Spini
- Mathieu Cossutta
- Till Junge

Spatially weighted context data approach

- A novel approach to contextual data analysis
- It complements multilevel analysis, by allowing to account for the spatial dimension of the studied phenomena
- Why should we account for the space in multilevel models (applied to geographically stratified data)?
- How should we account for it?

Outline

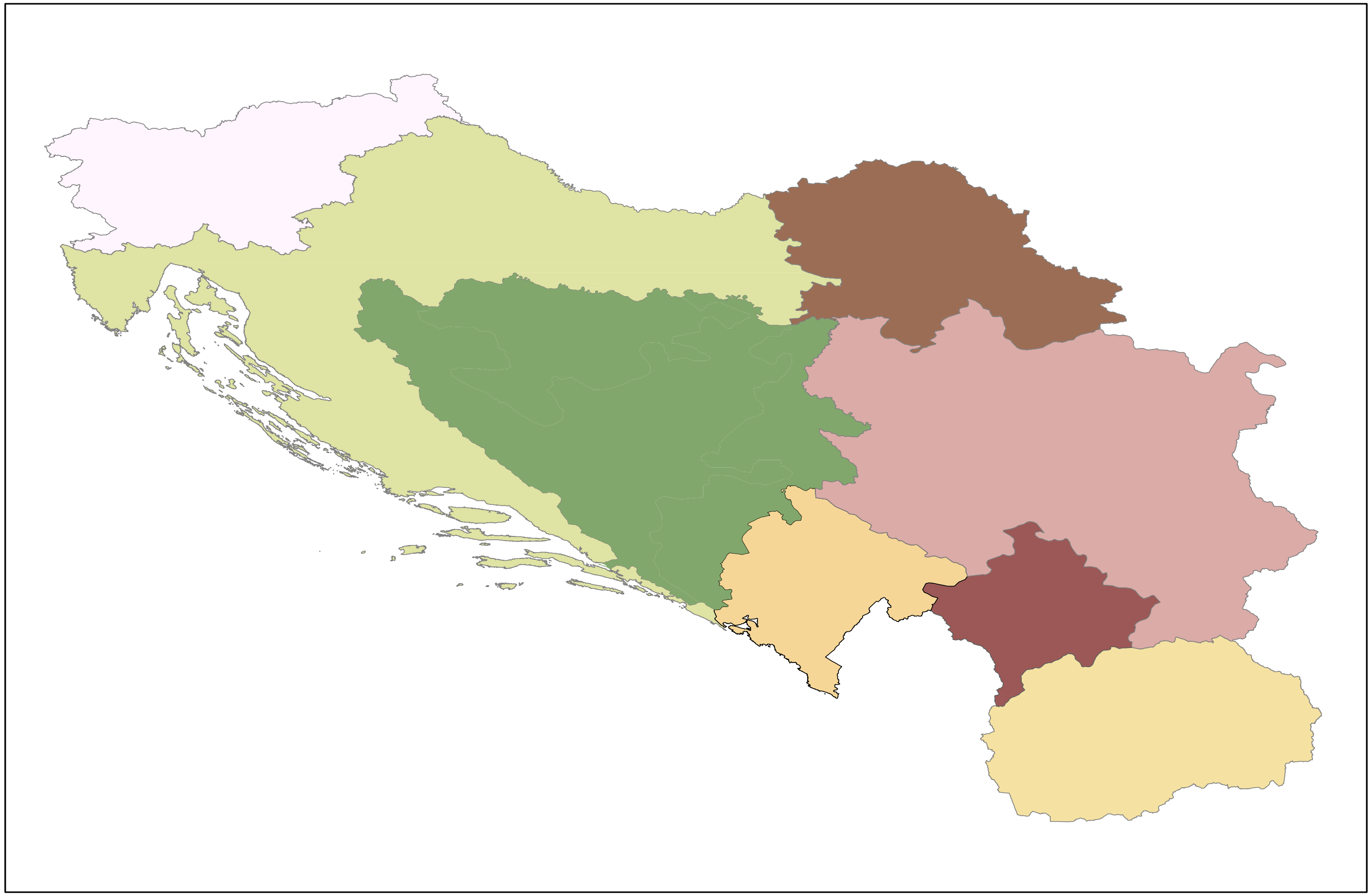
- TRACES project
- MLA: experiences of war and well-being
- Spatially weighted context data approach: 4 steps of analysis
- Spacom
- Extensions
- Conclusion

TRACES project

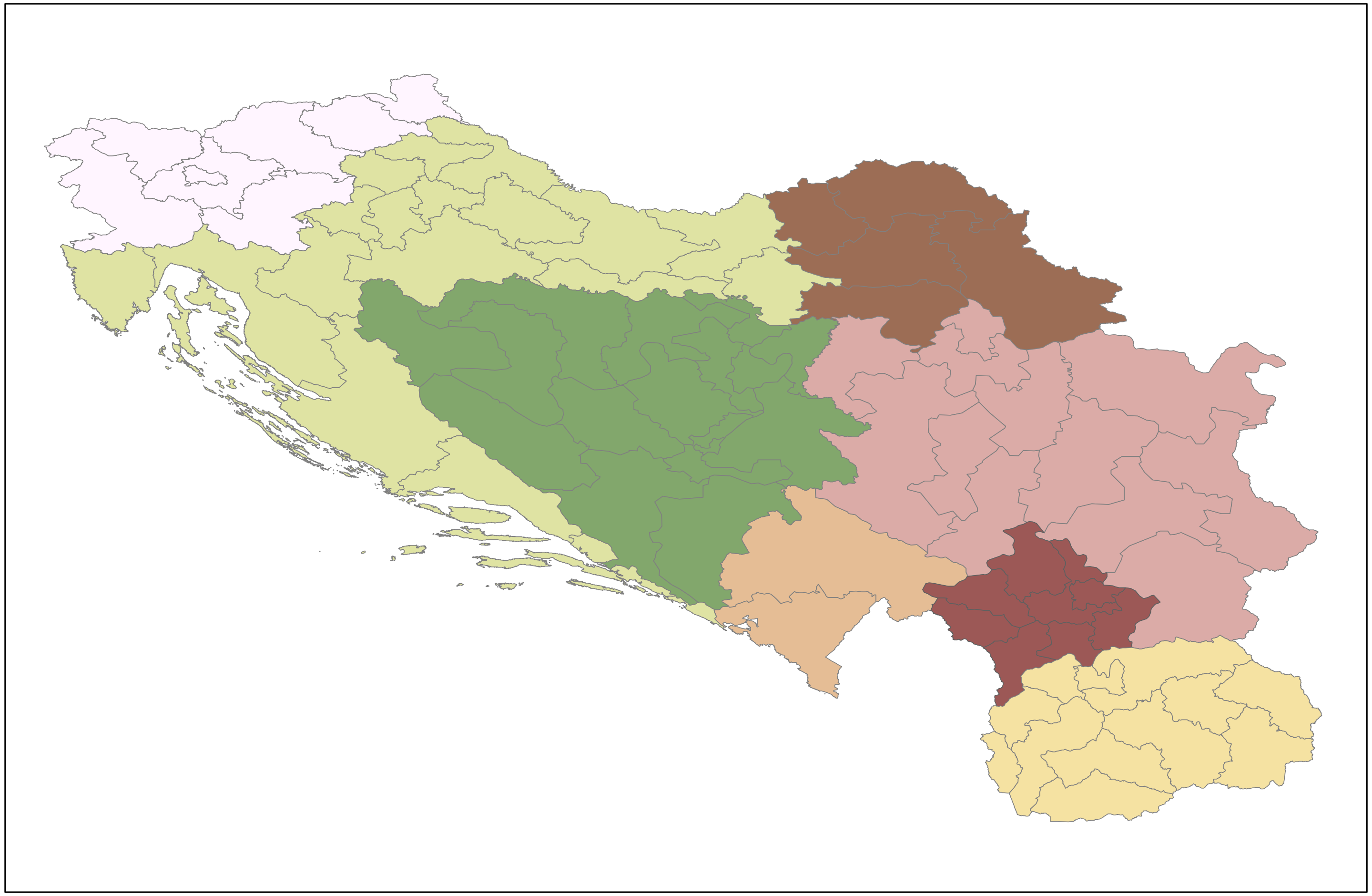
- **TRACES** (acronym for Transition to Adulthood and Collective Experiences Survey) - a scientific project conducted in former Yugoslavia in 2006 with the ambition to collect information on the collective experiences of young adults' vulnerability in the beginning of the nineties.
- The general hypothesis is that collective experiences of vulnerability, be they due to armed conflicts or economic penury, shape social representations and attitudes related to societal issues like rights, justice or intergroup relationships.
- Regionally stratified sample design covering all area of former Yugoslavia

Former Yugoslavia in 2006

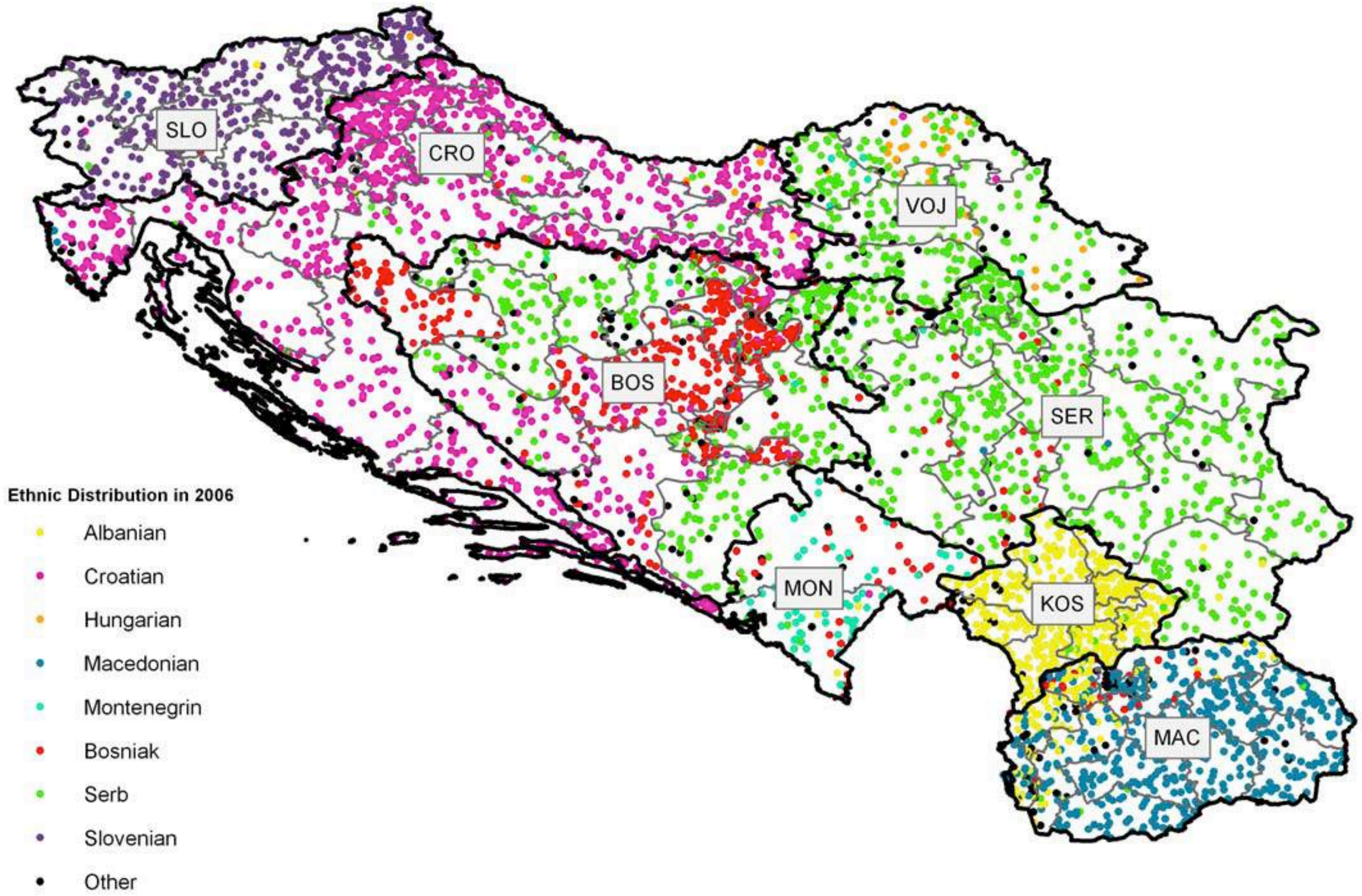
Political entities in 2006



80 TRACES areas



Geographically stratified sampling



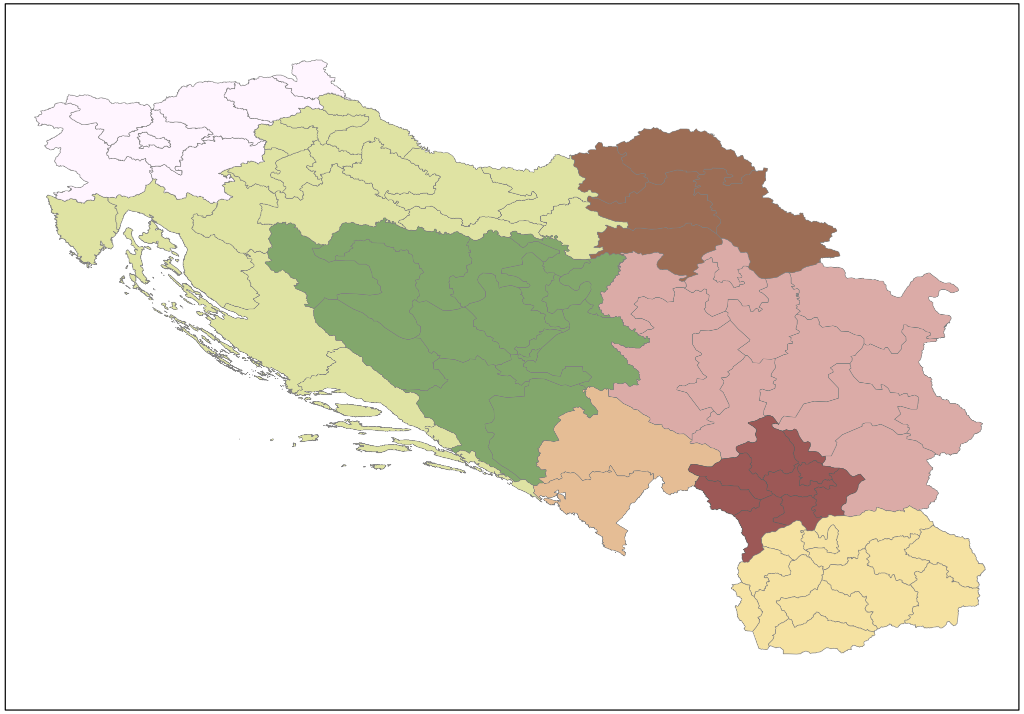
Sampling strategy

General adult population sample

- a random selection of 50 respondents belonging to the general adult population (born in 1981 or earlier) in each area
-Construction of contextual indicators
- N = 3975

