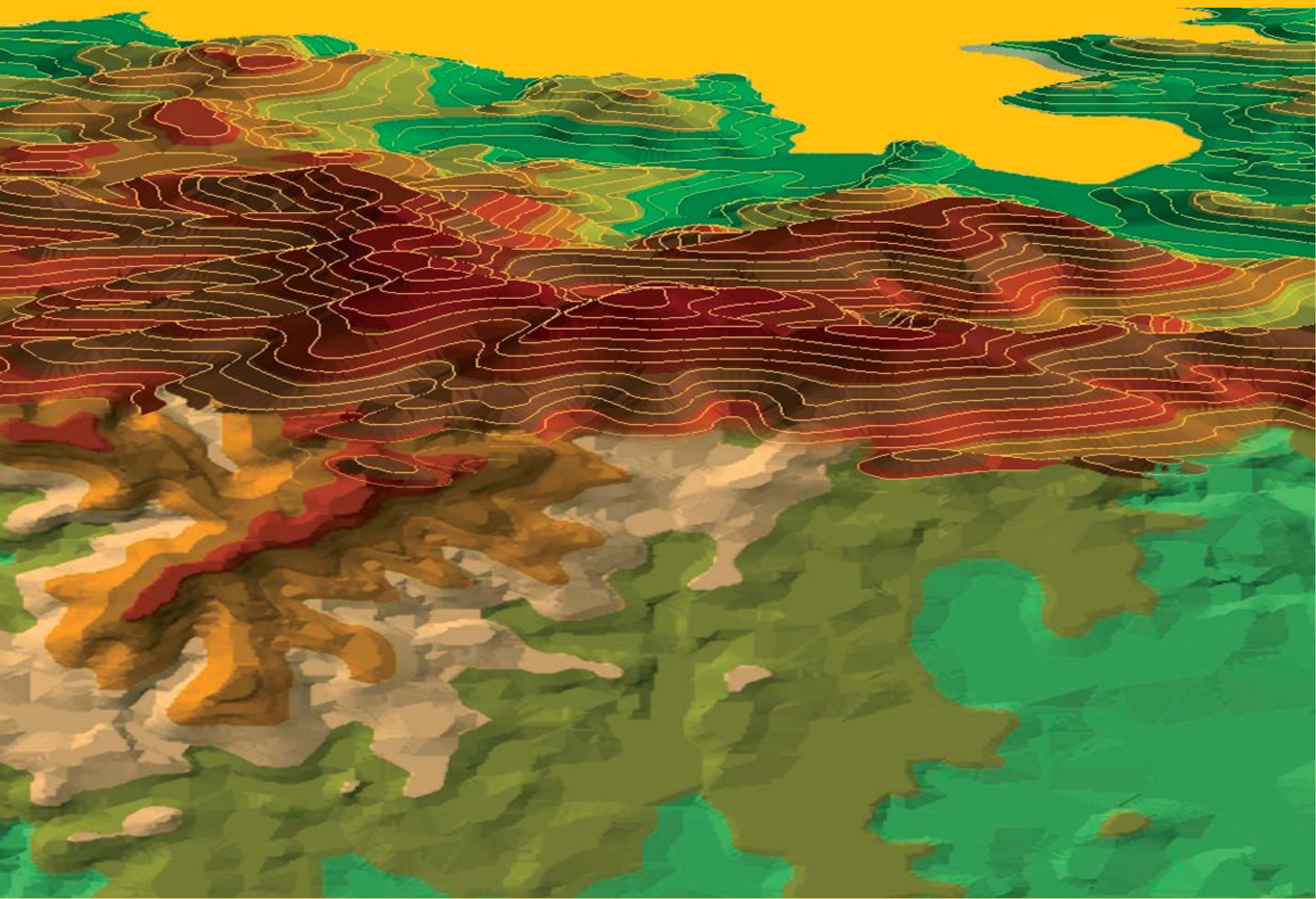
Vol. 28/2020 No. 1

MORAVIAN GEOGRAPHICAL REPORTS



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PUBLISHER

The Czech Academy of Sciences, Institute of Geonics (ID: 68145535)
Department of Environmental Geography
Drobného 28, 602 00 Brno, Czech Republic
(e-mail) mgr@geonika.cz
(home page) http://www.geonika.cz

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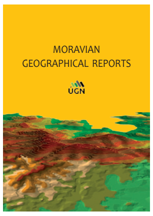
ISSN 2199-6202 (Online)



MORAVIAN GEOGRAPHICAL REPORTS

The Czech Academy of Sciences, Institute of Geonics

journal homepage: **http://www.geonika.cz/mgr.html**

doi: **https://doi.org/10.2478/mgr-2020-0001**

Changes in the geographical distribution of youth poverty and social exclusion in EU member countries between 2008 and 2017

Erik ŠOLTÉS [a *], Mária VOJTKOVÁ [a], Tatiana ŠOLTÉSOVÁ [b]

Abstract

With respect to the fulfillment of the objectives of the Europe 2020 strategy, the threat of poverty and social exclusion has not been sufficiently reduced in the European Union (EU) over the past decade, and large regional disparities persist. Young people are the most affected by the problems of income poverty, material deprivation and labour market exclusion, which are the three dimensions of poverty and social exclusion. In this article, we focus on comparing the EU countries in terms of the three listed dimensions, while revealing similarities and differences in the incidence and severity of these social phenomena among youth. In addition to measuring dimensions by the currently used AROPE (at risk of poverty or social exclusion) rate, we also use a larger spectrum of relevant indicators for a more comprehensive analysis. While the AROPE aggregate indicator uses the same methodology for the population of young people as for the whole population, our approach includes indicators that are specific to young people. We assume that all dimensions affect each other, so we apply multi-dimensional statistical methods such as principal components and cluster analysis to analyse them. These methods have revealed that some dimensions affect poverty and social exclusion to a greater extent and others to a lesser extent than might appear to be the case, based on AROPE's partial rates. Moreover, we present quantified integral indicators that together with the results of the multivariate methods, provide a rather complex picture concerning the geographical distribution of poverty and social exclusion, as well as their dimensions in the EU, for the population of persons aged 18–24 years in 2008 and 2017.

Key words: *youth, poverty, social exclusion, principal component analysis, cluster analysis, Europe 2020 Strategy, European Union*

Article history: *Received 12 June 2019, Accepted 7 February 2020, Published 31 March 2020*

1. Introduction

Poverty and social exclusion affect the health and well-being of many people and limit their opportunities to achieve their full potential. Without effective educational, health, social, tax-benefit and employment systems, the risk of poverty is passed on from one generation to the next. This causes poverty to persist, creating more inequality that can lead to the long-term loss of economic productivity from whole groups in society and hamper any inclusive and sustainable economic growth (Eurostat, 2018g, p. 104). Income poverty and social exclusion is a serious problem addressed by the Europe 2020 strategy, and social inclusion is one of the five key quantitative targets for smart, sustainable and inclusive growth. In the fight against poverty and social exclusion, however, one item with the least progress has been made so far in the Europe 2020 strategy, and regional disparities have not been reduced either (Eurostat, 2019b, p. 9; Eurostat, 2019c). In this strategy, the European Union has set itself the goal of reducing the population at risk of poverty or social exclusion to 20 million, so that the EU population has not more than 95.908 million poor or socially excluded people (Atkinson et al., 2017, p. 47). Progress in achieving the above-mentioned key target is monitored by Eurostat through an aggregate indicator AROPE (the 'at risk of poverty or social exclusion' rate), combining three rates: the at-risk-of-poverty rate (AROP); the severe material deprivation rate (SMD); and the very low work intensity

[a] Department of Statistics, Faculty of Economic Informatics, University of Economics in Bratislava, Slovakia (corresponding author: E. Šoltés, e-mail: *erik.soltes@euba.sk*)

[b] Department of Mathematics and Actuarial Science, Faculty of Economic Informatics, University of Economics in Bratislava, Bratislava, Slovakia

rate (VLWI). This three-dimensional concept of poverty and social exclusion, reflecting these three dimensions of income poverty, material deprivation and exclusion from the labour market, is used in this article as well.

The objective of the Europe 2020 strategy in the fight against poverty and social exclusion will no longer be met with certainty, which is confirmed by the fact that from the reference year 2008 to 2017, the AROPE rate has only decreased by 1.3 percentage points, and in the EU-27 and EU-28, there were 111.894 million, or 112.978 million Europeans at risk of poverty or social exclusion. In 2017, more than 1/5 of the EU population (22.4%) was at risk of poverty or social exclusion, and nearly 1/3 of them were simultaneously affected by two dimensions or even all three dimensions. The estimated population in the EU at risk of poverty in 2017 and/or severely materially deprived and/or living in households with very low work intensity, still exceeded the target threshold (approximately 96 million inhabitants) by over 15 million people. While there has been some progress in the entire population and also in the population of children under 18 and in the post-productive population, between 2008 and 2017 the proportion of people at risk of poverty or social exclusion in the population of young people aged 18–24 in the EU-27 increased by 0.9 percentage points, and in 2017 it was 29.1% (authors' calculation based on the database from Eurostat, 2020). Several authors, such as Camilleri and Camilleri (2016) and Pastore (2017), point to the unsatisfactory social inclusion of young Europeans, and to the difficulties in applying them to the labour market in relation to deficiencies in the education system. Publications that rely on official Eurostat statistics or national statistics classify young people as risky groups, as evidenced by the statement:

> "The most vulnerable groups appear to be the same across all three dimensions of poverty, inactive persons, single parents, households of only one person, people with low educational attainment, foreign citizens born outside the EU, and those residing in rural areas." (Eurostat, 2018g, p. 12).

Eurostat is currently using the above-mentioned three-dimensional concept (AROPE) to measure poverty and social exclusion. Despite the relatively broad spectrum of indicators characterising income poverty, material deprivation and labour market exclusion, the aggregate AROPE indicator, which assess these social phenomena comprehensively, using only three measures, provides only a partial picture of poverty and social exclusion. The aim of this research is to build a new integral indicator that will more comprehensively assess the poverty and social exclusion of young people in any year under review, with the individual dimensions of this multidimensional phenomenon captured by partial factors. Each factor will be based on a number of relevant indicators that characterise the incidence and depth of the respective dimension of poverty and social exclusion among young people. Such an approach will ensure that the partial factors will more comprehensively assess the dimension as one measure (AROP, SMD or VLWI), as used in the current concept. Based on such constructed factors using cluster analysis, the article will reveal similarities and differences in poverty and social exclusion of young people aged 18–24 in the EU area. As the fight against poverty and social exclusion is one of the priorities of the Europe 2020 strategy, through the above-mentioned factors and the integral indicator, we map the progress of EU countries in the various dimensions of the multidimensional phenomenon under review, from the Europe 2020 reference year (2008) up to the present (at the time of writing, the most recent available data was for 2017).

