A spatial factor model for summarizing area-level Townsend-like Index

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Introduction

- The complex concept of socio-economic deprivation is often desribed by area-level census-based composite measures
- These composite measures are used to investigate socio-economic inequalities in health

Introduction

- A “traditional” measure of socio-economic deprivation in UK is the Townsend Index
- This is a simple index calculated by summing the normalised values of four cencus variables
- Townsend Index is correlated with mortality/morbidity and its correlations are similar to a more complex alternatives such as the Index of Multiple Deprivation (includes 33 variables classified in 6 domains) discussed in Jordan et al. (2004)
- Townsend Index is also often used to assess the convergent validity of recently developed multi-dimensional indices through factor analysis in several European countries

Objectives

- Explore for first time the geographical variability of the components of a Townsend-like Index across Cypriot communities
- Investigate the construct validity of a Townsend-like Index in Cyprus through a spatial factor model that enables us to assess the extend to which components share a common latent factor
- In contrast to factor analysis, the spatial factor model takes into account the spatial auto-correlation of census socio-economic characteristics

Methods

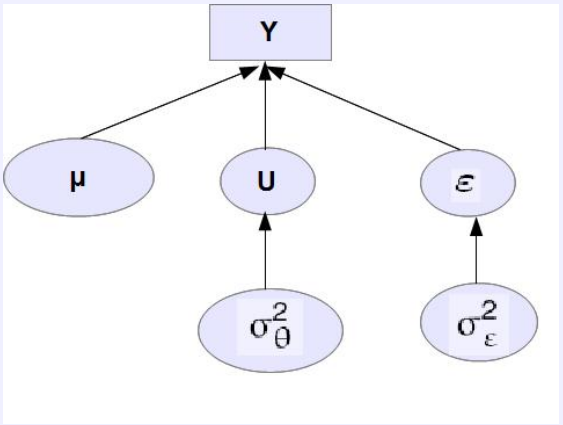
Three components of the Townsend Index were available at a community level ($n = 370$) from the 2001 census

- Unemployed economically active population (%)
- Not owner occupied households (%)
- Households with $>$ 1 person/room (%)
- No access to a car (very uncommon in Cyprus and not recorded in the census) was replaced with No access to a personal computer (%)

Univariate spatial model

- The geographical patterning and the amount of spatial variability in each indicator were investigated through a Bayesian Hierarchical model

$$
\begin{aligned}
y_i &= \mu + U_i + \varepsilon_i \\
\boldsymbol{U} &\sim \text{CAR}(\boldsymbol{W}, \sigma^2_U) \\
\varepsilon_i &\sim \text{N}(0, \tfrac{\sigma^2_\varepsilon}{m}) \\
\sigma^2_U, \sigma^2_\varepsilon &\sim \text{IGamma}(0.5, 0.005)
\end{aligned}
$$

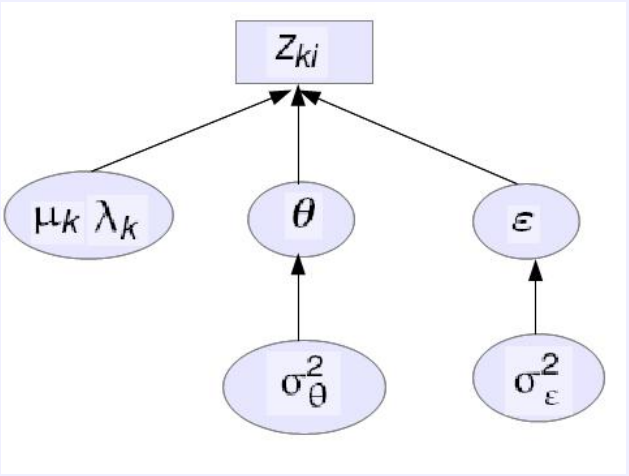


- The random effect $\boldsymbol{U}$ modeled the spatially structured variability and ε the unstructured variability
- $\boldsymbol{W}$ is the adjacent matrix and m is the appropriate total count of either households or persons

Spatial latent factor model

- The construct validity of a Townsend-like Index was investigated through a spatial latent factor model

$$
\begin{aligned}
z_{ki} &= \mu_k + \lambda_k \theta_i + \varepsilon_{ki} \\
\boldsymbol{\theta} &\sim \text{CAR}(\boldsymbol{W}, \sigma^2_\theta) \\
\varepsilon_{ki} &\sim \text{N}(0, \tfrac{\sigma^2_{\varepsilon_k}}{m_k}) \\
\lambda_k &\sim \text{TN}(0, 100) \\
\sigma^2_{\varepsilon_k} &\sim \text{IGamma}(1, 0.001) \\
\sigma^2_\theta &= 1
\end{aligned}
$$