Cohort sample

- a random selection of 30 residents born between 1968 and 1974 within each area
- N = 2254



Life events calendars

CALENDAR B
Bosnia-Herzegovina

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Year
Quarter	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	Quarter
Age																		Age
Marker event (optional)			*Beginning of war in BiH*			*Dayton Agreement*												Marker event (optional)
Date of event			×			×												Date of event
Area (Code)																		Area (Code)
Location																		Location
Area (Code)																		Area (Code)
Why did you move? Family																		Family Why did you move?
Economic																		Economic
War																		War
Other																		Other
Lack of resources																		Lack of resources
Homeless																		Homeless
Unemployed																		Unemployed
Separated from important people																		Separated from important people
Arbitrary treatment																		Arbitrary treatment
Discrimination																		Discrimination
Not allowed to express opinion																		Not allowed to express opinion
Exposed to threats																		Exposed to threats
Forced to leave home																		Forced to leave home
Imprisoned or kidnapped																		Imprisoned or kidnapped
Member of family killed																		Member of family killed
Damage to property																		Damage to property
Wounded by the fighting																		Wounded by the fighting
House looted																		House looted
Carrying a weapon																		Carrying a weapon
Using a weapon																		Using a weapon
Quarter	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	Quarter
	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	January, February, March / April, May, June / July, August, September / October, November, December	
Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Year

When?

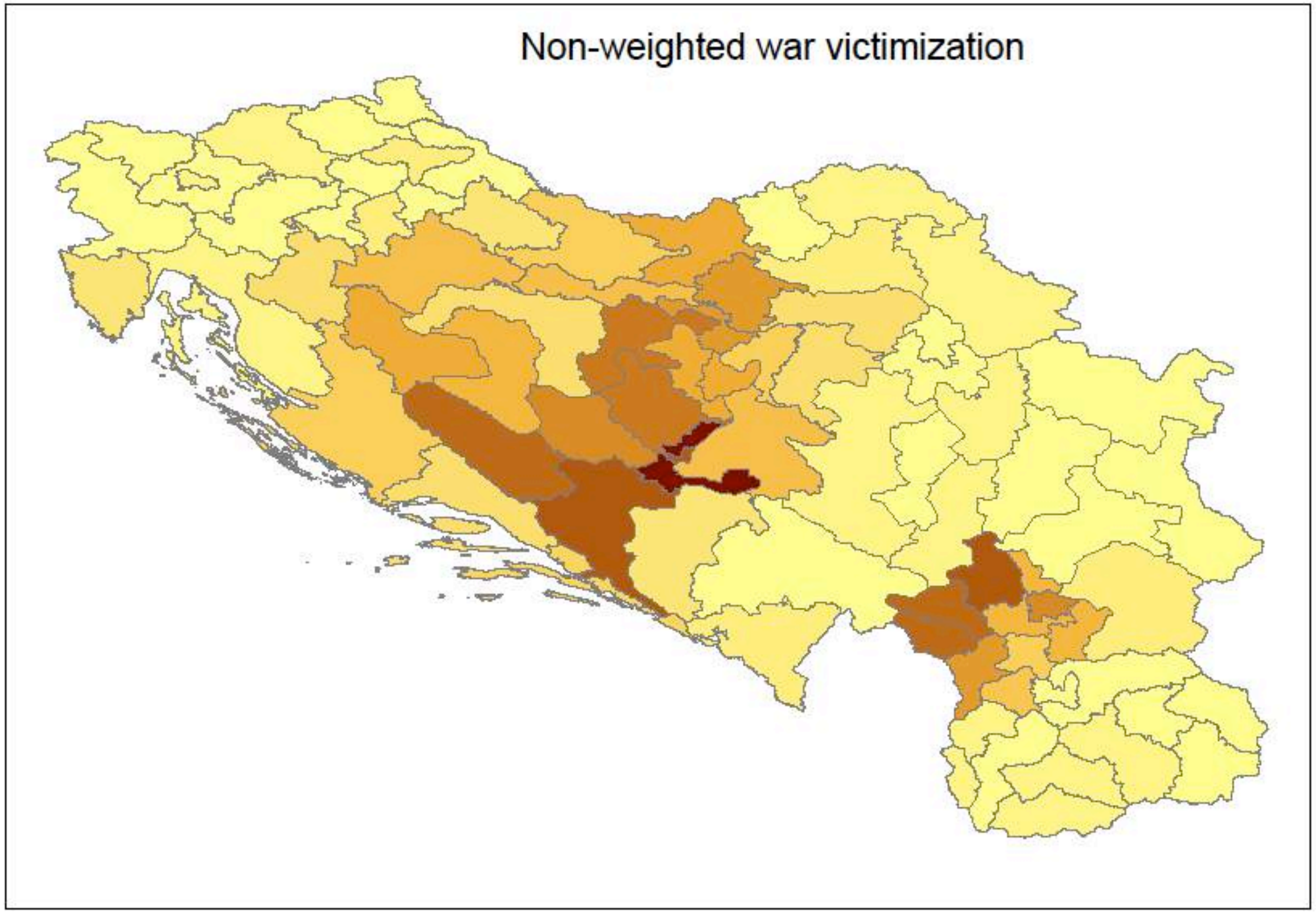
Where?

Risk of war victmization

- Life events calendars
- 6 events: forced to leave home, imprisoned, family member killed, damaged property, wounded, house looted

$$Risk_i = \frac{n_i^{events}}{indiv \times time_i}$$

Non-weighted risk of war victimization



Life satisfaction and war victimization – Standard multilevel analysis

- How does war trauma impact on individual well-being ?
- MLA – allows disentagling individual (composition) and contextual effects
- How individual and collective exposure to war impacts individuals' well-being?

Multilevel analysis

$$Y_{ij} = \beta_{0j} + \beta_{1j}X_1 + \ldots + \beta_{nj}X_n + \underline{e_{ij}}$$

Multilevel analysis

$$Y_{ij} = \underline{\beta_{0j}} + \beta_{1j} X_1 + \ldots + \beta_{nj} X_n + \underline{e_{ij}}$$

$$\beta_{0j} = \gamma_{00} + \underline{u_{0j}}$$

Multilevel analysis

$$Y_{ij} = \underline{\beta_{0j}} + \beta_{1j}X_1 + \ldots + \beta_{nj}X_n + \underline{e_{ij}}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01}Z_j + \underline{u_{0j}}$$

Multilevel analysis

$$LIFE\_SAT_{ij} = \underline{\beta_{0j}} + \beta_{1j}WAR\_VICTIM + \beta_{2j}COMB$$

$$+\beta_{3j}GENDER + \beta_{3j}AGE + \beta_{4j}EDUC + \underline{e_{ij}}$$

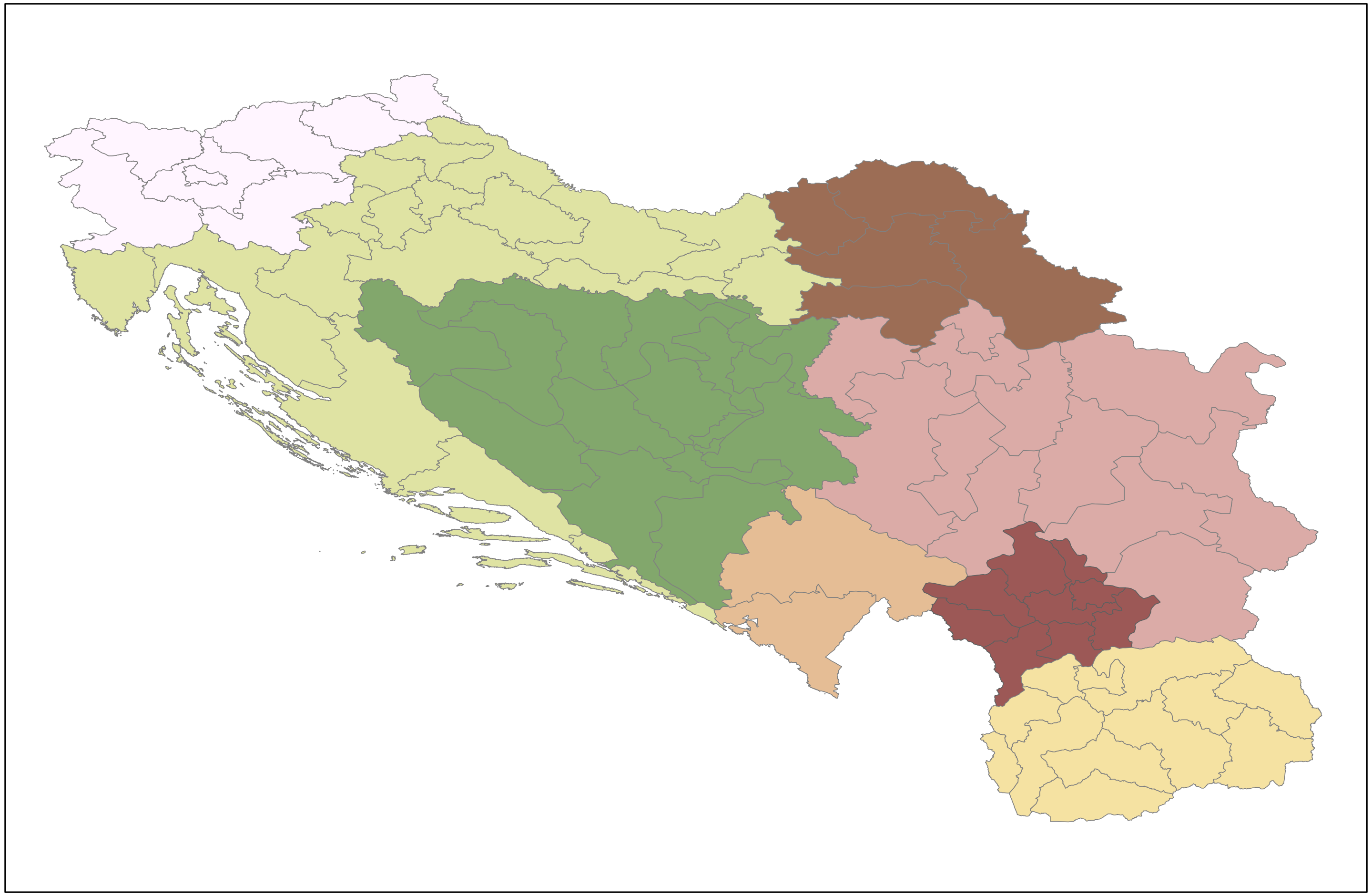
$$\beta_{0j} = \gamma_{00} + \gamma_{01}RISK\_WAR + \underline{u_{0j}}$$