Based on this analysis, the European Union and its individual member states may identify the dimensions on which they should concentrate in the forthcoming period in the fight against poverty and social exclusion of young people (the most vulnerable age group), and thus contribute to the Europe 2020 strategy as well as to the current Agenda 2030.

2. Motivation and background

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, emphasises the urgency of intensifying social inclusion, mainly through its first objective: No Poverty. In addition, within its 17 Sustainable Development Goals, it pays particular attention to youth employment in the labour market. For example, the 4th Goal: Quality Education, aims, among other things, to increase the number of young people with the appropriate skills to adequately engage in the labour market, and the 8th Goal for Decent Work and Economic Growth, pays special attention to job creation for young people not in the area of education, employment and training in order to avoid being discouraged from finding a job. According to Eurostat (2018h), which assesses progress in achieving the EU's 2030 Sustainable Development Goals, the population of young people aged 18–24 was most at risk of poverty or social exclusion in 2016. In addition, the situation of young people aged 18–24 has deteriorated the most compared to other age groups since 2010. Chen et al. (2018) rated inequality and poverty across generations in the EU and found that the generation of young people was the most affected by poverty in the different geographical areas of the EU between 2007 and 2015, and was significantly higher in the 18–24 age group than in other age groups.

According to Eurostat (2018h) and Chung et al. (2012), young people are among the most vulnerable groups because they are more likely to face low employment rates and more job insecurity. Jobs for young people are important for their social, economic and political inclusion. Young people who are not in employment or in education and training (NEET), are mostly exposed to an even higher risk of not applying to the labour market and experiencing social exclusion. The intense relationship between NEETs and the risk of poverty and social exclusion in the young population in EU countries was confirmed by Ruesga-Benito et al. (2018). According to Eurostat (2018f), the general pattern is that the development of youth unemployment reflects the evolution of unemployment across the population, but younger people are often more affected by rising unemployment than older people. The employment of young people during the last decade has been significantly influenced by the financial and economic crisis and its consequences (Carcillo et al., 2015). As Bradford and Cullen (2014) point out, austerity measures and cuts during the financial and economic crisis have had a significant impact on youth policies, with negative consequences for poverty and social exclusion among young people. The most affected countries were in southern Europe (Poulou, 2014, p. 1163), which showed the highest youth unemployment rates (especially in Spain, Greece and Italy), the highest share of persons employed involuntarily on a part-time or temporary basis (Greece, Spain, Italy and Cyprus), and the highest proportion of over-qualified young people (Spain, Cyprus, but also Ireland). Kretsos (2014) confirmed that drastic labour market and welfare state reforms in Greece during economic crises severely weakened the protection of young people from the risk of unemployment and other stressors. Soler et al. (2014) showed the dramatic impact on unemployment of the financial and economic crisis in Spain, while the disparities between the unemployment rate among young people and the population as a whole increased significantly – to the disadvantage of youth between 2009 and 2012.

According to Aassve et al. (2013), by far the worst prospects for reducing unemployment during the recession were young people aged 18–24. That is why, in 2013, all EU countries committed themselves to the Youth Guarantee Program, in which the European Council underlines the need to effectively improve the situation of NEETs and overcome the problem of youth unemployment in the EU (2013). It has to be said that, for example, according to the European Commission (2018), improvements have recently been made in the labour market, resulting in a significant decrease in the proportion of young people who are neither in employment nor in education or training (NEET).

As this article focuses on the geographical distribution of poverty and social exclusion among young people in the EU, two recent scientific articles (Pickard and Bessant, 2018; Skattebol and Redmond, 2019), dealing with a spatial analysis of the phenomena, must be acknowledged. Skattebol and Redmond (2019) found that young people who have grown up in poverty and especially in isolated suburbs, have limited access to out-of-school activities that could be beneficial for improving their communication skills, teamwork skills and other soft skills. Such social exclusion for geographic reasons significantly eliminates the possibility for young people to acquire new knowledge and skills. Pickard and Bessant (2018) noted that, due to the austerity measures during the recession, there was a disproportionate impact on particular demographic groups and especially young people. The authors have shown that greater exposure to the risk of poverty, material deprivation and youth unemployment in Eastern Europe, compared to the core of Europe, is associated with lower political participation by young people. The authors found that young people on the periphery of Europe (especially in Eastern Europe) tend to refrain from any involvement in political events. Therefore, poverty and the social exclusion of young people have a negative impact on decision-making processes in the democratic system.

These studies confirm that the issues of applying young people in the labour market and combating poverty and social exclusion among young people, are very timely, and they inspired us to analyse the incidence and severity of poverty and social exclusion of young people aged 18–24 in the EU geographical area in 2017, an a comparison to 2008.

Studies are increasingly appearing in the professional and scientific literature that do not assess the individual dimensions of poverty and social exclusion in isolation, but also assess their interaction. For example, relationships between household joblessness, income poverty and deprivation were analysed by de Graaf-Zijl and Nolan (2011), who found that the joblessness of households significantly affects the other two dimensions, although household labour intensity does not show a consistent pattern in groups of countries categorised together in terms of welfare regimes or in geographical terms. Income poverty in relation to material deprivation was also assessed by several authors: Guio and Maquet, 2006; Horáková et al., 2013; Labudová et al., 2010; Nolan and Whelan, 2010; and Želinský, 2010. The influence of labour market exclusion or low work intensity of households on poverty was demonstrated by Guagnano et al. (2013), Kis and Gábos (2016) and Mysíková et al. (2015). Ayllón and Gábos (2017) and Řezanková and Želinský (2014) confirmed the impact of very low work intensity and the joblessness of households on material deprivation in Central and Eastern Europe and the Czech Republic, respectively. The results of analyses presented by Šoltés et al. (2018), Šoltés and Ulman (2016), and Šoltés and Vojtková (2018) showed that there is a significant correlation between certain dimensions of poverty and social exclusion, such as income poverty, material deprivation and exclusion from the labour market.

The results of previous research have motivated us to consider the dimensions of poverty and social exclusion interdependently, and to analyse them comprehensively as part of a single phenomenon. Moreover, in the analyses presented in this article, we are not confining ourselves to the AROPE aggregate indicator and its sub-measures, but we also use other indicators to map and compare not only the incidence of income poverty and social exclusion, but also the depth of these negative phenomena in the young population in EU countries.

3. Data and methods

The research results presented in this article are based on timely and internationally comparable data that are publicly available on Eurostat's website. The geographical unit is a country, as most of the indicators are monitored or published by Eurostat for countries and, exceptionally, for territorial units broken down by classification NUTS2. In this article, a spatial as well as a temporal comparison of poverty and social exclusion of young people in the EU is presented. In order to make the results of the analyses for the years 2008 and 2017 comparable, in 2017 we do not consider Croatia, although since 2013 it is an EU member state. So, in both years we are observing the same group of EU-27 countries. The tools for analysis of the data are the multidimensional statistical methods outlined in Section 3.2.

3.1 Statistical data

The basic indicators mapping poverty and social exclusion in the EU include the above-mentioned partial indicators: AROP = at-risk-of-poverty rate; SMD = severe material deprivation rate; and VLWI = very low work intensity rate, making up the aggregate indicator AROPE, which maps "only" the occurrence of poverty and social exclusion, but not the depth of those negative phenomena. Therefore, we have decided to use some additional indicators that characterise the dimensions of poverty and social exclusion from different perspectives (including their severity). Such an approach should lead to the creation of a more objective and more complex picture of the observed phenomena. This dimension of poverty and social exclusion was captured in this project by the following indicators:

The dimension of Income poverty (IP)

- At-risk-of poverty rate after social transfers (Eurostat, 2018c) – AROP
- Persistent at risk of poverty rate (Eurostat, 2018c) – Persistent_P

- In work at risk of poverty rate (Eurostat, 2018a) – In-work_P
- Housing cost overburden rate (Eurostat, 2014a) – HC_overburden

The dimension of Material deprivation (MD)

- Severe material deprivation rate (Eurostat, 2018d) – SMD
- Severe housing material deprivation rate (Eurostat, 2014c) – SHD
- Overcrowding rate (Eurostat, 2014b) – Overcrowd

The dimension of Labour market exclusion (LME)

- Unemployment rate (Eurostat, 2010) – UN
- Long-term unemployment rate (Eurostat, 2015) – Long_UN
- Share of unemployment young adults living with their parents (Eurostat, 2018b) – UN_YALWP
- Young people neither in employment nor in education and training (Eurostat, 2019a) – NEET

The above-mentioned indicators will be labelled later as source indicators. It is to be noted that our preliminary analyses revealed that the very low work intensity rate (Eurostat, 2018e) of the AROPE aggregate indicator was not an appropriate measure for assessing the poverty and social exclusion of young people in 2008 and 2017, and it is therefore not included in the list of source indicators. The irrelevance of this measure may be related to the findings of a European social inclusion monitoring (Atkinson et al., 2017), according to which in the population of young adults there is a relatively low occurrence of households with very low work intensity and a relatively high incidence of income poverty, while the opposite is true for older adults.

Employment does not protect large numbers of young adults from poverty, while many older adults are not catapulted into poverty because of a lack of employment (Atkinson et al., 2017, p. 340). Moreover, as in this scientific work, many authors, e.g. Carcillo et al. (2015) and Chung et al. (2012), prioritised indicators such as unemployment rate and NEET rate in analysing the problem of young people entering the labour market and retaining employment.

3.2 Statistical methods

To achieve the main objectives of this project – to reveal the current similarities and differences in the incidence and severity of poverty and social exclusion among young people in the EU – it is possible to apply advanced methods of multivariate statistical analysis (Hair et al., 2018; Hebák et al., 2005; Johnson and Wichern, 2002; Khattree and Naik, 2000). In Section 4, correlation analysis and principal component analysis will be applied to verify the suitability of the source indicators, and to prepare for the cluster analysis, and to create an integral indicator as presented in Section 5 (respectively 5.1 and 5.2).

At the beginning, we will examine the relationships between source indicators using correlation analysis. If the source indicators are interdependent, it is necessary to apply a method to find hidden relationships, e.g. the principal components method. Principal components analysis is technique for forming new variables which are linear composites of the original variables (source indicators). The maximum number of new variables is equal to the number of the original source variables, and the new variables are not correlated, i.e. a set of independent variables is created.