- This model allows us to assess the extent to which components share a common latent factor representing the socio- economic deprivation

Proportion of variability explained

- A Gibbs algorithm was implemented in WinBUGS to generate a sample from the posterior distribution of the parameters. **Univariate spatial model**
- The empirical variances of the spatially structured and unstructured random effects

$$s^2_U = \frac{1}{n-1} \sum_{i=1}^{n} (U_i - \bar{U})^2$$

$$s^2_\varepsilon = \frac{1}{n-1} \sum_{i=1}^{n} (\varepsilon_i - \bar{\varepsilon})^2$$

were calculated in each iteration of the Gibbs algorithm
- The proportion of variability explained by the spatially structured random effect is given by the ratio

$$\frac{s^2_U}{s^2_U + s^2_\varepsilon}$$

Proportion of variability explained

Spatial latent factor model

- The empirical variances of the spatially structured common latent factor and unstructured random effect for each indicator k

$$s_\theta^2 = \lambda_k^2 \sum_{i=1}^{n} (\theta_i - \bar{\theta})^2$$

$$s_\varepsilon^2 = \frac{1}{n-1} \sum_{i=1}^{n} (\varepsilon_{ki} - \bar{\varepsilon}_k)^2$$

  were calculated in each iteration of the algorithm
- The proportion of variability explained by the spatially structured common latent factor for each indicator k is given by the ratio

$$\frac{s_\theta^2}{s_\theta^2 + s_\varepsilon^2}$$

Results of univariate spatial analysis

Census variable	Unem	Crowd	NOO	No PC
Unemployment	1.00	0.37	0.24	-0.26
Crowding		1.00	0.23	-0.06
Not owner occuppied			1.00	-0.21
No PC				1.00

Table : Bivariate correlations between variables

- Pairwise correlations were generally low
- Internal consistency between the variables was insufficient (Cronbach's $\alpha = 0.55$ even when % No PC was excluded)

Results of univariate spatial analysis

Census variable	Mean	2.5%	97.5%
Unemployment	25.50	18.34	33.82
Crowding	26.63	19.26	34.87
Not owner occuppied	44.37	34.67	53.77
No PC	97.15	92.40	99.93

Table : Posterior mean and 95% credible intervals for the proportion of spatially structured variability

- PC ownership displayed a striking spatial structure; however, more resembling of an urban-rural dichotomy
- It was not considered further since its correlations with the rest were in the opposite direction