Results of MLA across 80 areas

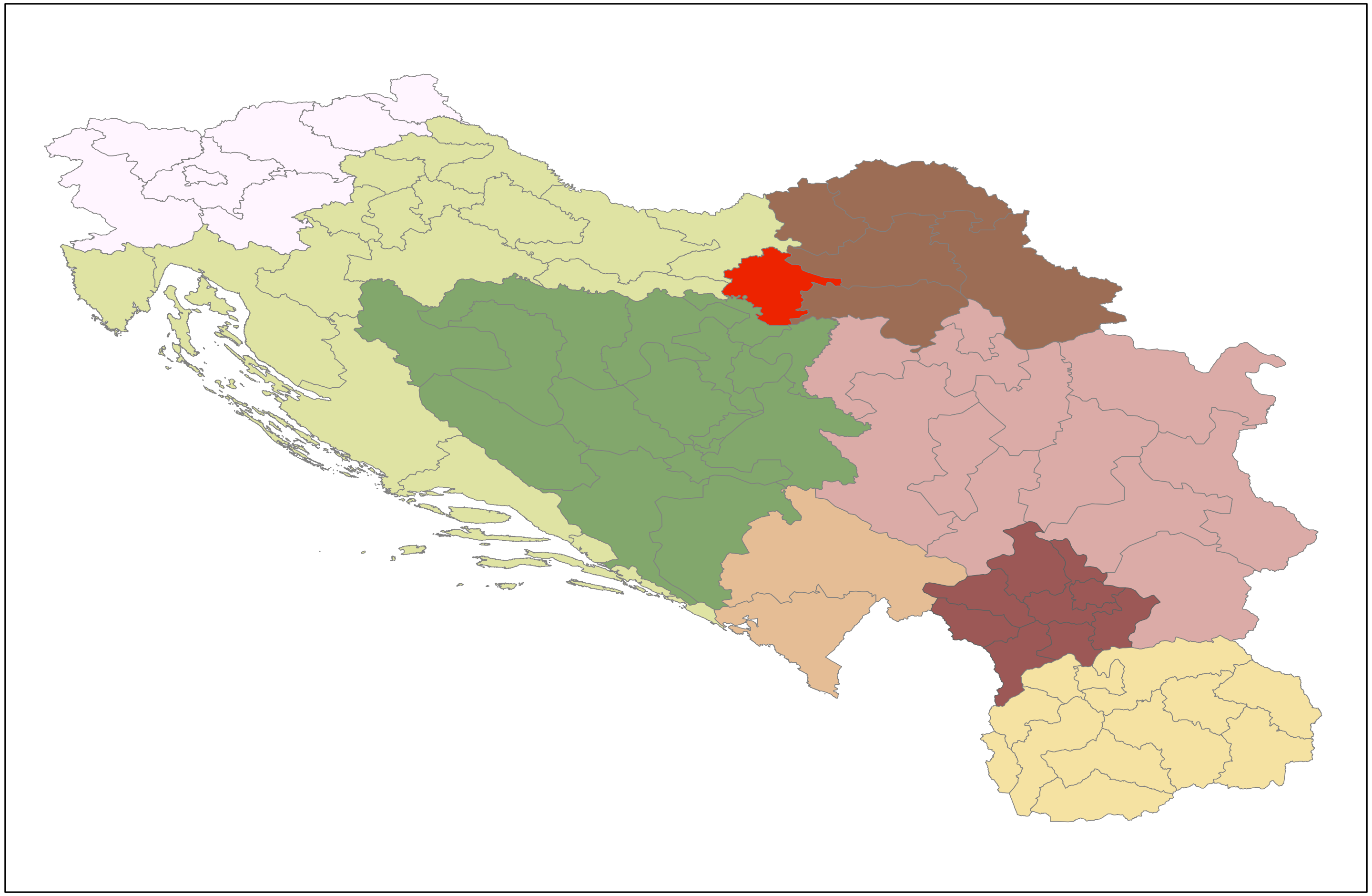
	B	SE
Victim of war	-0.17*	0.08
Combatant	-0.05	0.08
Men	-0.10	0.06
Age in 1990	-0.01	0.01
High school	0.11	0.08
Higher education	0.44**	0.09
Risk of war victimization	-1.71	9.17

Non-significant effect of the Risk of war victimization

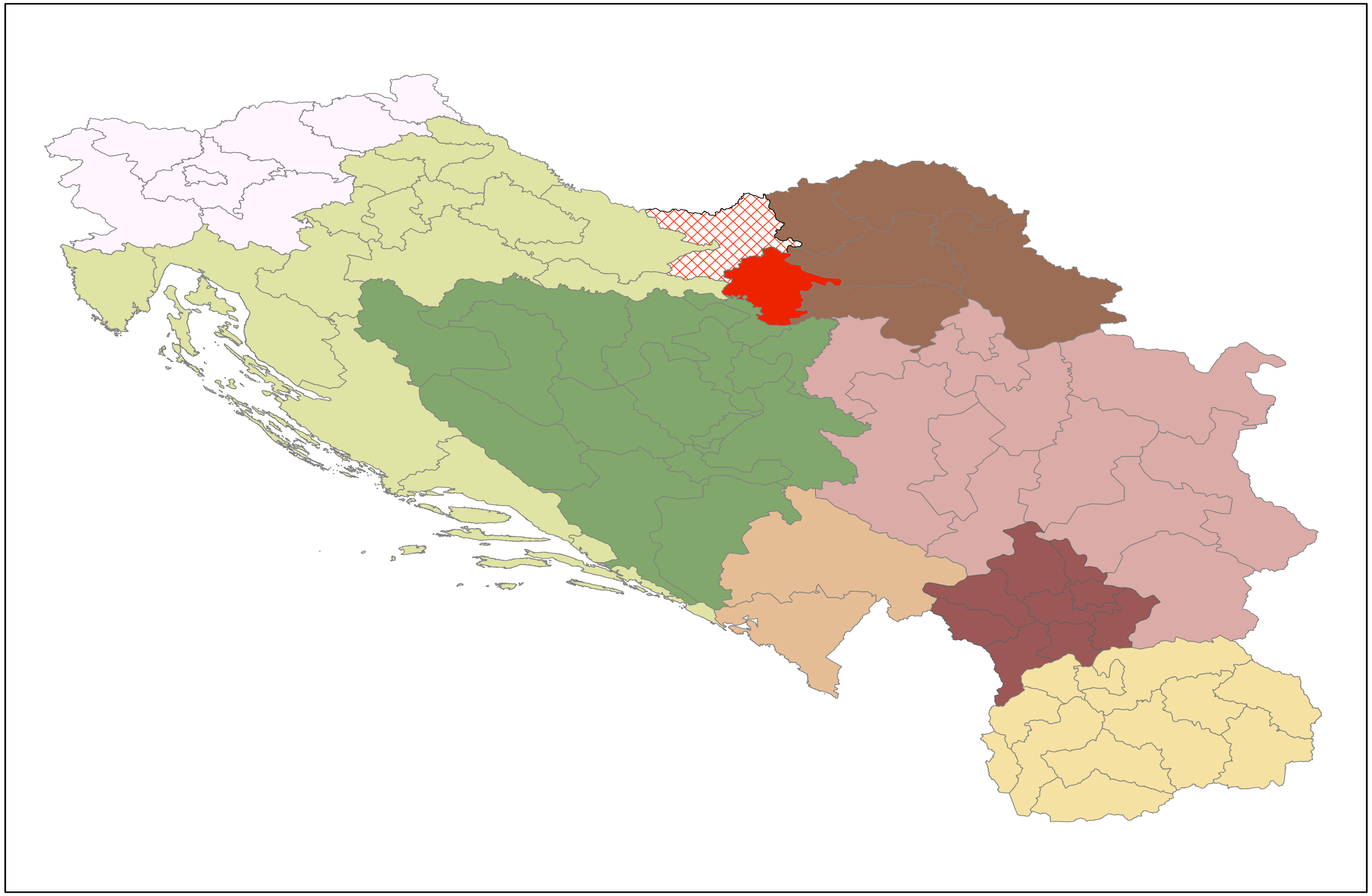
MLA – assumption of independence



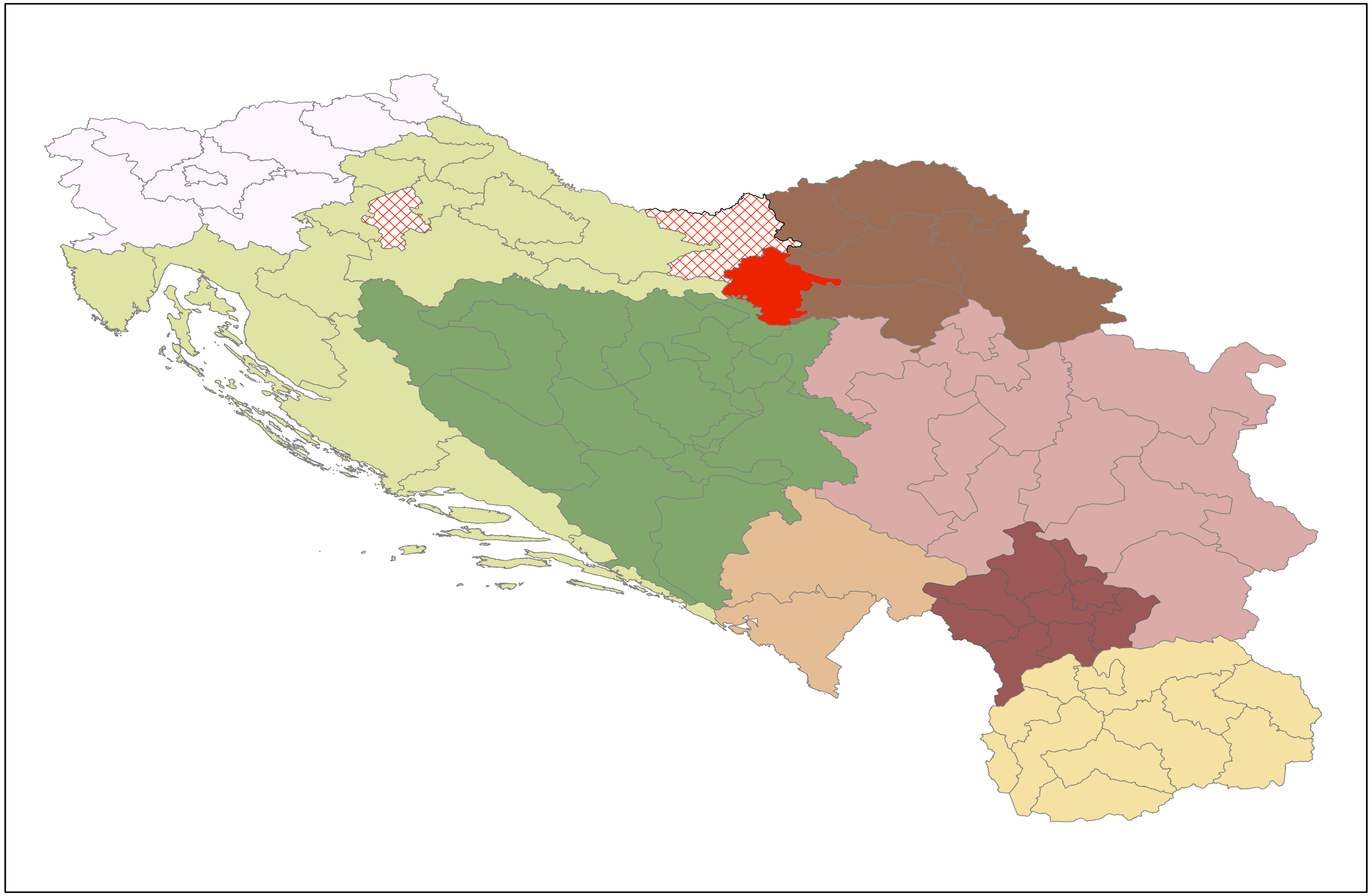
MLA – assumption of independence



MLA – assumption of independence



MLA – assumption of independence



Modifiable areal unit problem

- Openshaw (1984)
- Scale effect – the strength and direction of ecological correlations depend on the level of aggregation
- Zoning effect – ecological correlations depend on the precise drawing of contextual boundaries

Illustration: Zoning effects in neighbourhood influences on health

	Ecological correlation: % long-term illness and...		
	% whites	% kids	% home owners
Official wards	-0.20	0.02	0.19
Distribution across 50 pseudo-wards			
MIN	0.00	-0.56	0.22
MAX	0.08	-0.19	0.86
M	-0.03	-0.39	0.43
SD	0.06	0.06	0.09