If Σ is the variance-covariance matrix of p variables $X_1, \ldots X_p$, then the total variance of these variables is defined as $tr(\Sigma)$ (the trace of matrix Σ), which is the sum of all diagonal elements of the matrix Σ. The first principal component of p by 1 vector $\mathbf{x} = (x_1 \ldots x_p)^T$ is the linear combination:

$$\boldsymbol{a}_1^T\boldsymbol{x} = a_{11}x_1 + \cdots + a_{1p}x_{1p}$$

where $\mathbf{a}_1 = (a_{11} \ldots a_{1p})^T$, with $\mathbf{a}_1^T\mathbf{a}_1 = 1$ and such that var $(\mathbf{a}_1^T\mathbf{x})$ is the maximum among all linear combinations of x, with the coefficient vector having unit length. The eigenvalues (λ) of Σ are the variances of the corresponding principal components. In that case, it is advised to start with the correlation matrix, because the measurements of different variables are not on the same scale.

Then either the principal component scores or representative variables from each component can be used to perform cluster analysis. Cluster analysis is a technique used for combining observations into groups or clusters such that:

- Each group or cluster is homogeneous or compact with respect to certain characteristics. That is, observations in each group are similar to each other; and
- Each group should be different from other groups with respect to the same characteristics.

To measure the similarity of objects in individual clusters, we will use the squared Euclidean distance, which assumes the non-correlation of source indicators.

Cluster analysis involves a wide range of methods, and in this project we chose the common application of Ward's hierarchical clustering method. This method forms clusters by maximising within-cluster homogeneity. That is, the Ward's method tries to minimise the total within-group or within-cluster sums of squares. Clusters are formed at each step such that the resulting cluster solution has the fewest within-cluster sum of squares. More formally, let $\bar{\mathbf{x}}_h$ and $\bar{\mathbf{x}}_{h'}$ be the cluster mean vectors. This measure reduces distance of clusters $\boldsymbol{C}_h$ and $\boldsymbol{C}_{h'}$ to:

$$\mathrm{D}(C_h, C_{h'}) = \frac{n_h n_{h'}}{n_h + n_{h'}} \left(\bar{\mathbf{x}}_h - \bar{\mathbf{x}}_{h'}\right)^{\mathrm{T}} \left(\bar{\mathbf{x}}_h - \bar{\mathbf{x}}_{h'}\right)$$

where $\boldsymbol{n}_h$ and $\boldsymbol{n}_{h'}$ are numbers of objects in clusters. For clusters with a single element in each of them, it reduces to half to the squared Euclidean distance between them. Ward's method tends to join clusters with a small number of observations, and it is strongly biased toward producing clusters with roughly the same number of observations.

In the last part of this analysis, we will focus on creating an integral indicator of poverty and social exclusion, which we will construct as a weighted arithmetic average of the principal components. For a particular component, we will use the ratio of variability of the source indicators that is explained by this component.

4. Analysis of source indicators suitability and preparation for next analyses

The assumption that the monitored phenomena often pertain to the same groups of people, especially if they belong to the same dimension, is confirmed by significant positive dependences among the source indicators which were revealed by correlation analysis. Those dependences are displayed on correlation maps of source indicators (see Fig. 1).

While in 2017 we see the strongest correlation between indicators from the labour market exclusion dimension (the last 4 indicators), in 2008 the indicators from this dimension showed only a mild to moderate inter-dependence. Among the rates that characterise income poverty (the first 4 indicators), we quantified a moderate to strong linear dependence in both years.

The exception is the Persistent at risk of poverty rate in 2008 and Housing cost overburden rate for 2017, which had a rather weak linear relationship with indicators from this dimension. When comparing the years 2008 and 2017, the most consistent results were recorded for material deprivation, where we confirmed a relatively strong linear dependence in both years. Among the indicators from different dimensions, the intensity of dependence was significantly weaker and in many cases was not statistically significant.

For cluster analysis, where we used the Euclidean distance as a measure of dissimilarity of individual countries, it was necessary to transform the original interdependent source indicators into uncorrelated factors. Principal component analysis was implemented to serve that purpose. We attempted to create such factors that would be determined by those source indicators which would facilitate their interpretation. Simultaneously, we wanted to decrease the number of factors, i.e. to achieve a reduced number of factors compared to the source indicators, while those factors would still comprise at least 75% of information provided by the source indicators.

In order to assess the suitability of source indicators for principal component analysis, we applied the Kaiser-Meyer-Olkin measure (Stankovičová and Vojtková, 2007). The KMO statistics (Tab. 1) showed average to above-average suitability of the source indicators for further analysis.

While in 2008 the eligibility values of individual source indicators were at an acceptable level (exceeding 0.5), in 2017 the Housing cost overburden rate was not suitable for principal component analysis (value of Kaiser-Meyer-Olkin measure for "Housing cost overburden rate" was less than 0.5). Thus, in the further analyses for 2017, we did not consider this indicator. The overall adequacy of input data reached the value 0.590 in 2008 and the value of 0.713 in 2017.

On basis of Kaiser's rule for eigenvalues (Fig. 2) in correlation matrices, which states that only factors with eigenvalues greater than average eigenvalue should be used (the average eigenvalue of a correlation matrix is 1), we decided to set the number of factors to three in both years. The first three principal components account for 76.55%

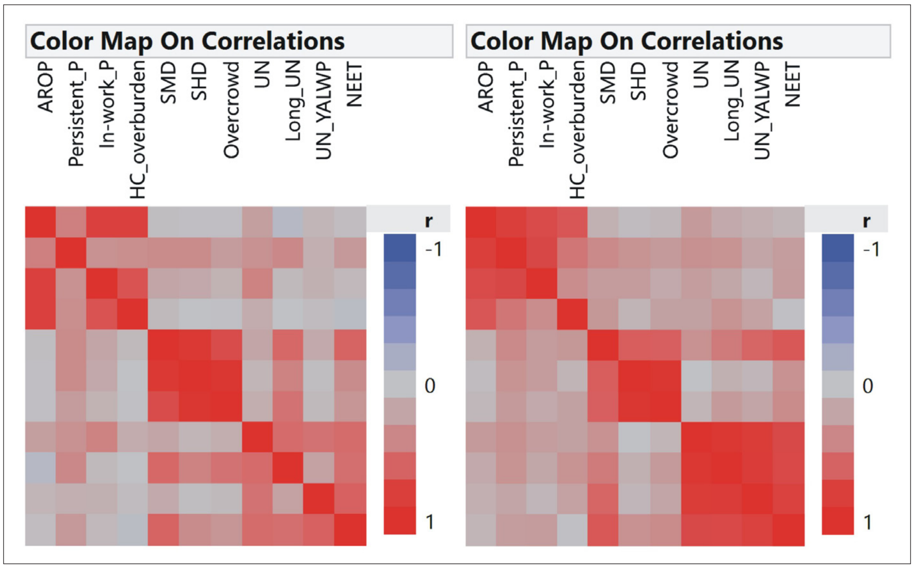


Fig. 1: Correlation maps of source indicators for 2008 (left) and 2017 (right)
Source: Eurostat data; authors' computations using SAS JMP

Kaiser's Measure of Sampling Adequacy:
Year 2008: Overall MSA = 0.590
Year 2017: Overall MSA = 0.713

Year	AROP	Persistent_P	In_work_P	HC_overburden	SMD	SHD	Overcrowd	UN	Long_UN	UN_YALWP	NEET
2008	0.548	0.514	0.583	0.725	0.684	0.520	0.534	0.634	0.544	0.612	0.700
2017	0.568	0.715	0.741	–	0.730	0.579	0.609	0.728	0.787	0.739	0.873

Tab. 1: Values of Kaiser-Meyer-Olkin measure for source indicators for 2008 and 2017
Source: Eurostat data; authors' computations in SAS Enterprise Guide

Eigenvalues

Number	Eigenvalue	Percent	Cum Percent
1	4.1180	37.436	37.436
2	2.5794	23.449	60.885
3	1.7233	15.666	76.551
4	0.7314	6.649	83.201
5	0.6237	5.670	88.871
6	0.3876	3.524	92.395
7	0.3694	3.358	95.753
8	0.2226	2.023	97.777
9	0.1409	1.281	99.057
10	0.0692	0.629	99.687
11	0.0345	0.313	100.000

Eigenvalues

Number	Eigenvalue	Percent	Cum Percent
1	4.5715	45.715	45.715
2	2.1398	21.398	67.113
3	1.8990	18.990	86.102
4	0.4218	4.218	90.320
5	0.3557	3.557	93.877
6	0.2049	2.049	95.926
7	0.1549	1.549	97.475
8	0.1176	1.176	98.651
9	0.0736	0.736	99.388
10	0.0612	0.612	100.000

Fig. 2: Eigenvalues of the correlation matrices (PCA method) for 2008 (top) and 2017 (bottom)
Source: Eurostat data; authors' computations in SAS JMP

Rotated Factor Loading

	Factor 1	Factor 2	Factor 3
AROP	-0.033830	0.951403	0.048513
Persistent_P	0.332888	0.435283	0.250618
In-work_P	0.131660	0.827523	0.105338
HC_overburden	-0.046433	0.827010	-0.005224
SMD	0.837164	0.060023	0.340253
SHD	0.996508	0.060441	0.057603
Overcrowd	0.881005	0.043261	0.071366
UN	0.038406	0.253797	0.694705
Long_UN	0.394037	-0.065072	0.560444
UN_YALWP	-0.007807	0.063720	0.682023
NEET	0.324822	-0.012051	0.827999

Rotated Factor Loading

	Factor 1	Factor 2	Factor 3
AROP	0.085950	-0.058608	0.906586
Persistent_P	0.163566	0.225266	0.880602
In-work_P	0.078026	0.173135	0.796313
SMD	0.452568	0.631788	0.146984
SHD	-0.020977	0.985139	0.121492
Overcrowd	0.120430	0.879900	0.089708
UN	0.899187	-0.015567	0.225889
Long_UN	0.890355	0.138557	0.144229
UN_YALWP	0.919010	0.101681	0.039283
NEET	0.795002	0.343404	0.077666

Fig. 3: Factor loadings after Equamax rotation for 2008 (top) and 2017 (bottom)
Source: Eurostat data; authors' computations in SAS JMP

of the total variability in 2008, and in 2017 for 86.10% of the variance information provided by the source indicators. These principal components are linearly independent and they provide the required amount of information (over 75%). In order to adequately interpret them, however, we performed some rotations and the results of an orthogonal rotation by the Equamax method are shown in Figure 3.