Results of univariate spatial analysis

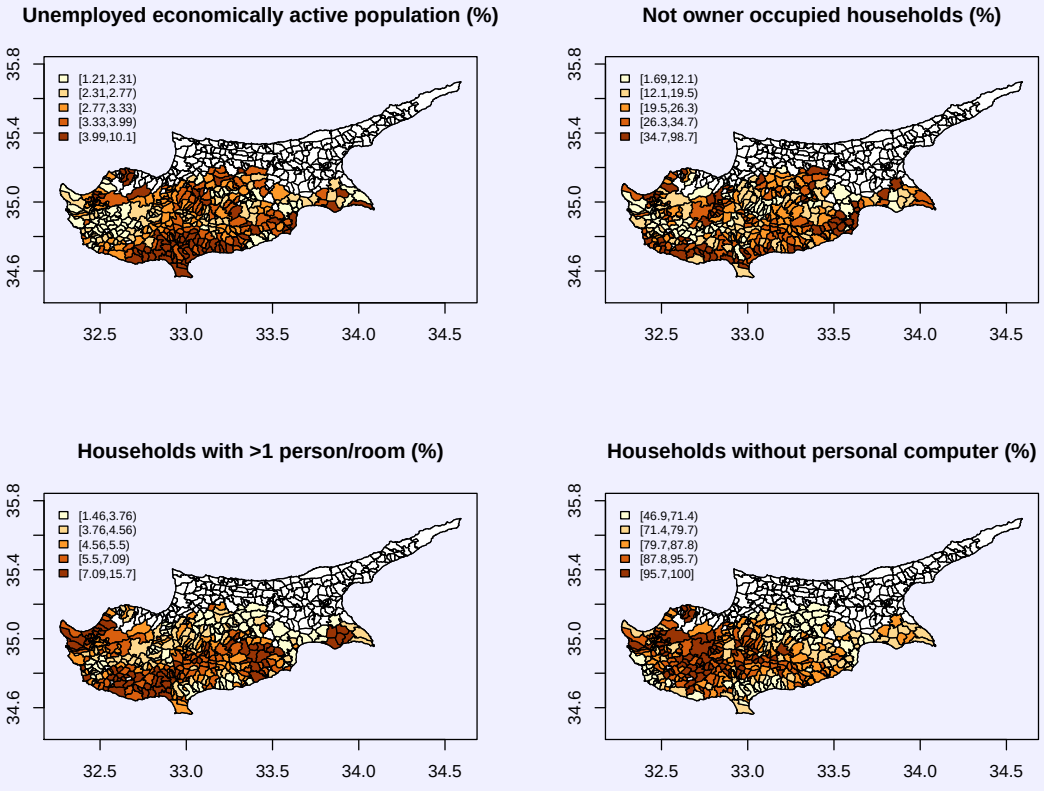


Figure : Spatially smoothed choropleth maps of indicator variables across Cypriot communities in quintile class intervals

Results of multivariate spatial factor analysis

Census variable	Mean	2.5%	97.5%
Unemployment	25.03	18.06	33.06
Crowding	0.28	0.00	1.38
Not owner occuppied	9.23	9.23	14.11

Table : Posterior mean and 95% credible intervals for the proportion of variability explained in each indicator by the common latent factor

- The remaining three indicators exhibited a different geography since the shared component only accounted for a small proportion of total variability in each indicator
- The shared component was mainly driven by Unemployment

Results of multivariate spatial factor analysis

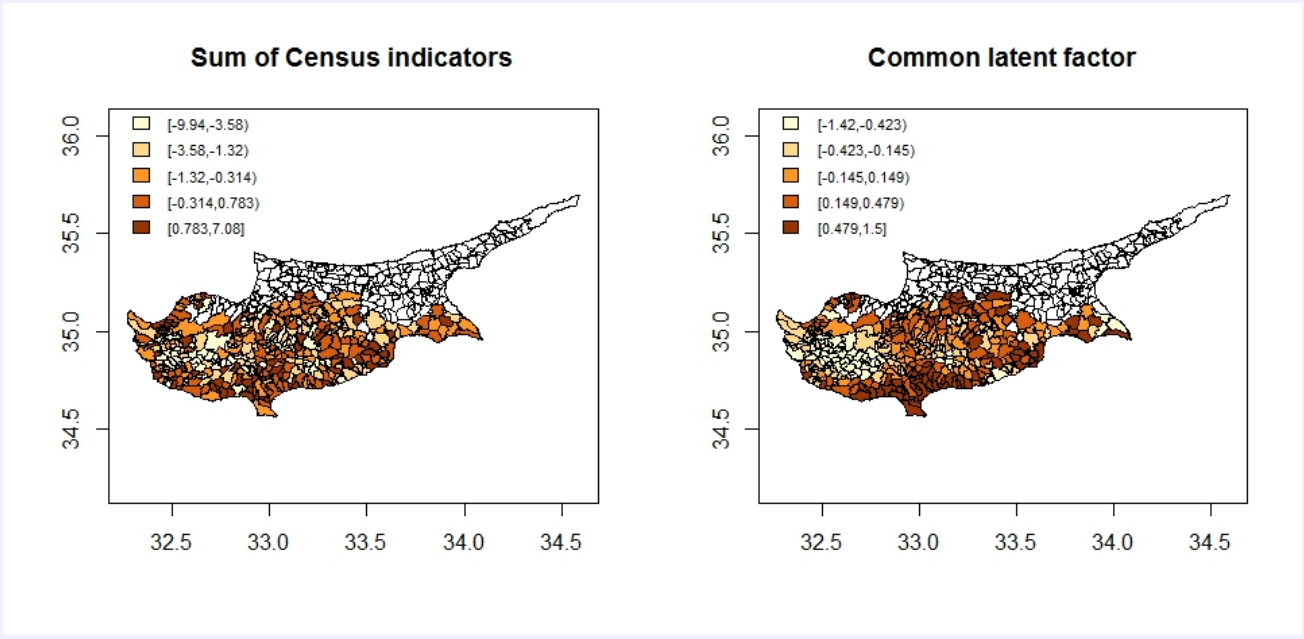


Figure : Choropleth maps of the Sum of Census Indicators(left) and the Common Latent Factor (right) across Cypriot communities in quintile class intervals

Assocation of the composite measures with mortality

- The Pearson correlation of the Common Latent Factor with Standartised Mortality Ratios (SMR) was
- The Pearson correlation of the Sum of Census Indicators with SMR was

Conclusions

- A spatial factor model has been employed to investigate the construct validity of a Townsend-like Index in Cyprus
- A Townsend-like Index does not appear to be an adequate measure of socio-economic deprivation in Cyprus
- Efforts are concentrated in developing a home-grown index from a wider set of possible indicators and exploring its predictive ability based on its association with health outcomes

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