Source: Flowerdew, Manley & Sabel (2008), Social Science and Medicine

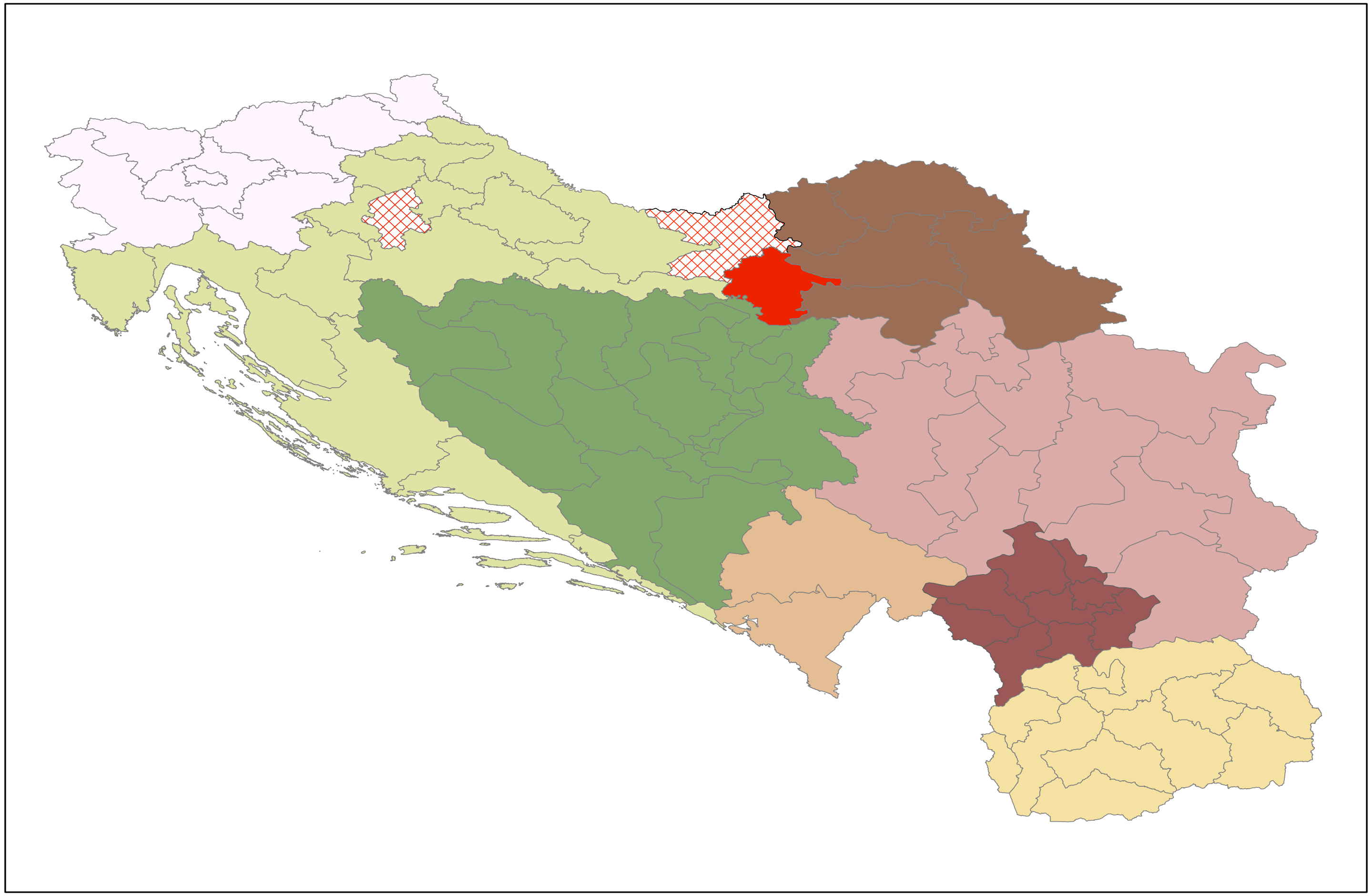
MLA with spatially dependent context data

- Banerjee, Carlin and Gelfand (2004) – MLA with spatially dependent random effects
- Savitz and Raudenbush (2009) – MLA with spatially dependent error term
- These models *neutralise* spatial dependency

Spatially weighted context data approach

- Spatially weighted contextual *predictor*
- Continuous weighting functions – allow to study the impact of collective experiences beyond discrete and (more or less arbitrarily) defined contextual units
- Allow to explore the scale of contextual effects

MLA – assumption of independence



Spatially weighted context data approach

- 4 steps of analysis:

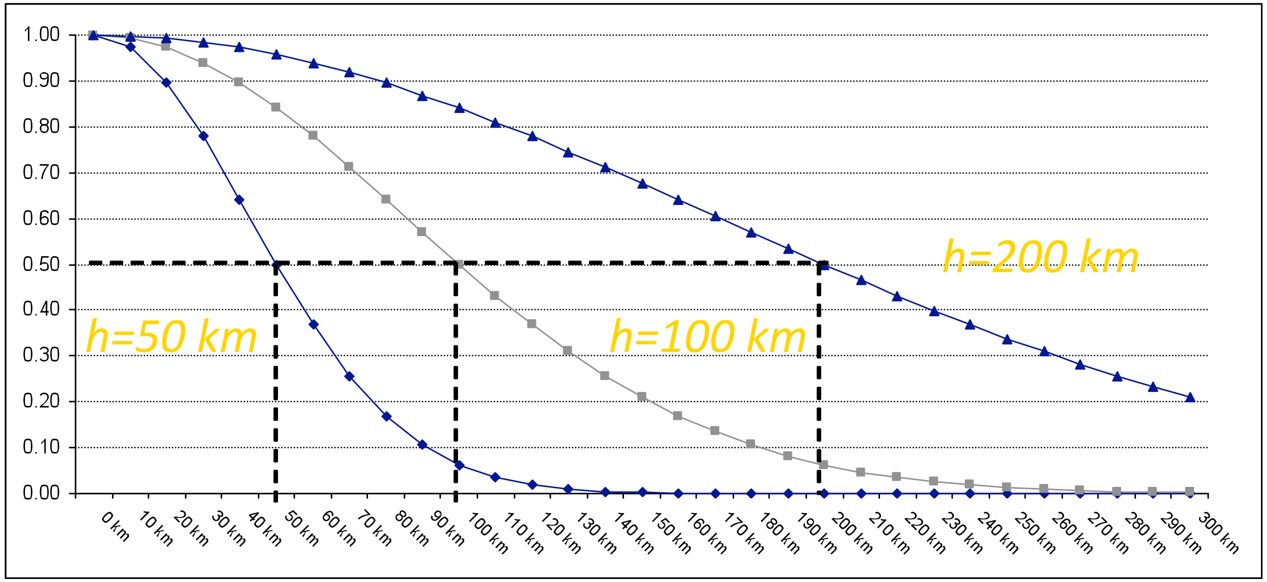
1. Creation of spatial weighting matrices
2. Construction of spatially weighted context data
3. Multilevel modelling with spatially weighted context data
4. Computation of estimates of explained spatial dependency

Step 1: Computation of spatial weights

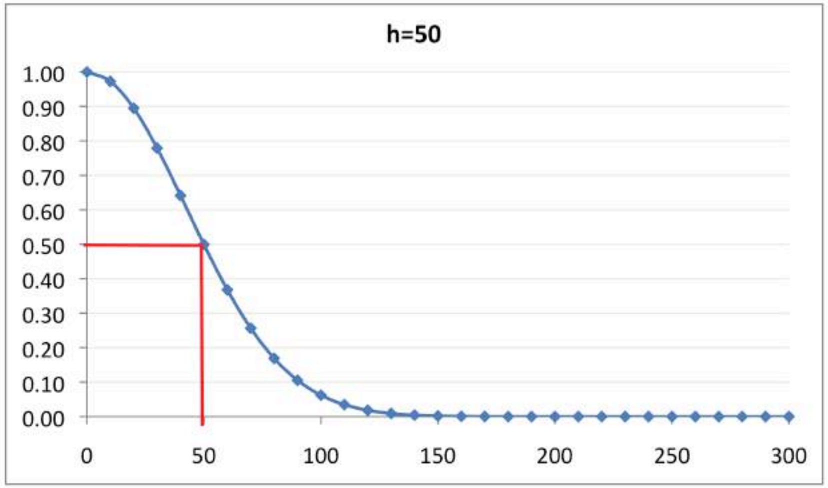
- Spatial weights are computed by applying a kernel function with specified bandwidth value to a distance matrix

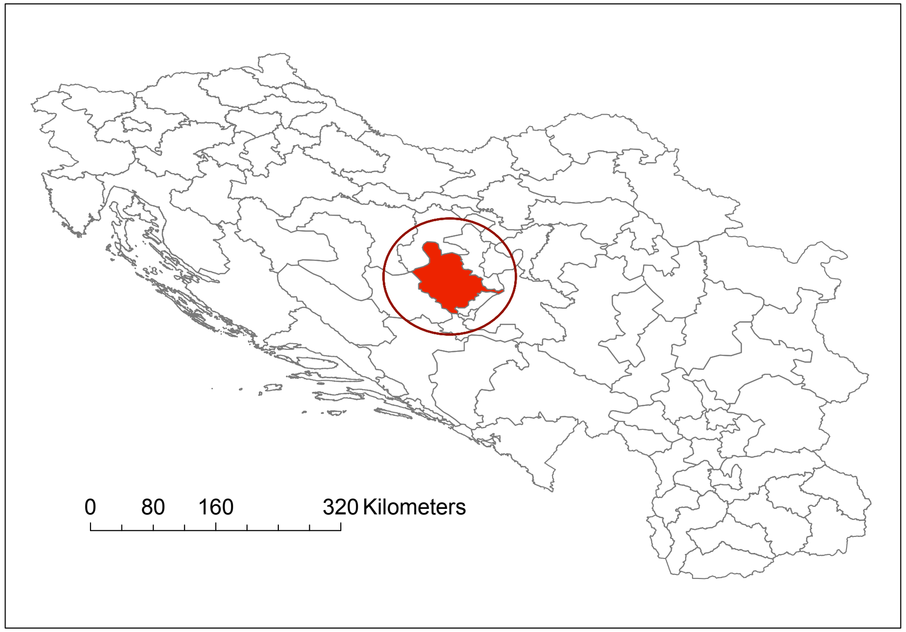
Implemented kernel function

$$w_{ij} = \left(\frac{1}{2}\right)^{\frac{d^2}{h^2}}$$

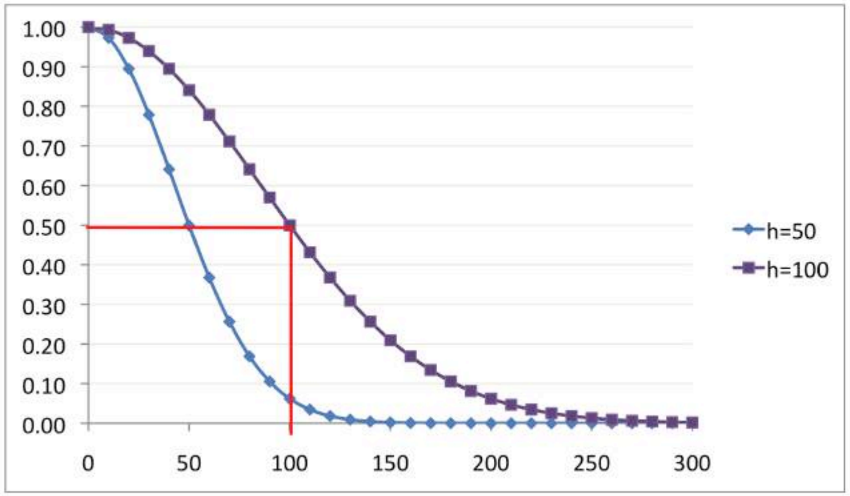


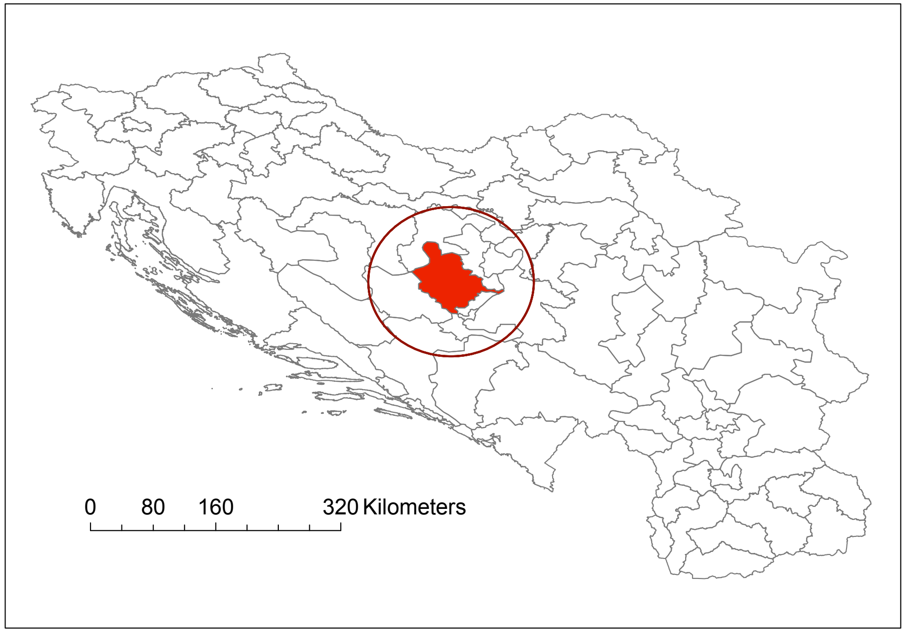
Step1: Computing spatial weights, bandwith value (h) = 50 km