From the values of the rotated component loadings (Fig. 3), we can see correlations between the source indicators and the rotated principal components or factors. After rotation, the principal components were formed in such a way that they significantly correlate with the indicators of one dimension compared to the indicators of the other two dimensions. As we can see from this table, income poverty is presented by the second factor for 2008 and the third factor for 2017. The material deprivation dimension is represented by the first factor for 2008 and the second factor for 2017. The labour market dimension exclusion is characterised by the third factor in 2008 and the first factor in 2017. For the sake of clarity, txhe further representatives of income poverty will be referred to as IP, and MD will be used to indicate the material deprivation factor, and the LME is the factor for labour market exclusion. Although these factors are convincingly determined by measures of the relevant dimension, some indicators have a positive moderate correlation with other dimensions. In 2008, the long-term unemployment rate correlates with the MD factor. In both years, the indicators of persistent risk of poverty and the NEET rate show moderate positive dependence with MD. The LME factor is positively related to the severe material deprivation rate.

5. Results

Although the results of the correlation analysis and principal component analysis have brought some interesting findings, in Section 4 they have been mainly used as a tool for transforming the source indicators into new variables appropriate for further analysis. The principal components analysis resulted in three independent factors, each representing one dimension of poverty and social exclusion. These factors (precisely, the factor scores) will be used in Sections 5.1 and 5.2 as input variables for cluster analysis and for the creation of an integral indicator, respectively.

5.1 Results of a cluster analysis of EU member countries in terms of income poverty and the social exclusion of youth in 2008 and 2017

The factor scores we have obtained in Section 4, are appropriate for cluster analysis with the aim to create clusters of EU member countries, where countries falling into a common cluster would be most similar in terms of poverty and the social exclusion of young people, while countries in different clusters would be significantly different. To make the cluster analysis not self-purposeful, we will characterise individual clusters based on factors each representing one of the IP, MD, or LME dimensions. The characteristics of the clusters will provide an overview of the state of poverty and the social exclusion of young people in the countries under review, without having to deal with each country separately. Since the sophisticated procedures used in the cluster analysis ensure relatively high within-group homogeneity, so the cluster characterisation also well describes the state of the countries included in the cluster. It should be kept in mind, however, that there are also differences between countries within a single cluster. Cluster analysis will therefore give us a clear picture of the weaknesses as well as the strengths of the social inclusion of young people in EU countries. Moreover, by comparing the results for 2008 and 2017, we can see whether the EU countries under review have made progress in combating poverty, deprivation and labour market exclusion among young people, or conversely, the inclusion of youth in that country has deteriorated compared to other EU countries.

Using Ward's method (Hebák et al., 2005), which due to its excellent results is the most popular of hierarchical clustering procedures (Loster and Pavelka, 2013), we obtained the dendrograms represented in Figure 4. The dendrogram is supplemented by the so-called 'heat maps' of the three factors: IP, MD and LME respectively. The spatial distribution of income poverty, material deprivation and labour market exclusion in the youth population in 2008 and 2017 is provided by heat maps in Figure 5.

The results of the cluster analysis (Fig. 4) and the factors themselves (Fig. 5) obtained by principal components analysis provide some interesting information that we firstly interpret for 2008 and then for 2017.

In 2008, we found the most suitable results in the 4th cluster (the Czech Republic, Cyprus, Austria, Estonia, Slovenia, Malta), which had no major problems in any dimension of poverty and the social exclusion of young people aged 18–24, which are confirmed by the above-average good (in some cases average) values of the factors IP, MD, LME shown in heat maps in Figure 4. The 4th cluster was characterised by the smallest threat of income poverty, and after the 5th cluster (Denmark, the Netherlands) the second smallest exclusion from the labour market.

As the second best cluster, we can mark the 1st cluster (Belgium, Luxembourg, United Kingdom, France, Portugal, Germany, Finland), in which young people, in comparison with other EU countries, were exposed to income poverty and exclusion from the labour market at approximately the average level. In the material deprivation dimension, this cluster recorded above-average good results (average results for Portugal).

Other clusters of countries were characterised by problems in one or more of the dimensions of poverty and the social exclusion of young people. The material deprivation of young people affected the 6th cluster of countries (Bulgaria, Hungary, Latvia, Lithuania, Poland, Slovakia, Romania) to a much greater extent than other countries. In this cluster, Romania and Slovakia, which were the last joined to the clustering process, stand out. In 2008, young people in Romania were subjected to extreme material deprivation, while we see a large difference between Romania and the following Bulgaria, but the gap between Romania and the other 25 EU-27 countries (except Bulgaria) is particularly evident. Romania, unlike other countries in this cluster, has seen one of the greatest threats to income poverty among young people. On the contrary, Slovakia was doing very well in terms of income poverty among young people. In terms of income poverty and material deprivation, Slovakia was at a comparable level to that of countries in the 4th cluster, but recorded significantly worse results in the labour market exclusion dimension.

The 1st, 4th and 6th clusters include a total of 20 EU-27 countries in 2008. The remaining 7 countries are in the other 3 clusters. The 2nd cluster (Greece, Sweden) in 2008 was characterised by a high threat of relative income poverty (at the Romanian level) and above-average exclusion of young people from the labour market. In the income poverty dimension, however, the worst results were identified in the 5th cluster of countries (Denmark, the Netherlands), in which we mainly attribute this to Denmark. The biggest problems with the participation of young people in the labour market have been revealed in the 3rd cluster of countries (Ireland, Spain, Italy). The 5th and 3rd cluster of countries have had significant social inclusion problems and the struggle against youth poverty only in one dimension

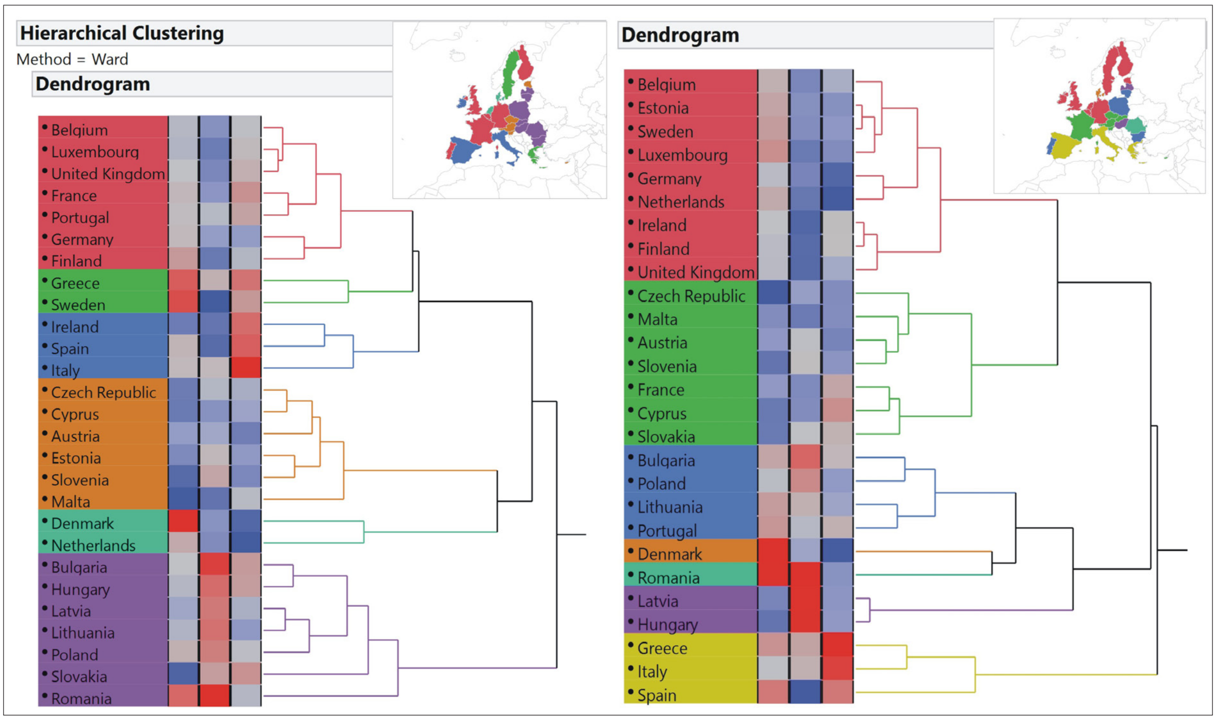


Fig. 4: Dendrograms of EU country clusters according to factors of poverty and the social exclusion of youth in 2008 (left) and 2017 (right)
Source: Eurostat data; processed by the authors in SAS JMP

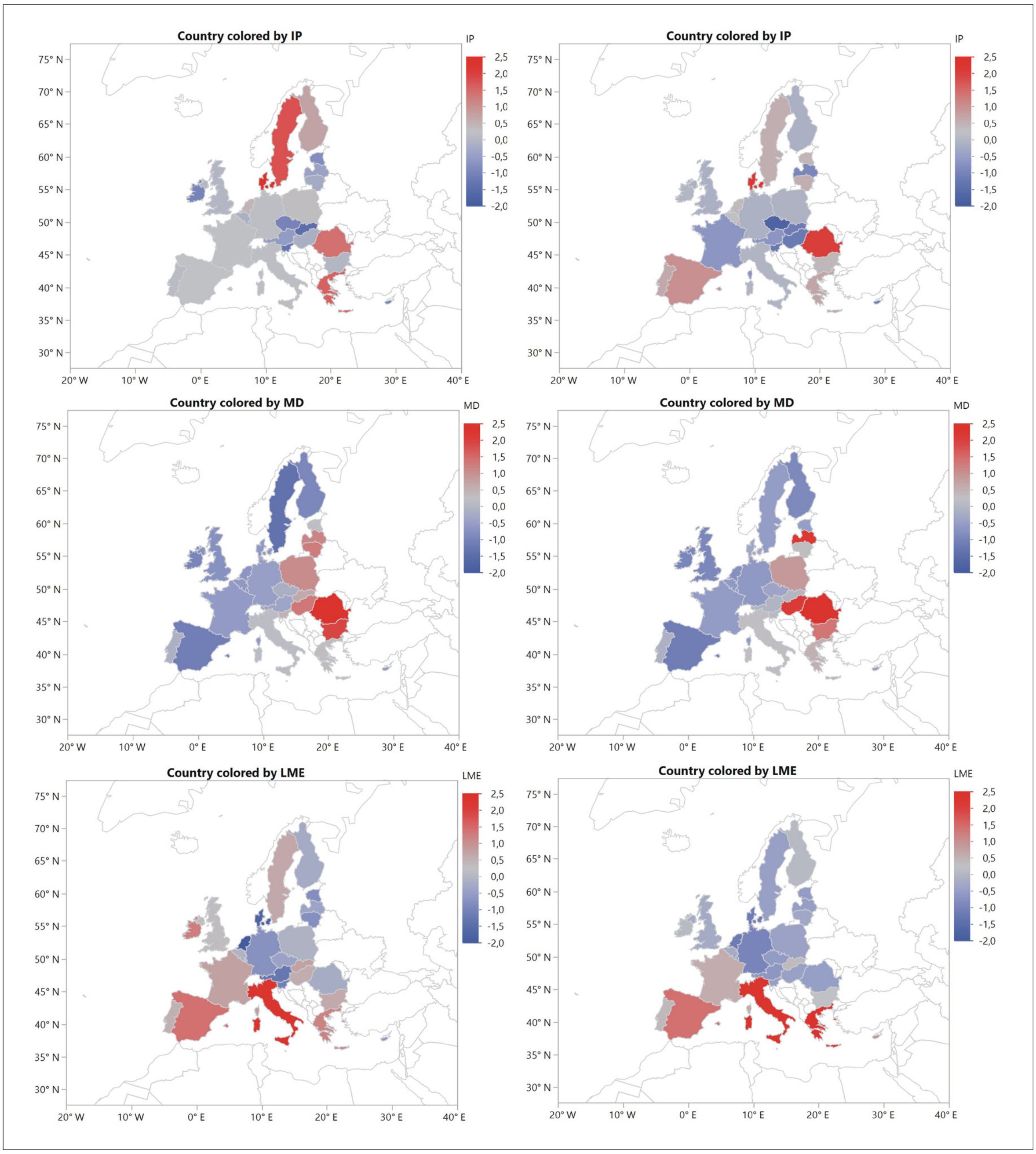


Fig. 5: Heat maps of factor: IP – Income Poverty (first row); factor MD – Material Deprivation (second row); and factor LME – Labour Market Exclusion (third row), for the population of young people (18–24 years old) in 2008 (left) and 2017 (right). Sources: Eurostat data; processed by the authors in SAS JMP

that we have mentioned, and in the other two dimensions they have achieved at least average results in the EU-27 geographic area.

In 2017, the best results were diagnosed in the 1st cluster (Belgium, Estonia, Sweden, Luxembourg, Germany, the Netherlands, Ireland, Finland and the United Kingdom) and in the 2nd cluster (the Czech Republic, Malta, Austria, Slovenia, France, Cyprus and Slovakia).

In the 2nd cluster of countries, the population of young people among all the clusters had the least threat of income poverty and it showed no major problems in the material deprivation dimension. Looking at the clustering process within cluster 4 in the dendrogram in Figure 4 (on the right), we see that four countries (Czech Republic, Malta, Austria, Slovenia) were merged into one group, which achieved better than average results in 2017 in all three dimensions, and that three countries (France, Cyprus and Slovakia) were merged into another group, in which we diagnosed the problem of getting young people into the labour market in 2017.

The 1st cluster is characterised by the smallest material deprivation of young people and by average to above average good results in the LME dimension. Most countries in this cluster, however, report an above-average threat of income poverty among young people.

The first two clusters include 16 countries from the 26 EU countries under review. These two clusters consist of almost the same countries as the 1st and 4th cluster of 2008, which we also rated positively. The first two clusters of 2017, unlike clusters 1 and 4 of 2008, do not include Portugal, but include Sweden, the Netherlands, Ireland and Slovakia. Sweden and Ireland in international comparisons in 2017 did not show such problems with participation of young people in the labour market as in 2008, and Slovakia managed to reduce problems in this dimension, in particular by eliminating the long-term unemployment of young people.

The 3rd cluster (Bulgaria, Poland, Lithuania and Portugal) is characterised by considerable material deprivation of young people in 2017, with the most critical situation in Bulgaria. Similarly to the countries of the 1st cluster, as well as the countries in the 3rd cluster, they reported an above-average threat of income poverty in the population of young people in 2017. In the LME dimension, the 3rd cluster reached approximately average values.

The other four clusters are very specific. Romania (5th cluster) had extreme material deprivation of young people in 2017, but unlike Bulgaria, this was mainly due to severe housing deprivation, but also (as in Bulgaria) a high rate of overcrowding. What made Romania significantly different from other clusters, was that the risk of income poverty for young people was extremely high. In this dimension, the differences between Romania and other EU countries in 2017 deepened in comparison with 2008. Moreover, if we realise that the at-risk-of-poverty rate and its derived measures, such as the persistent at-risk-of-poverty rate and in-work at-risk-of-poverty rate measure, and relative poverty with respect to the median of national income, the income poverty in Romania is even more acute. To be precise, the poverty risk threshold is set at 60% of the median equivalent disposable income.

The alarming state of poverty in Romania is underlined by the fact that this country has the lowest at risk of poverty threshold among all EU countries. In 2017, this threshold was 1,645 euro per year in Romania, while in Western and Northern Europe it was 8 to 9 times higher. Even countries with a relatively low median income (Bulgaria and Hungary) had a significantly higher at risk of poverty threshold (2,154 euro per year and 2,993 euro per year, respectively) than Romania. In the context of this, poor results of Denmark (4th cluster) in the income poverty dimension are not so surprising. Denmark had the second highest at risk of poverty threshold after Luxembourg (17,630 euro per year), which is approximately 10.5 times higher at risk of poverty threshold than in Romania. The only dimension in which Romania has achieved relatively good results in the youth population was the labour market exclusion dimension. In the LME dimension, Denmark, similar to the Netherlands, achieved the best results in the EU-27.

The 6th cluster consists of Latvia and Hungary. In these two countries, young people faced severe deprivation in 2017, especially in the housing sector. In the other two dimensions, the population of young people in these two countries was above average.

The countries of the 7th cluster in 2017 (Spain, Italy, Greece) faced the challenge of participating young people to the labour market, with the worst situation in Greece. In 2017, young Greeks had more problems in this dimension than in the pre-crisis period, while in Italy and Spain the situation in 2017 was comparable to 2008. The threat of income poverty, however, increased significantly in Spain. As regards the material deprivation of young people, in 2008 Spain achieved very good results and in 2017 it was even the leader in this dimension. If we look at the 2017 clustering process (Fig. 4, on the right), Spain was the last among all the countries analysed to be clustered. Thus, in 2017, Denmark, Romania and Spain were characterised by the least similarity with other EU countries in the field of poverty and social exclusion of young people.

5.2 Evaluation of poverty and social exclusion of youth in EU member countries based on integral indicators in 2008 and 2017

In the previous section, on the basis of the factors resulting from the principal components analysis, we have created clusters of countries in terms of youth social exclusion. The values of these factors served to create cluster profiles and, above all, to reveal the strengths and weaknesses of individual clusters. In this section, we present the values of an integral indicator of poverty and social exclusion, which we constructed as a weighted arithmetic average of the factors IP, MD and LME, separately for 2008 and 2017. For a particular factor, we used the ratio of variability of the source indicators that was explained by this factor. For example, according to Figure 2 (on the left) in 2008, the first factor explained 37.44%, the second factor explained 23.45%, and the third factor explained 15.67% of the total variance of the original indicators. Together they explained 76.55%. The first factor (factor MD) was therefore assigned an absolute weight of 37.436, which corresponds to a relative weight of 0.489 (37.436/76.551). The other factors (IP and LME) were assigned an absolute weight of 23.449 (relative weight of 0.306) and 15.666 (relative weight of 0.205), when calculating an weighted arithmetic average core. Values of integral indicators are captured in heat maps in Figure 6, where we also present the values of the aggregate indicator AROPE rate.

By comparing the ranking of the EU countries evaluated for 2017 on the basis of the AROPE rate and that on the basis of the integral indicator, we found that the lowest threat of poverty and social exclusion of young people in 2017 was in the Czech Republic. According to both approaches, the fight against poverty and social exclusion is the worst for Greece. Greece is followed by Bulgaria and Romania, while in the case of an assessment based on an integral indicator, the order of these countries is opposite and, in addition, among these countries Italy is also included. The main reason for these differences is that more source indicators have been used in our approach than in the AROPE-based approach. The second important reason is that in the relevant year 2017, the LME dimension was more weighted in the construction of the integral indicator, especially at the expense of the IP dimension. The latter has resulted in an assessment where in our approach countries with a high level of poverty risk are less "penalised" due to poor IP performance than in the AROPE-based approach. Among these countries, let us mention Denmark or the Netherlands, which ranked significantly better by ranking compiled according to the integral indicator than by the AROPE rate (see Fig. 6) in 2017.

On the other hand, in an approach based on an integral indicator, countries with poor results in the LME dimension were more "penalised". For example, in Italy in 2017, young people were at high risk of not applying to the labour market. For this reason, the assessment of poverty and the social exclusion of young Italians under our approach, was considerably worse than according to the official AROPE rate, which is also evident in Figure 6.