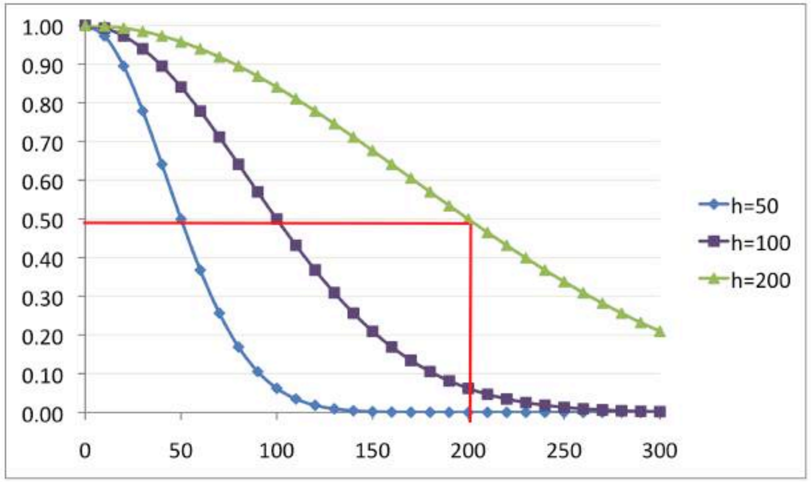


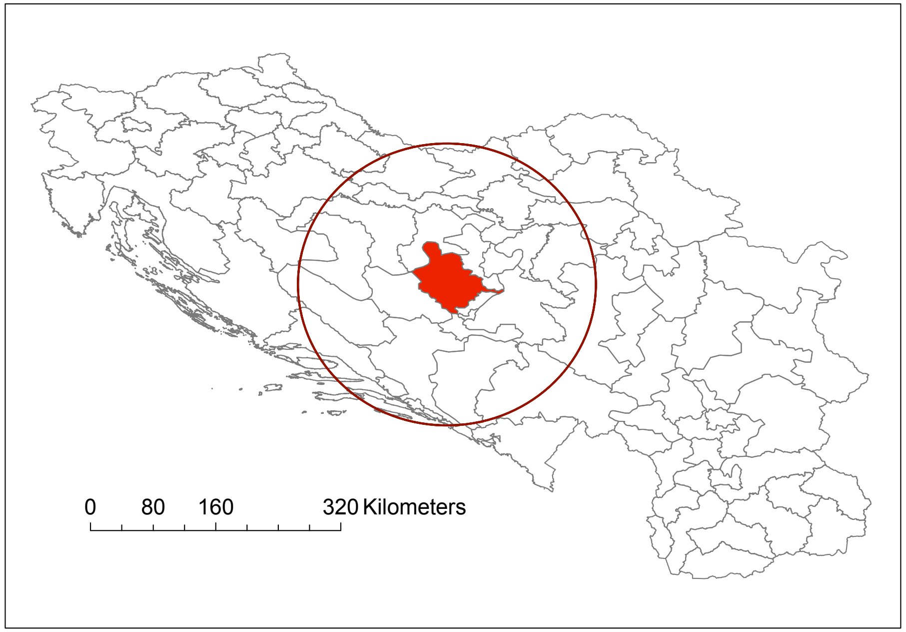
Step1: Computing spatial weights, bandwith value (h) = 100 km





Step1: Computing spatial weights, bandwith value (h) = 200 km





Step 2: Spatially weighted contextual indicator

- Weighting performed on the individual level
- Spatially weighted **mean**

- Spatially weighted risk of war victimization

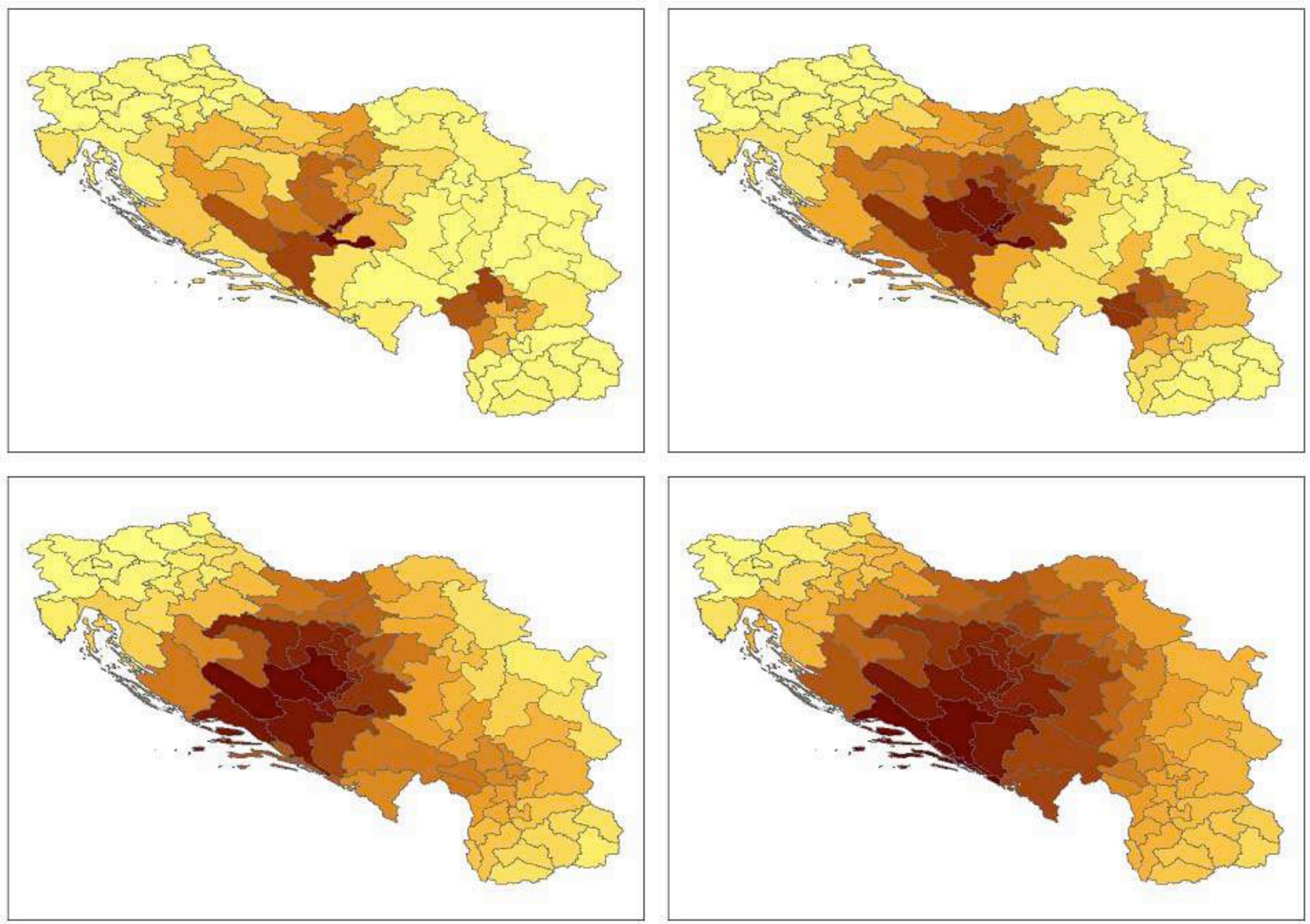
$$Risk_i^{weighted} = \frac{\sum_{k=1}^{80} Risk_k \times w_{ik}}{\sum_{k=1}^{80} w_{ik}}$$

Step 2: Spatially weighted contextual indicator

- ***N*** areas
- ***n*** individuals
- ***a*** a vector of area codes of length ***n***
- ***x*** a vector of predictor values of length ***n***
- $\boldsymbol{w^s}$ a ***N x N*** matrix of geographical weights where $\boldsymbol{w^s_{IJ}}$ is the spatial weight of values in area I on values in area J
- $\boldsymbol{w^d}$ a vector design weights of length ***n***

$\boldsymbol{a}$	$\boldsymbol{x}$	$\boldsymbol{w}^d$	$\cdots$	$\boldsymbol{w}_c^I$
a_1	x_1	w_1^d	$\cdots$	$\vdots$
a_1	x_2	w_2^d	$\cdots$	$\vdots$
a_1	x_3	w_3^d	$\cdots$	$\vdots$
$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$
a_I	x_i	w_i^d	$\cdots$	$w_i^d w_{a_I i}^s$
a_I	x_{i+1}	w_{i+1}^d	$\cdots$	$\vdots$
a_I	x_i	w_i^d	$\cdots$	$\vdots$
$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$
a_N	x_n	w_n^d	$\cdots$	$\vdots$

Step 2: Collective war experiences and scale



Unweighted

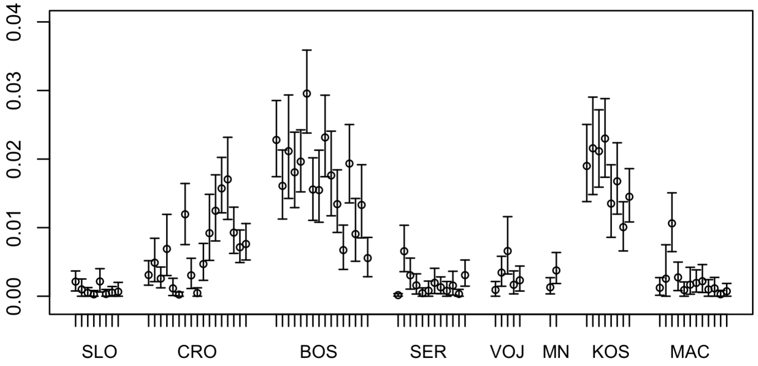
h=50 km

h=100 km

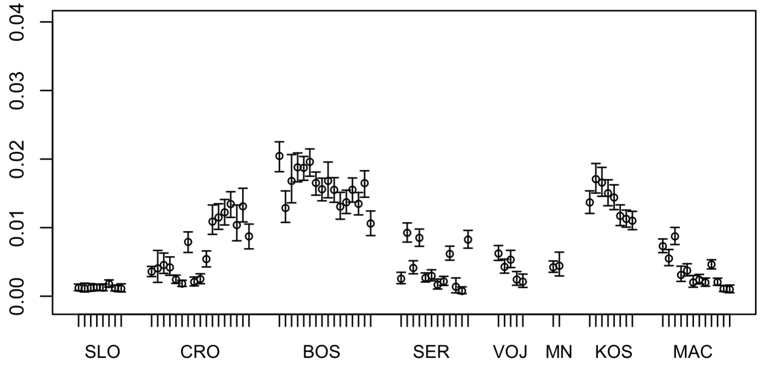
h=200 km

Step 2: Scale and precision of estimates

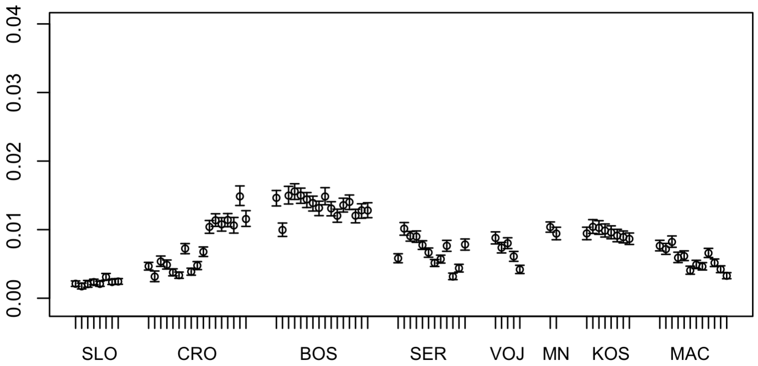
Unweighted



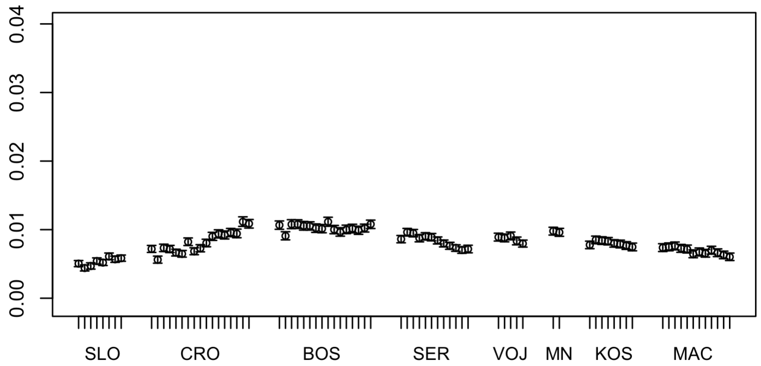
h=50 km



h=100 km



h=200 km



Step 3: Multilevel analysis with spatially weighted contextual indicator

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_1 + \ldots + \beta_{nj} X_n + e_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} Z_j + u_{0j}$$

Step 3: Multilevel analysis with spatially weighted contextual indicator

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_1 + \ldots + \beta_{nj} X_n + e_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01} \boxed{W^g Z_j} + u_{0j}$$