The advantage of our approach compared to the AROPE-based approach, is that it takes into account a wider range of relevant indicators and is not limited to only three measures

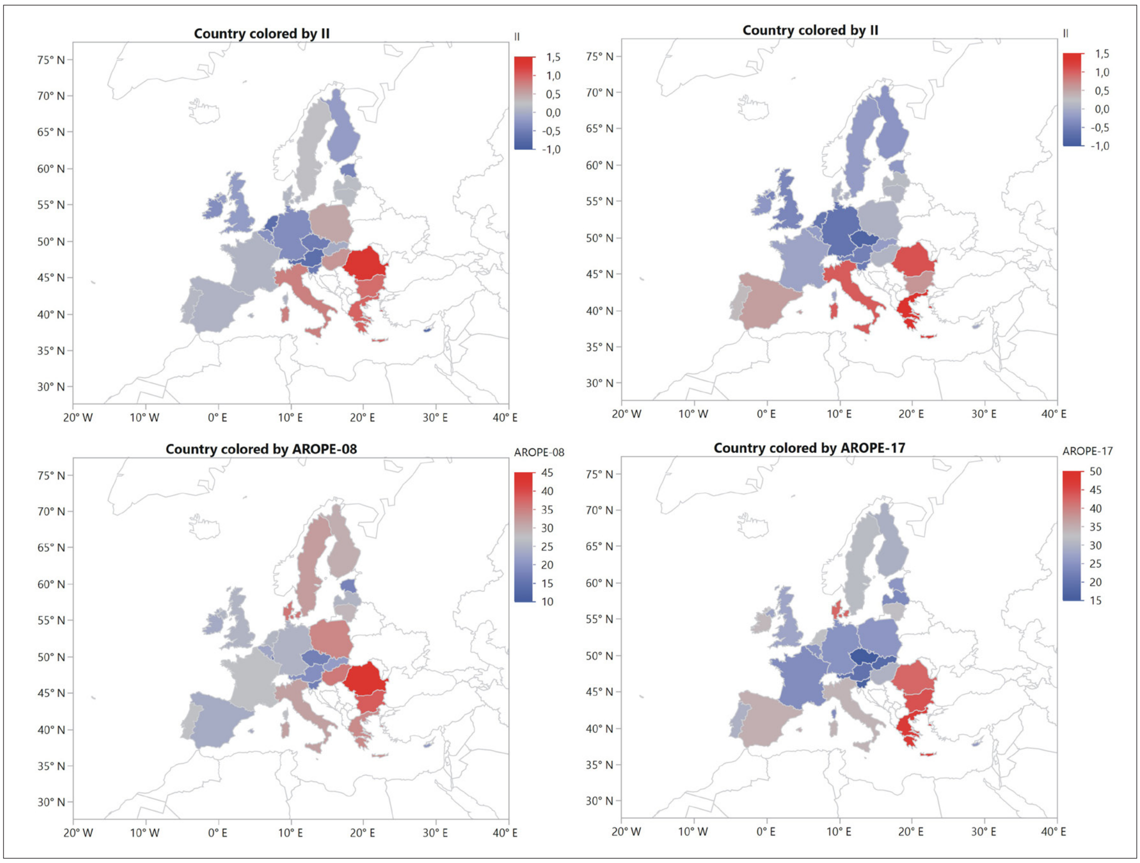


Fig. 6: Heat maps of integral indicator of poverty and social exclusion (first row) and AROPE rate (second row) for population of young people (18–24 year olds) in 2008 (left) and 2017 (right)
Sources: Eurostat data; processed by authors in SAS JMP

that only assess the occurrence of three sub-phenomena (income poverty, material deprivation and labour market exclusion). In our approach, we look at these phenomena from a different perspective. One of the perspectives, which we believe to be very important, is the severity or depth of the phenomena being monitored. In our approach, the severity of the observed phenomena is incorporated through the persistent at risk of poverty rate, the severe material deprivation rate and the long-term unemployment rate. In addition, in our approach we consider indicators that are specific to the population of young people.

This approach has therefore given us a more objective picture of young people's poverty and social exclusion than in the AROPE-based approach. In the case of the AROPE-based approach, we have to realise that the occurrence of individual phenomena can overlap, which means that income poverty, material deprivation and labour market exclusion can affect the same group of people. Therefore, the sub-measures of the AROPE aggregate indicator cannot adequately quantify the contribution of individual dimensions to the overall incidence of poverty and social exclusion. The advantage of our approach is that we use linear independent factors, each representing one dimension of poverty and social exclusion. Each of these factors contributes to the formation of an integral indicator according to its proportion to explain the variability of the source indicators. In our approach, we can therefore quantify which dimension has greater impact and which has less impact on poverty and social exclusion. In the population aged 18–24 years, the LME dimension has been shown to have a greater impact on poverty and social exclusion than might appear to be the case based on the VLWI rate included in the AROPE indicator.

6. Discussion and conclusions

In this article, we assess the poverty and social exclusion of young people in the EU countries based on 11 source indicators of poverty and social exclusion, the relevance of which has been confirmed by Ayllón and Gábos (2017), Chen et al. (2018), Chung et al. (2012), de Graaf-Zijl and Nolan (2011), European Commission (2018), Eurostat (2018h), Mysíková et al. (2015), Ruesga-Benito et al. (2018), and Šoltés et al. (2018). Through multivariate statistical procedures, a substantial part of the information contained in these indicators is transformed into three uncorrelated factors. These three factors represent the three dimensions of poverty and social exclusion, confirming the merits of three-dimensional concept of poverty and social exclusion, which is currently also used for the AROPE aggregate indicator for monitoring poverty and social exclusion in the Europe 2020 strategy. The weakness of the AROPE aggregate, however, is that each of the dimensions - income poverty (IP), material deprivation (MD) and labour market exclusion (LME) – is captured by only one measure, which evaluates that dimension from a single perspective.

In addition, the above measures (AROP, SMD and VLWI) assess only the occurrence of the social phenomenon under consideration and do not take into account the severity of these phenomena, which we try to capture in our analysis through other available indicators. By comparing the results obtained with our approach and the AROPE-based approach, we found that in the relevant years (2008 and 2017), the labour market exclusion dimension had a more significant impact on poverty and social exclusion among young people than how it was quantified by the AROPE indicator. The

AROPE aggregate indicator is currently used for the whole population, as well as for the population of young people. The measurement of poverty and social exclusion in the population of young people, however, has certain specific characteristics, particularly concerning the LME dimension. In our approach, these specifics have been captured at least partially by the chosen source indicators.

As mentioned above, from the spectrum of the original correlated indicators characterising poverty and social exclusion of young people in the EU-27 countries, linear independent factors representing the three dimensions of poverty and social exclusion of the population under review were created separately for the reference year 2008 and the most recent year 2017. By using a weighted average of the factors, we have obtained an integral indicator for 2008 and 2017. Based on the above, this integral indicator assesses the poverty and social exclusion of young people aged 18–24 years more comprehensively than the currently-used the AROPE aggregate indicator.

The factors computed in this analysis and the construction of the integral indicator make it possible to identify the weaknesses and strengths of the EU-27 countries in terms of poverty and the social exclusion of young people, and to map the progress of countries in this area with respect to fulfilling the Europe 2020 strategy. Since poverty and social exclusion is a multidimensional phenomenon and different countries may have problems in different dimensions, we used cluster analysis to reveal the different patterns of the three partial phenomena of poverty and social exclusion. Interpreting the resulting clusters of countries through factor values was an effective tool for diagnosing the bottlenecks of the EU-27 countries in the fight against poverty and the social exclusion of young people. The integral indicator designed for 2008 revealed countries that had to face the greatest poverty and social exclusion of young people at the strategy Europe 2020 starting line in the geographical space of the EU-27. The values of the integral indicator created for 2017 and their comparison with the values of the integral indicator for 2008, showed which countries just before the end of the Europe 2020 strategy, still have significant problems with poverty and the social exclusion of young people, and they revealed which countries achieved the most progress in the period, eventually failed in the subject area.

For clarity, let us point out the basic differences between the AROPE aggregate indicator and the integral indicator. The AROPE aggregate indicator is made up of three sub-measures (poverty risk rate, severe material deprivation rate and very low work intensity rate), while the labour market exclusion dimension is represented by a population living in very low work intensity households [(quasi-) jobless households]. The general pattern of decomposition of AROPE is that the (quasi-) jobless population is the smallest part of the population at risk of poverty or social exclusion. On the other hand, the largest share is the population, which according to Eurostat methodology, is at risk of income poverty. In our 2017 analysis, which took into account a larger range of relevant source indicators, however, it turned out that the factor representing the dimension of labour market exclusion was the first principal factor, meaning that from all the factors this one accounted for the largest proportion of the total common variance; thus in creating an integral indicator, we have given this factor the greatest weight. On the contrary, the factor representing the income poverty dimension in 2017 was evaluated as the third factor, and therefore we had to give it the least weight among all three relevant factors, given its contribution.

Our analyses have shown that the exclusion of young people from the labour market has a greater impact on poverty and social exclusion than might appear to be the case on the basis of the very low work intensity rate in the aggregate indicator AROPE. Based on statistical procedures, we found that when assessing the exclusion of young people from the labour market, it is appropriate to replace the standard 'very low work intensity rate', with measures such as unemployment rate, long-term unemployment rate or NEET rate. The suitability of these measures is also confirmed by Carcillo et al. (2015) and Chung et al. (2012). In addition, the unemployment rate and the NEET rate complement each other, because according to Dietrich and Möller (2016), unemployment statistics ignore some young unemployed and the NEET concept seeks to correct this deficiency and include inactive youth in a broader sense.

A lower weight was estimated for the income poverty dimension in our analysis, compared to the AROPE rate-based approach. Within this dimension, we have highlighted questionable international comparability of the 'at-risk-of-poverty', which, given the relative poverty concept on which it is based, identifies a relatively high level of poverty risk also in economically advanced countries such as Denmark, the Netherlands, Sweden or Luxembourg. Many times, however, this does not correspond to the good results in the field of social inclusion, which other statistics point to. Poverty rates currently in use only take into account a country's income, which does not always reflect the cost of living, and therefore they do not always correctly identify people affected by poverty. We agree with the proposal of Copus et al. (2015) that Eurostat and national statistical offices should include standard cost of living indicators in the EU-SILC survey, and use them to adjust the AROP rate. Copus et al. (2015) also justify the importance of using regional at-risk-of-poverty rates, and they have constructed a map of these rates at NUTS 3 across 20 European countries. Due to considerable regional disparities in the area of income poverty, Dvornáková (2012) and Faura-Martínez et al. (2016) propose to set regional 'at risk of poverty' thresholds, and thus to more objectively quantify the risk of poverty in a given country as well as across the EU. We assume that if our approach was applied to territorial units broken down by NUTS 2 classification or NUTS 3 classification, based on 'regional at-risk-of-poverty' thresholds for income poverty assessment, more homogeneous clusters would be generated and disparities revealed between territorial units within individual EU countries. At present, however, only a limited number of poverty and social exclusion indicators at NUTS 2 or NUTS 3 level are currently being monitored and therefore such an analysis could not be carried out.

The results of our research based on the cluster analysis and construction of the integral indicators have confirmed the findings of several scientific papers (Aassve et al., 2013; Andriopoulou et al., 2017; Carcillo et al., 2015; Chen et al., 2018; Pastore, 2017) that some EU countries, especially from southern Europe, have still failed to cope with the consequences of the economic crisis, and these consequences were felt by the younger generations in 2017. The most important findings from our analysis of changes in the geographical distribution of poverty and social exclusion are presented below.

In 2017, we expressed quantitatively the largest social exclusion of the younger generations in southern and eastern Europe, namely Greece, subsequently Romania, Italy and Bulgaria, followed by Spain. We must emphasise, however, that poverty and the social exclusion of young people in Greece were significantly higher than in other EU countries. While in the countries of southern Europe (Greece, Italy, Spain), this was mainly due to considerable problems with the entry of young people into the labour market, in the case of Eastern European countries (Romania and Bulgaria) it was due mainly to high material deprivation, and in the case of Romania also the very high threat of youth monetary poverty. Hungary and Latvia also have (since 2008) to face the great threat of material deprivation of young people. In addition to Romania, the fight against income poverty among young people should also be made more effective by Spain and Denmark.

The best social inclusion of young people for 2017 was expressed quantitatively on the basis of our integral indicator in the Czech Republic, Malta, Germany, the Netherlands, Slovenia and Austria. With the exception of the Netherlands, which has a relatively high risk of income poverty, all of these countries have had above average good results in all three dimensions. The Czech Republic and Slovenia have achieved the lowest threat of income poverty, followed by Hungary, Cyprus and Slovakia. Young peoples in the Netherlands, Germany and Austria, compared to other EU countries, had excellent conditions in labour market entry in 2017. Denmark achieved comparatively good result in the labour market exclusion dimension as in the Netherlands, but due to the high threat of income poverty, it was only at an average in the EU rankings.

In 2017, in comparison with 2008, the situation with respect to poverty and the social exclusion of young people aged 18–24 years has deteriorated mainly in Cyprus, Greece and Spain. In the case of Cyprus and Greece, this negative change was mainly due to an increase in the exclusion of young people from the labour market, which was the largest among the EU Member States in these two countries. The negative impact of the deteriorated labour market situation for young Greeks has been offset in the definitive values of the integral indicator by significant progress in the fight against monetary poverty. On the contrary, Spain has seen a negative development in this dimension (IP), with only Estonia, Ireland, Luxembourg and Lithuania recording a greater deterioration.

Between 2008 and 2017, poverty and the social exclusion of young people were largely eliminated in Hungary, Sweden, Poland, the Czech Republic, Bulgaria, Germany and Romania. We see that this group is dominated by the countries of Central Europe and especially the Visegrad Group (except Slovakia). Some significant achievements of Hungary and Sweden in the income poverty and labour market exclusion dimensions have been dampened by an increase in material deprivation among young people, the largest in the EU in the two countries in question. Poland, the Czech Republic and Germany have seen less progress in all dimensions, but this has resulted in a remarkable overall elimination of young people's poverty and social exclusion. Bulgaria's and Romania's significant progress in the material deprivation and labour market dimensions have been partially reduced by the deterioration in income poverty.

Nowadays in the European Union, the youngest generation is the most affected by poverty and social exclusion. On the other hand, the expectations of economists for the younger generation are increasing, which is related to 'unfavourable' demographic development, the basic feature of which is an aging population. The social inclusion of the younger generation therefore must be included among the key objectives of the European Union. The results of the analyses presented in this article may contribute to this inclusion. The social policies of the EU countries under review could also be based on the results of our analyses, which reveal the phenomena to which the country should focus, in an effort to ensure the social inclusion of young people. As poverty and social exclusion of young people have specific features compared to the older population, appropriate methodologies, for measuring the individual partial phenomena of poverty and social exclusion, need to be put in place. These methodologies should provide the most accurate picture of the various dimensions of poverty and social exclusion of the relevant population. This article highlights some of the weaknesses in measuring poverty and social exclusion through the AROPE rate and its sub-indicators for the population of young people, and it presents an approach that assesses poverty and the social exclusion of youth more comprehensively and more objectively.

Acknowledgement

This work was supported by the VEGA project: Availability and affordability of housing in Slovakia (No. 1/0770/17).

References:

AASSVE, A., COTTINI, E., VITALI, A. (2013): Youth prospects in a time of economic recession. Demographic Research, 29: 949–962.

ANDRIOPOULOU, E., KARAKITSIOS, A., TSAKLOGLOU, P. (2017): Inequality and poverty in Greece: Changes in times of crisis. GLO Discussion Paper, No. 119, Global Labor Organization (GLO), Maastricht [online]. [cit. 15.04.2019]. Available at: https://www.econstor.eu/handle/10419/168569

ATKINSON, A. B., GUIO, A. C., MARLIER, E. (2017): Monitoring social inclusion in Europe–2017 edition. Luxembourg, Publications Office of the European Union.

AYLLÓN, S., GÁBOS, A. (2017): The interrelationships between the Europe 2020 poverty and social exclusion indicators. Social Indicators Research, 130(3): 1025–1049.

BRADFORD, S., CULLEN, F. (2014): Youth policy in austerity Europe. International Journal of Adolescence and Youth, 19(sup1.): 1–4.

CAMILLERI, M. A., CAMILLERI, A. (2016): Education and social cohesion for economic growth. International Journal of Leadership in Education, 19(5): 617–631.

CARCILLO, S., FERNÁNDEZ, R., KÖNIGS, S., MINEA, A. (2015): NEET Youth in the aftermath of the crisis: Challenges and policies [online]. OECD Social, Employment and Migration Working Papers, No. 164, OECD Publishing [online]. [cit. 21.03.2019]. Available at: https://www.oecd-ilibrary.org/docserver/5js6363503f6-en.

CHEN, T., HALLAERT, J.-J., PITT, A., QU, H., QUEYRANNE, M., RHEE, A., SHABUNINA, A., VANDENBUSSCHE, J., YACKOVLEV, I. (2018): Inequality and poverty across generations in the European Union. Staff Discussion Notes No. 18/01. Washington, DC, International Monetary Fund.

CHUNG, H., BEKKER, S., HOUWING, H. (2012): Young people and the post-recession labour market in the context of Europe 2020. Transfer: European Review of Labour and Research, 18(3): 301–317.

COPUS, A., MELO, P. C., KAUP, S., TAGAI, G., ARTELARIS, P. (2015): Regional poverty mapping in Europe – Challenges, advances, benefits and limitations. Local Economy: 30(7): 742–764.

DE GRAAF-ZIJL, M., NOLAN, B. (2011): Household joblessness and its impact on poverty and deprivation in Europe. Journal of European Social Policy, 21(5): 413–431.

DIETRICH, H., MÖLLER, J. (2016): Youth unemployment in Europe – business cycle and institutional effects. International Economics and Economic Policy, 13(1): 5–25.

DVORNÁKOVÁ, T. (2012): At-risk-of-poverty threshold. Statistika, 49(2): 44–61.

EUROPEAN COMMISSION (2018): Social protection committee annual report 2018. 2018 SCP review of the social protection performance monitor and developments in social protection policies. Luxembourg, Publications Office of the European Union.

EUROPEAN COUNCIL (2013): Council Recommendation of 22 April 2013 on establishing a Youth Guarantee, 2013/C120/01 [online]. [cit. 11.04.2019]. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2013:120:0001:0006:EN:PDF

EUROSTAT (2010): Glossary: Unemployment [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Unemployment_rate

EUROSTAT (2014a): Glossary: Housing cost overburden rate [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Housing_cost_overburden_rate

EUROSTAT (2014b): Glossary: Overcrowding rate [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Overcrowding_rate

EUROSTAT (2014c): Glossary: Severe housing deprivation rate [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Severe_housing_deprivation_rate

EUROSTAT (2015): Glossary: Long-term unemployment [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Long-term_unemployment

EUROSTAT (2018a): EU statistics on income and living conditions (EU-SILC) methodology – in-work poverty [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/EU_statistics_on_income_and_living_conditions (EU-SILC)_methodology_-_in-work_poverty

EUROSTAT (2018b): EU statistics on income and living conditions (EU-SILC) methodology - population structure [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/EU_statistics_on_income_and_living_conditions_(EU-SILC)_methodology_-_population_structure#Description

EUROSTAT (2018c): Glossary: At-risk-of-poverty rate [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:At-risk-of-poverty_rate

EUROSTAT (2018d): Glossary:Material deprivation [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Material_deprivation

EUROSTAT (2018e): Glossary: Persons living in households with low work intensity [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Persons_living_in_households_with_low_work_intensity

EUROSTAT (2018f): Key figures on Europe. Luxembourg, Publications Office of the European Union.

EUROSTAT (2018g): Smarter, greener, more inclusive? Indicators to support the Europe 2020 strategy. Luxembourg, Publications Office of the European Union.

EUROSTAT (2018h): Sustainable development in the European Union. Monitoring report on progress towards the SDGs in an EU context. Luxembourg, Publications Office of the European Union.

EUROSTAT (2019a): Glossary: Young people neither in employment nor in education and training (NEET) [online]. [cit. 13.03.2019]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:NEET

EUROSTAT (2019b): Smarter, greener, more inclusive? Indicators to support the Europe 2020 strategy. Luxembourg, Publications Office of the European Union.

EUROSTAT (2019c): Smarter, greener, more inclusive? How is the European Union progressing towards its Europe 2020 targets? [online]. [cit. 22.01.2020]. Available at: https://ec.europa.eu/eurostat/documents/2995521/10133668/1-07102019-BP-EN.pdf/2e56ad51-82cb-0912-fd3d-81770eff251a

EUROSTAT (2020): Database [online]. [cit. 22.01.2020]. Available at: https://ec.europa.eu/eurostat/data/database

FAURA-MARTÍNEZ, Ú., LAFUENTE-LECHUGA, M., GARCÍA-LUQUE, O. (2016): Risk of poverty or social exclusion: Evolution during the economic crisis and territorial perspective. Revista Española de Investigaciones Sociológicas (REIS), 156(156): 59–76.

GUAGNANO, G., SANTARELLI, E., SANTINI, I. (2013): Subjective poverty in Europe: The role of household socioeconomic characteristics and social capital. Working paper No. 113. SAPIENZA University of Rome [online]. [cit. 19.04.2019]. Available at: http://eprints.bice.rm.cnr.it/5182/1/Subjective_poverty_in_Europe_wp113.pdf

GUIO, A., MAQUET, I. E. (2006): Material deprivation and poor housing. What can be learned from the EU-SILC 2004 data? How can EU-SILC be improved in this matter? Draft paper from the conference: Comparative EU statistics on income and living conditions: issues and challenges [online]. [cit. 15.03.2019]. Available at: https://www.stat.fi/eusilc/guio_maquet.pdf

HAIR, J., BLACK, W., BABIN, B., ANDERSON, R. (2018): Multivariate Data Analysis (8th ed.). New York, Cengage Learning EMEA.

HEBÁK, P., HUSTOPECKÝ, J., PECÁKOVÁ, I., PRŮŠA, M., ŘEZANKOVÁ, H., SVOBODOVÁ, A., VLACH, P. (2005): Vícerozměrné statistické metody (3). Praha, Informatorium.