Spatially weighted
contextual indicator

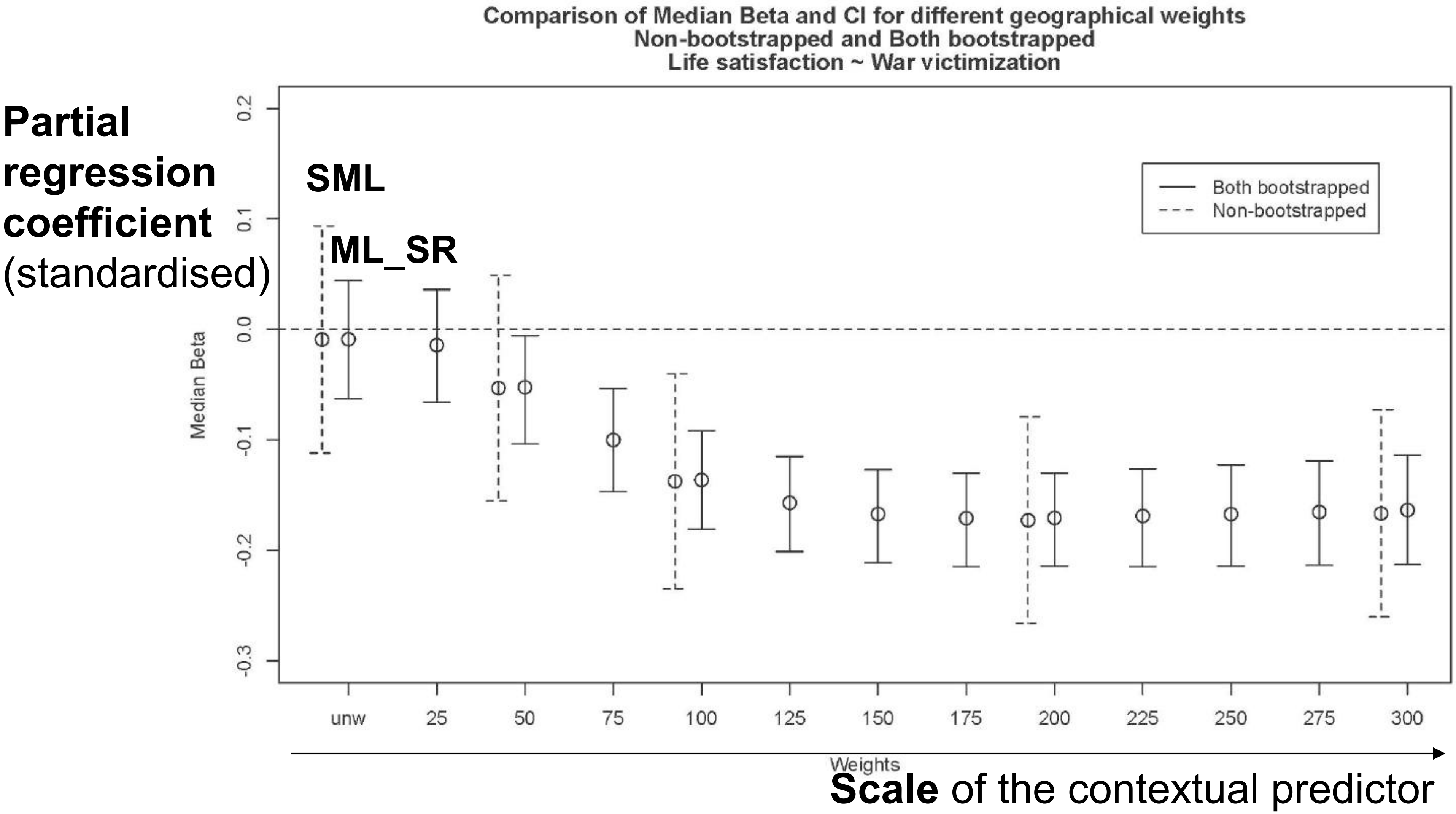
Step 3: Multilevel analysis with spatially weighted contextual indicator

- Standard MLA assumes:
- contextual units are a random sample of the underlying population
- contextual indicators are measured without an error
- problematic estimates of standard errors

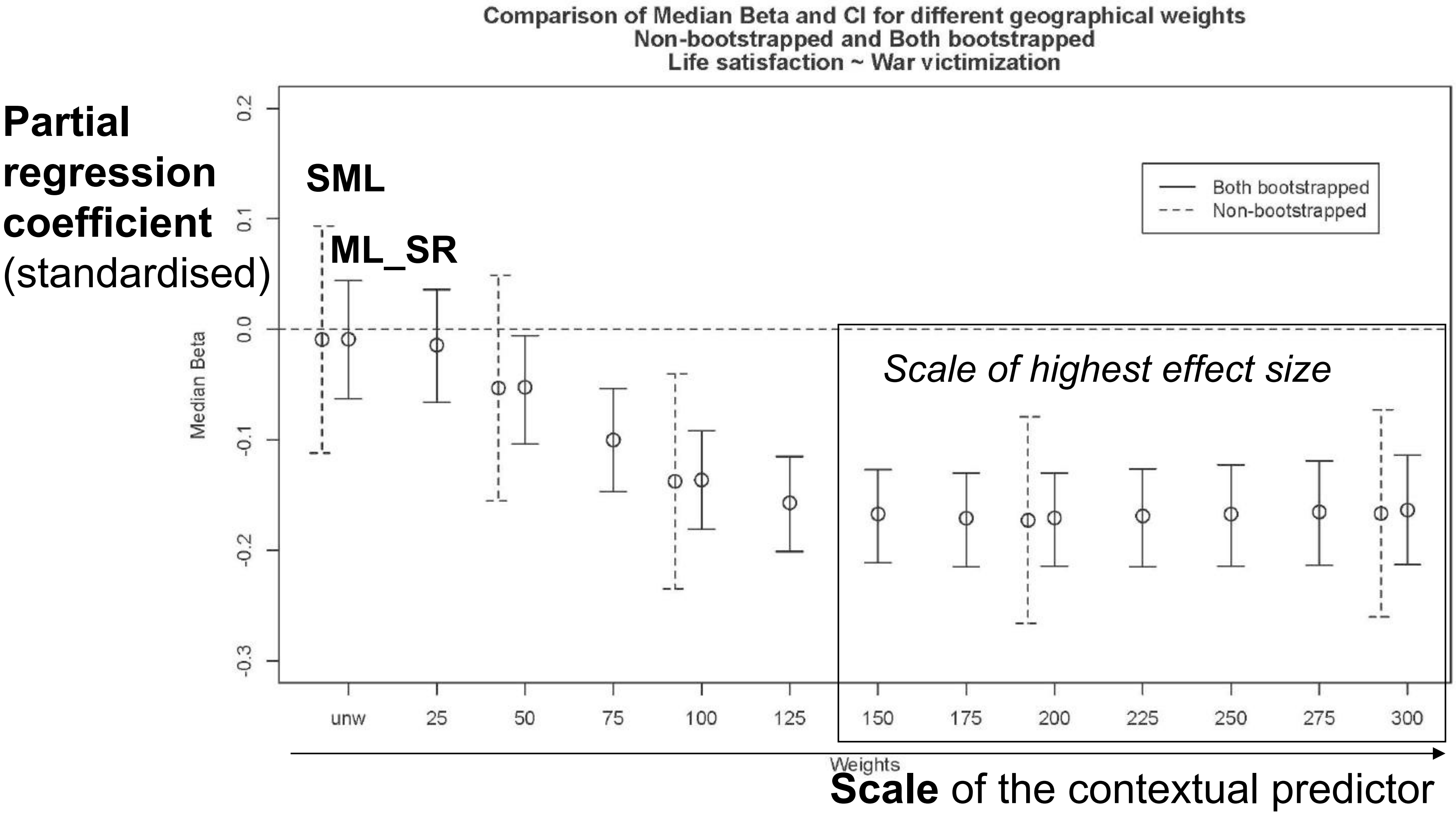
Step 3: Multilevel analysis with spatially weighted contextual indicator

- SML – standard multilevel analysis
- **ML_SR**
  - multilevel analysis with stratified resampling: resampled both individual data and contextual indicator ($n_{resamples}$=1000)
  - generates robust point estimates for regression coefficients and model fit indicators, and computes confidence intervals adjusted for measurement dependency and measurement error of the aggregate estimates.

Step 3: Modelling scale effects

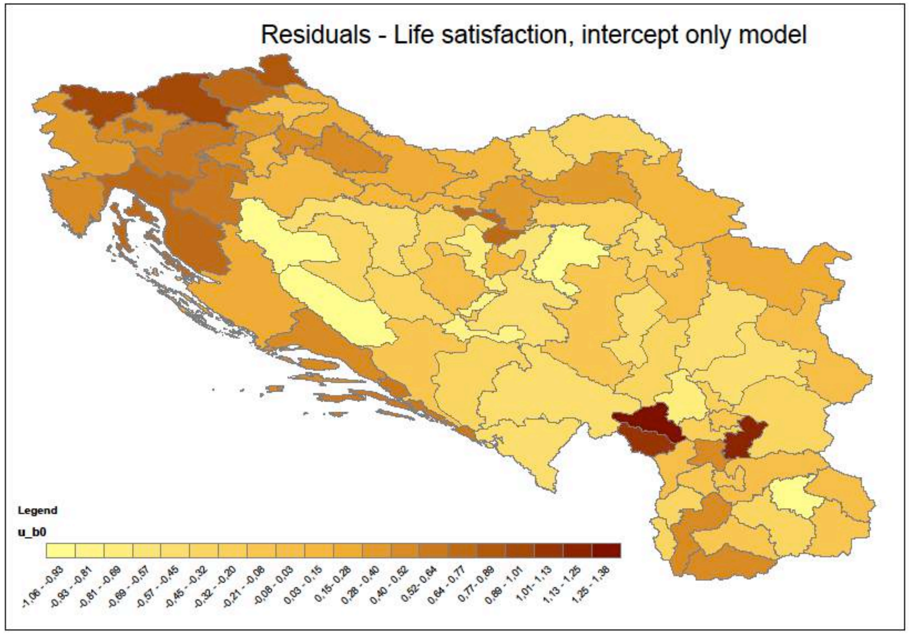


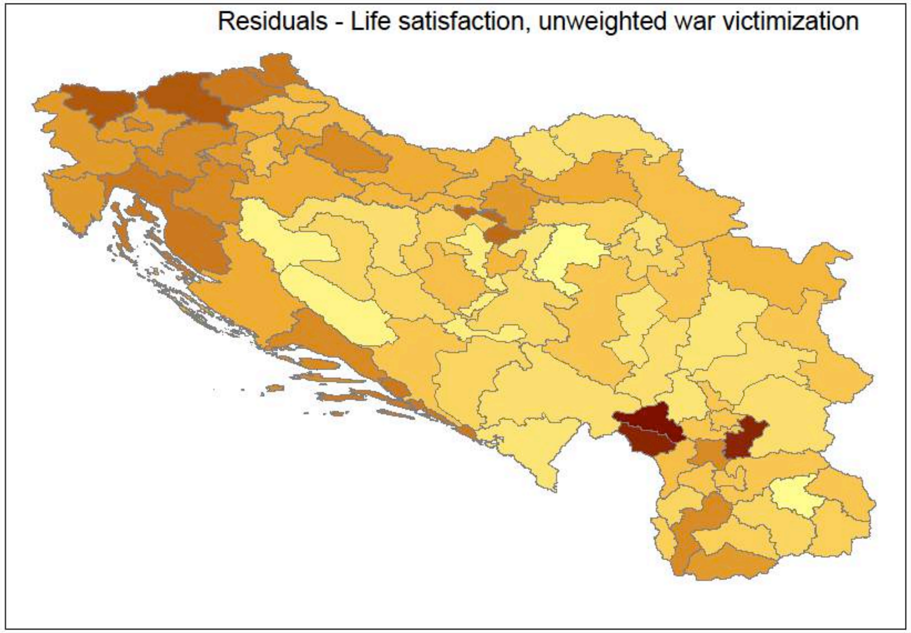
Step 3: Modelling scale effects



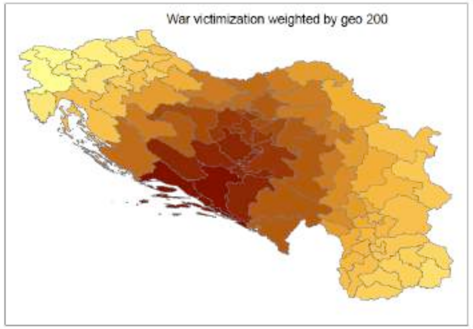
Step 4: Residual spatial dependency

Area-level residuals: « no predictor » & «unweigthed predictor »



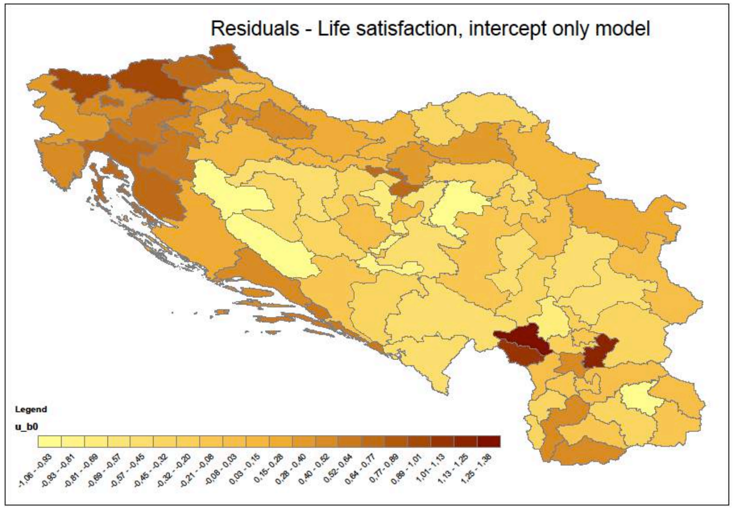


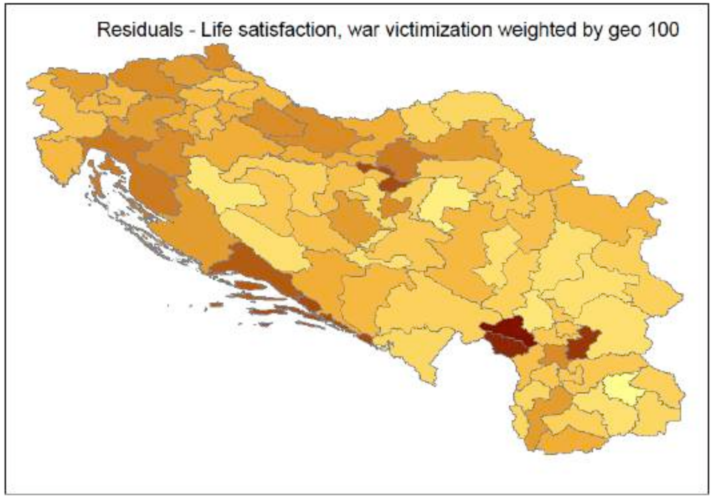
Step 4: Explained and unexplained spatial dependency



Univariate distribution:
Predictor at optimal scale

Area-level residuals: « no predictor » & «predictor weighted at optimal scale »





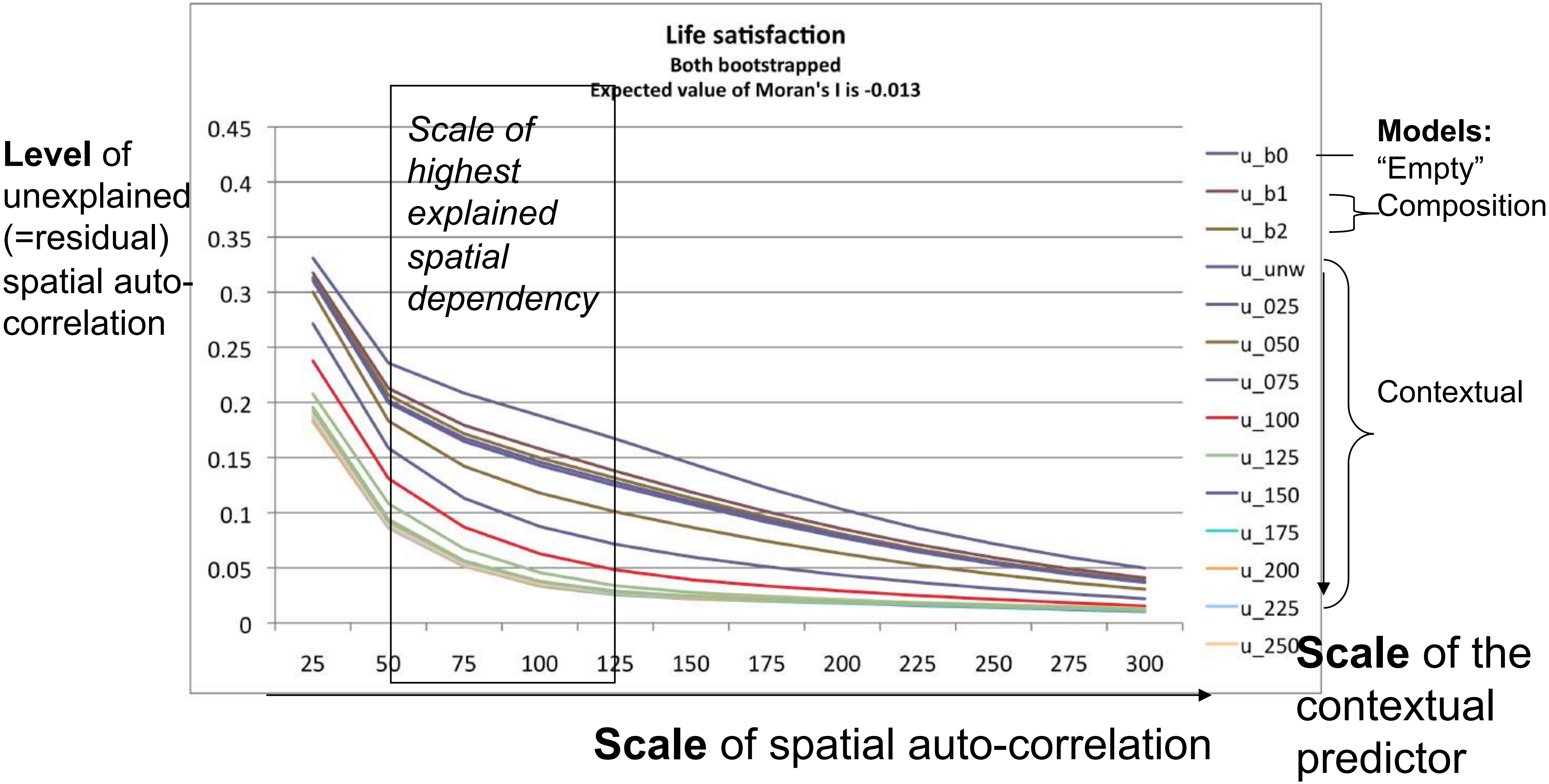
Step 4: Quantifiying spatial auto-correlation

- Moran's I coefficient:

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

Spatial weighting matrix

Step 4: Spatial variogram



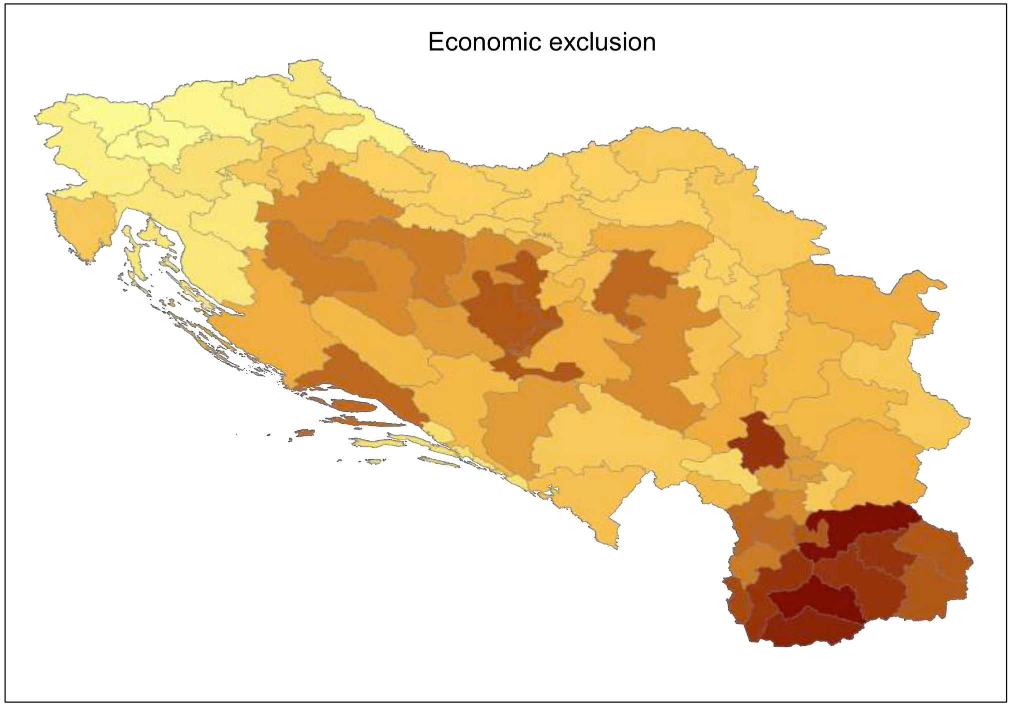
Exposure to war and well-being

- Contrary to MLA, a significant impact of collective experiences of war on well-being
- Different impact at different scales
- Bootstrap confidence intervals vs ML standard errors
- Explained spatial dependency

Different scale effect of different collective experiences

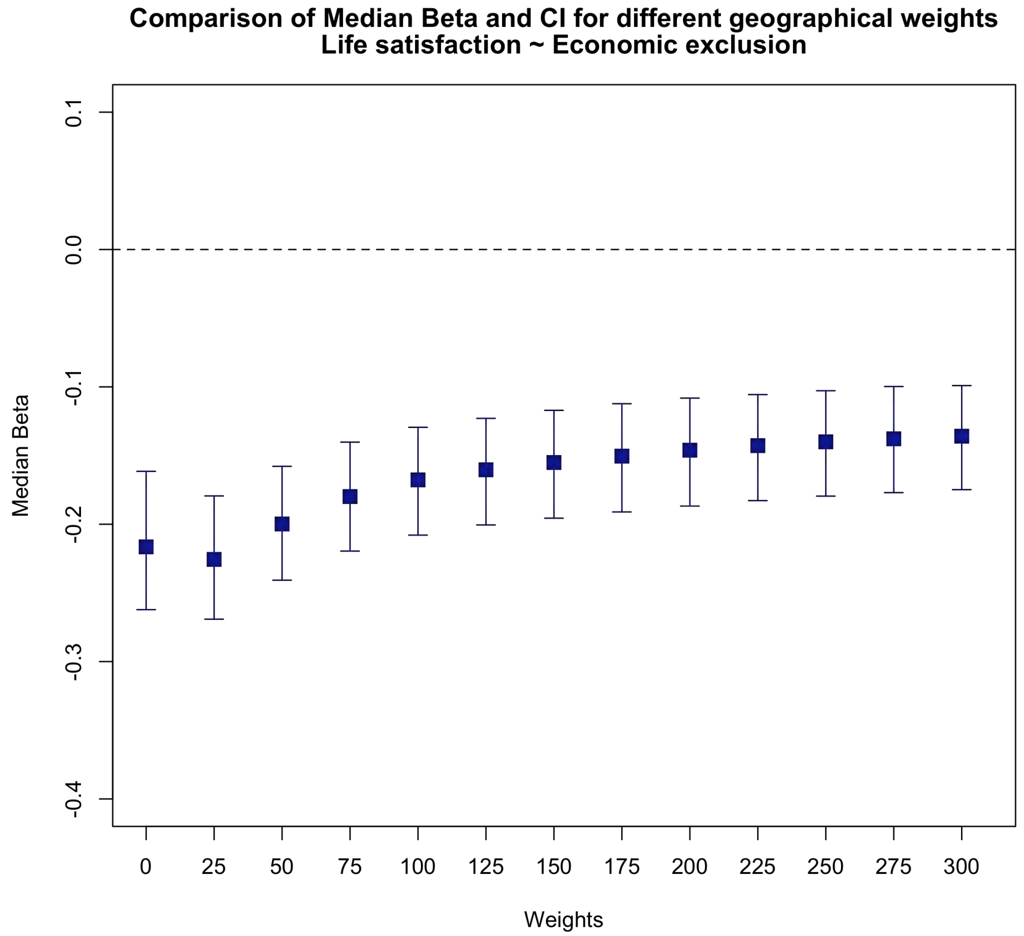
Risk of economic exclusion

- life events calendar
- two events: unemployment and poverty during the 1990-2006 period



Step 3: Different scale effect of different collective experiences

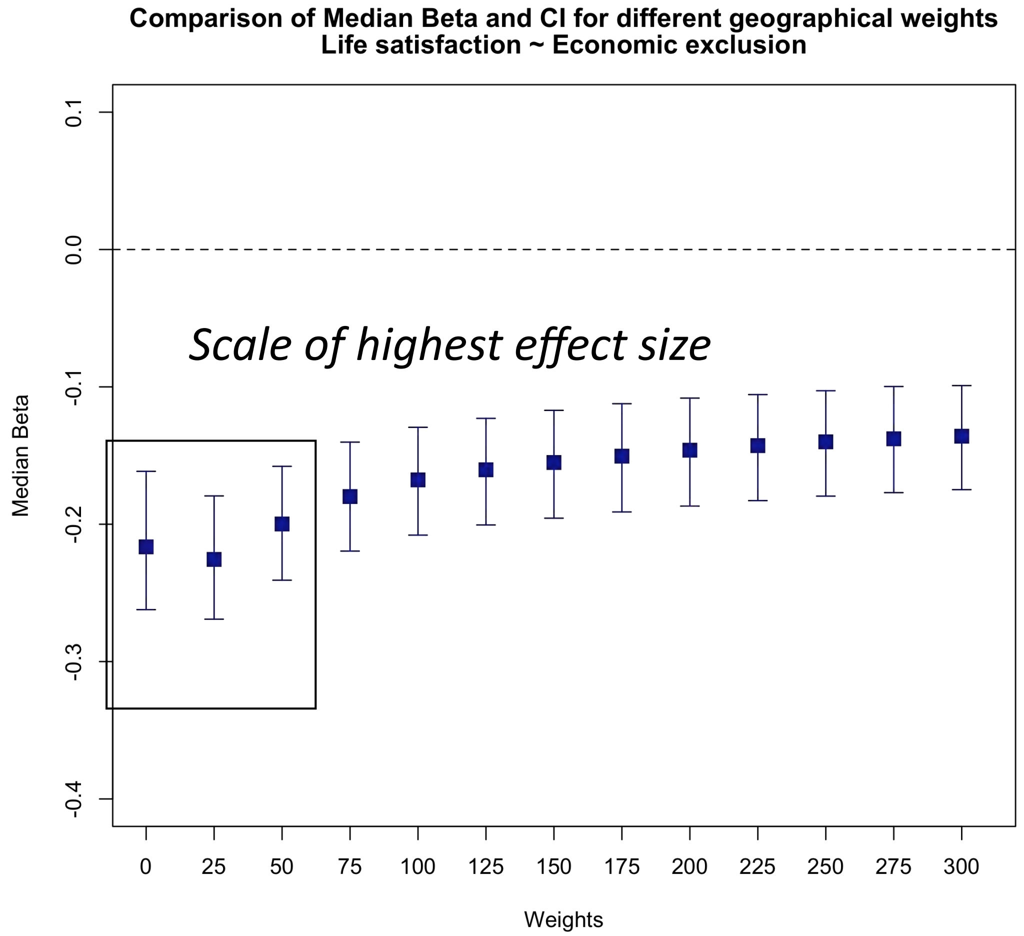
Partial regression coefficient (standardised)



Scale of the contextual predictor

Step 3: Different scale effect of different collective experiences

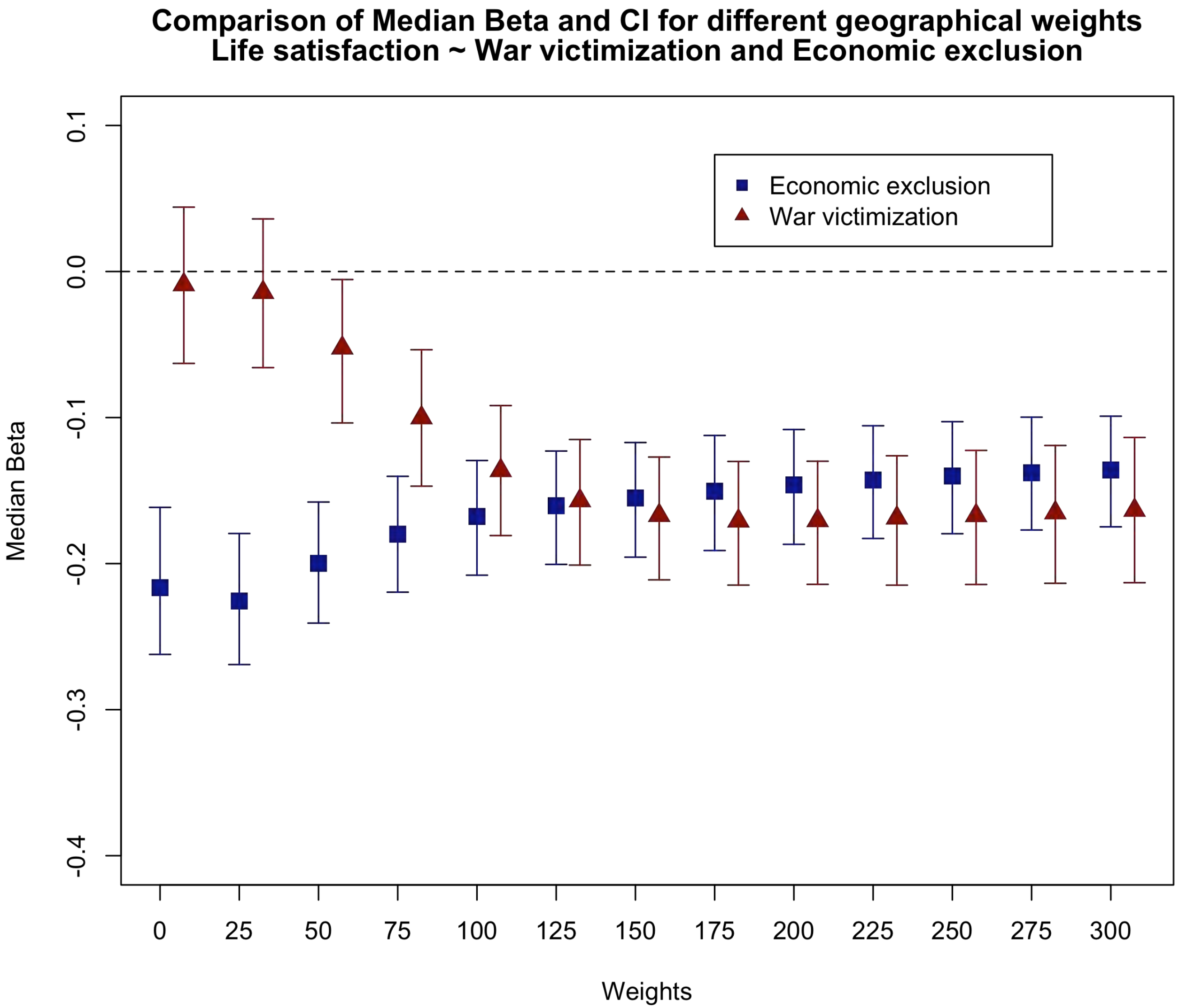
Partial regression coefficient (standardised)



Scale of the contextual predictor

Step 3: Different scale effect of different collective experiences

War Victimization has the highest impact on the large scale, while Economic Exlcusion has the highest impact on the small scale



spacom – Structure of the package

	Step of analysis	Functions in spacom
1.	Create weights	WeightMatrix()
2.	Create spatially weighted contextual indicator	SpawExact() SpawAggregate()
3.	MLA with spatially weighted contextual indicator	MLSpawExact() ResampleMLSpawExact() ResampleMLSpawAggregate()
4.	Residual spatial autocorrelation	MLSpawResidMoran()
	Exploratory analysis	ExploreMLExact()

Data in package	Name of dataset
Distance matrices	d_geo, d_ident, d_ethnic, d_migr
Individual level dataset	traces_ind
Contextual indicator for aggregation	traces_event
Precise contextual indicator	homog_census

Extensions: Socialising spatial dependency

- Distance as demographic dissimilarity

$$d_{ij} = \sum_{g=1}^{6} \left| \hat{r}_{ig} - \hat{r}_{jg} \right|$$

- Distance as lack of common identification

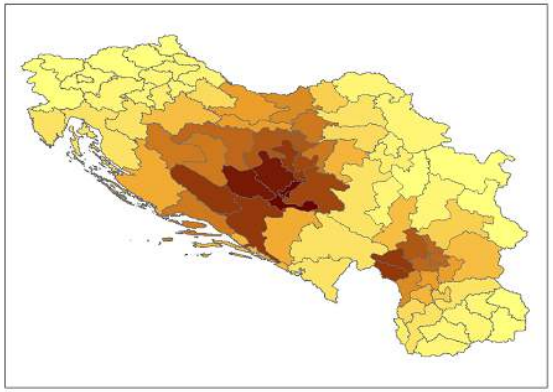
$$d_{ij} = MIN\left(\sqrt{y_i \times y_j}, \sqrt{r_i \times r_j}\right)$$

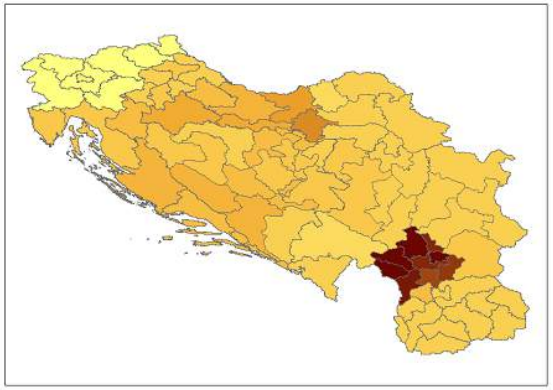
- Distance as lack of contact

$$d_{ij} = \frac{(N_i + N_j)\big/ 2}{\hat{n}_{i \to j} + \hat{n}_{j \to i}} \times \frac{4}{\ln(n_{i \to j} + n_{j \to i}) + 1}$$

Comparing spatial patterns across different social definitions of 'proximity'

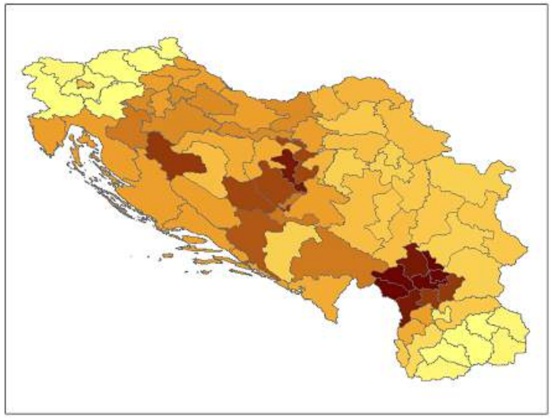
Geographic Proximity

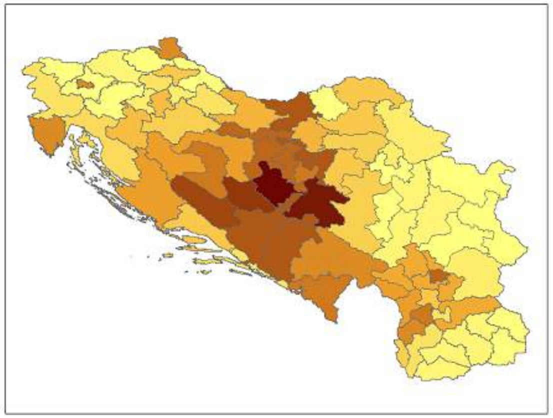




Proximity as common identification

Proximity as similarity





Proximity as contact

Modelling the social mediation of spatial patterns

	Model A "Geographic space"	Model B "Territorial identification"	Model C "Combined spaces"
Individual-level predictors			
Personal experience of war trauma	0.08 (0.03 - 0.13)	0.07 (0.02 - 0.11)	0.07 (0.02 - 0.12)
Combatant	0.04 (-0.01 - 0.08)	0.04 (0.00 - 0.09)	0.04 (0.00 - 0.09)
Male	0.04 (0.00 - 0.08)	0.04 (0.00 - 0.08)	0.04 (0.00 - 0.08)
Age in 1990	0.00 (-0.03 - 0.05)	0.00 (-0.04 - 0.04)	0.00 (-0.04 – 0.04)
Level of education			
- Secondary	0.03 (-0.02 - 0.08)	0.04 (-0.01 - 0.09)	0.04 (-0.01 – 0.09)
- Tertiary	-0.01 (-0.06 - 0.04)	-0.01 (-0.06 - 0.04)	-0.01 (-0.06 – 0.04)
Contextual-level predictors			
Collective experience of war trauma			
- Weighted by geographic space	0.09 (0.03 - 0.14)	-	-0.04 (-0.10 – 0.03)
- Weighted by territorial	-	0.21 (0.17 - 0.25)	0.23 (0.17 - 0.27)

Conclusion (I): Why is classic MLA insufficient?

- Multilevel regression analysis : statistical inferences based on assumptions that cannot be met in comparative survey research?
  - The contextual system is composed of independent units
  - Contextual units are randomly drawn from an underlying population
  - Contextual values are measured without error
- Spatial auto-regressive analysis: “keeping the bathwater and throwing out the baby”? (Gould, 1970)

Conclusion (II): What do spatially weighted context data add?

- Spatially weighted data enable to…
  - explore the spatial structure of collective experiences that generate context effects
  - describe how contextual effects, and spatial dependency explained by contextual models, vary as a function of scale
  - identify *social* interdependences or influences that mediate observable geographic spatial patterns between contextual units,
  - produce estimates of contextual effects and associated confidence intervals that rely on realistic assumptions

Conclusion (III): When to use spatially weighted context data? Boundary conditions

- Spatially weighted context data presuppose…
  - contextualised research questions: relational inference within the system, no inference beyond the system
  - a complete set of contextual units, defined below the scale of the contextual effects of interest
  - a complete matrix of distances between contextual units on relevant dimensions
  - precise contextual measures or appropriate micro-level data for aggregation-with-error
  - stratified sampling designs

Future applications

- LIVES IP 15: Stephanie Glaeser & Guy Elcheroth
- Spatially weighted indicators of inequalities

Acknowledgement and references

- **Full paper:**
- Elcheroth, G., Penic, S. Fasel, R., Giduici, F., Gläser, S., Le Goff, J.-M.,Joye, D., & Spini, D. (conditional acceptance). Spatially weighted contextdata and their application to collective war experiences, Sociological Methodology
- Working paper version: http://www.lives-nccr.ch/en/page/lives-working-papers-n40
- **R-package (including replication data):**
- Junge, T., Penic, S., Cossuta, M., & Elcheroth, G. (2013).*Spacom: Spatially weighted context data for multilevel modelling.R package version 1.0-0.* http://cran.r-project.org/web/packages/spacom/
- **TRACES dataset:**
- Accessible through the Swiss data archives: www.uni.ch/daris
- Data documentation: Spini, D., Elcheroth, G., & Fasel, R. (2011). TRACES : Methodological and technical report. *LIVES Working Paper, 4.*
- **Substantive background (edited book):**
- Spini, D., Elcheroth, G., & Corkalo, D. (forthcoming). *War and Community: Collective experiences in the former Yugoslavia. Berlin & New York:* Springer.

Thank you!