HORÁKOVÁ, M., JAHODA, R., KOFROŇ, P., SIROVÁTKA, T., ŠIMÍKOVÁ, I. (2013): Příjmová chudoba a materiální deprivace v České republice podle indikátorů EU – vývoj v důsledku krize, fiskální konsolidace a sociální reformy (1st ed.). Praha, Výzkumný ústav práce a sociálních věcí.

JOHNSON, R. A., WICHERN, D. W. (2002): Applied multivariate statistical analysis. Upper Saddle River, New Jersey, Prentice hall.

KHATTREE, R., NAIK, N. D. (2000): Multivariate data reduction and discrimination. North Carolina, John Wiley & Sons.

KIS, B. A., GÁBOS, A. (2016): Consistent poverty across the EU. Corvinus Journal of Sociology and Social Policy, 7(2):3–27.

KRETSOS, L. (2014): Youth policy in austerity Europe: the case of Greece. International Journal of Adolescence and Youth, 19(sup1.): 35–47.

LABUDOVÁ, V., VOJTKOVÁ, M., LINDA, B. (2010): Application of multidimensional methods to measure poverty. E-M: Ekonomie a Management, 13(1): 6–22.

LOSTER, T., PAVELKA, T. (2013): Evaluating of the results of clustering in practical economic tasks. In: 7th International Days of Statistics and Economics. Conference proceedings (pp. 804–818). Prague, University of Economics in Prague.

MYSÍKOVÁ, M., VEČERNÍK, J., ŽELINSKÝ, T. (2015): Impact of the low work intensity on poverty in the Czech Republic and the Slovak Republic. Ekonomický časopis, 63(6): 555–575.

NOLAN, B., WHELAN, C. T. (2010): Using non-monetary deprivation indicators to analyze poverty and social exclusion: Lessons from Europe? Journal of Policy Analysis and Management, 29(2): 305–325.

PASTORE, F. (2017): Getting it right: youth employment policy within the EU. CESifo Forum 18(2): 26–33.

PICKARD, S., BESSANT, J. [eds.] (2018): Young people re-generating politics in times of crises. Basingstoke, Palgrave Macmillan.

POULOU, A. (2014): Austerity and European Social Rights: How Can Courts Protect Europe's Lost Generation? German Law Journal, 15(6): 1145–1176.

RUESGA-BENITO, S., GONZÁLEZ-LAXE, F., PICATOSTE, X. (2018): Sustainable development, poverty, and risk of exclusion for young people in the European Union: The case of NEETs. Sustainability, 10(12): 4708.

ŘEZANKOVÁ, H., ŽELINSKÝ, T. (2014): Factors of material deprivation rate in the Czech Republic by household type. Ekonomický časopis, 62(4): 394–410.

SKATTEBOL, J., REDMOND, G. (2019): Troubled kids? Locational disadvantage, opportunity structures and social exclusion. Children‘s Geographies, 17(1): 76–89.

SOLER, P., PLANAS, A., FEIXA, C. (2014): Young people and youth policies in Spain in times of austerity: between juggling and the trapeze. International Journal of Adolescence and Youth, 19(sup1.): 62–78.

STANKOVIČOVÁ, I., VOJTKOVÁ, M. (2007): Viacrozmerné štatistické metódy s aplikáciami. Bratislava, Iura Edition.

ŠOLTÉS, E., HURBÁNKOVÁ, Ľ., KOTLEBOVÁ, E., ŠOLTÉSOVÁ, T., VOJTKOVÁ, M. (2018): Chudoba a sociálne vylúčenie v EÚ a v SR v kontexte stratégie Európa 2020. Pardubice, Univerzita Pardubice, Fakulta ekonomicko-správní.

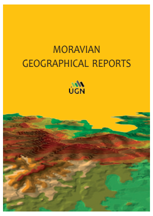
ŠOLTÉS, E., ULMAN, P. (2016): Material deprivation in Poland and Slovakia – a comparative analysis. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie, 11(947): 19–36.

ŠOLTÉS, E., VOJTKOVÁ, M. (2018): Work intensity in Slovakia in relationship with socio-economic characteristics of households. Entrepreneurial Business and Economics Review, 6(1): 115–134.

ŽELINSKÝ, T. (2010): Analysis of poverty in Slovakia based on the concept of relative deprivation. Politická ekonomie, 58(4): 542–565.

Please cite this article as:

ŠOLTÉS, E., VOJTKOVÁ, M., ŠOLTÉSOVÁ, T. (2019): Changes in the geographical distribution of youth poverty and social exclusion in EU member countries between 2008 and 2017. Moravian Geographical Reports, 28(1): 2–15. Doi: https://doi.org/10.2478/mgr-2020-0001



MORAVIAN GEOGRAPHICAL REPORTS

sciendo

The Czech Academy of Sciences, Institute of Geonics
journal homepage: http://www.geonika.cz/mgr.html
doi: https://doi.org/10.2478/mgr-2020-0002

The socioeconomic performance of small and medium-sized industrial towns: Slovenian perspectives

David BOLE [a] *, Jani KOZINA [a], Jernej TIRAN [a]

Abstract

The socioeconomic performance of industrial small and medium-sized towns (SMSTs) in comparison to that of non-industrial SMSTs, is subject to evaluation in this paper, to see if the presence of industry has adverse effects on socioeconomic factors. We studied 32 variables accounting for dimensions of socioeconomic performance in Slovenian SMSTs and conducted various statistical tests. We found only minor differences between the two groups, pertaining mainly to some elements of economic structure and demography, and some mixed relations of industrial employment and socioeconomic performance. The results demonstrate that industrial SMSTs should not be labelled automatically as 'disadvantaged'. We discuss why our results differ from general research expectations in the literature: in the local context, we outline the "egalitarian syndrome" and policies of polycentric spatial development; in the global context, we discuss the "failed tertiarisation effect" and the differences between post-socialist and "Western" countries. We conclude by proposing that research should be re-oriented towards the more place-sensitive issues of industrial towns across Europe.

Keywords: *small and medium-sized towns, industry, socioeconomic development, post-socialism, tertiarisation effect, Slovenia*

Article history: *Received 19 September 2019, Accepted 20 January 2020, Published 31 March 2020*

1. Introduction

Small and medium-sized industrial towns (SMSTs) are rarely perceived as an independent object of research, and little is known about their socioeconomic performance. Such towns are seen as having a dual problem. Firstly, small towns in general are "losers" in relative terms because they cannot compete with the agglomeration economies of larger metropolitan regions, which have more productive firms (Combes et al., 2012) or attract more knowledge workers and knowledge-intensive companies (Van Winden, 2010).

Secondly, those smaller towns with an economic base in traditional mining and industrial activities, such as steel and textiles, are more prone to urban decline because they are unable to find a niche in the international economic environment (Fol and Cunningham-Sabot, 2010; Martinez-Fernandez et al., 2012). They could easily fit into the category of (perceived) "places that don't matter", described by Rodríguez-Pose (2018) as lagging and declining areas with little economic potential. Traditional industrial SMSTs are thus characterised as having old productive economies, in contrast to the "new" productive economies supported by creative and knowledge-based activities (Hamdouch et al., 2017), indicating that industrial towns are inherently vulnerable and are more likely to experience the painful processes of restructuring in the near future.

On the other hand, researchers and policy makers largely ignore the socioeconomic performance of SMSTs (Meili and Mayer, 2017) in general, let alone those with an industrial economic base. The dominant research theme suggests that the presence of industry in towns is associated with pending deindustrialisation and consequently inferior socioeconomic performance, especially in the context of urban shrinkage, where older industrial urban areas are "economically disadvantaged" and prone to demographic shrinkage (Wolff and Wiechmann, 2018) or have unsustainable development trajectories (Vaishar et al., 2016). Despite all the research on (post)industrial urban development, however, few have empirically tested how the presence of a traditional industrial sector impacts the socioeconomic performance of SMSTs (Meili and Mayer, 2017), or it is limited only to a few employment and demographic variables (Hamdouch et al., 2017). Additionally, there is no research comparing industrial

[a] Research Centre of the Slovenian Academy of Sciences and Arts, Anton Melik Geographical Institute, Ljubljana, Slovenia (*corresponding author: D. Bole, e-mail: *david.bole@zrc-sazu.si*)

versus non-industrial towns to establish the effects of sectoral structure on the socioeconomic performance of SMSTs.

This paper attempts to bridge this research gap and empirically test the socioeconomic performance of industrial SMSTs in comparison to non-industrial SMSTs, and to see if the presence of industry has adverse effects on the socioeconomic aspects of SMSTs. Given the recent discussions on (re)industrialisation or the so-called Industry 4.0 (Davies, 2015), this paper first contributes to a renewed understanding of the role and the effects of the industrial sector on people living and working in SMSTs. This renewed understanding encompasses a wider array of socioeconomic variables, pertaining not only to economic performance and demographics but also to previously neglected aspects of the living environment and voting behaviours. Second, by understanding how industry in SMSTs affects their socioeconomic performance, we can add to the discussion on tailored (post)industrial policies, which do not favour only large, service-oriented and liberal urban environments but also consider the specifics of smaller industrial towns.

This research project is guided by two main research questions:

- Is there a difference in socioeconomic performance between industrial SMSTs and their non-industrial counterparts that have shifted towards consumption or service oriented economic activities?; and
- What is the association between industry and socioeconomic performance in SMSTs?

We define industrial SMSTs as second- and third-tier towns with populations between 5,000 and 60,000, with a predominant industrial economic base. We explore this research problem in the case of Slovenia, which is interesting from several perspectives: Slovenia has one of the most polycentric urban structures in Europe (Meijers, 2008), similar to Switzerland, Germany or the Netherlands; and it has a specific urban system with a large share of SMSTs with an industrial profile. This makes Slovenia a good "test" case for conducting such research, in contrast with more de-industrialised countries where industrial SMSTs are scarce. Slovenia is also relatively unknown to the wider international research community but has an intermediate position in East Central Europe, often exhibiting mixed characteristics from the capitalist West and post-socialist East.

The paper is structured as follows: after the literature review, we describe the context of the Slovenian urban system, especially polycentrism, socialist industrialisation and egalitarianism, since they are important for understanding the results. In the methodological section, we present the selection of indicators and the two main methods used in the research. Afterwards, we present the results and later discuss them in relation to local specificities and link them with overarching global processes. The last section draws conclusions with special emphasis on future policies in industrial SMSTs.

2. Theoretical background

To understand why industrial SMSTs are repeatedly linked with urban decline and poorer socioeconomic performance, it is helpful to highlight the literature that influenced generations of urban researchers. The roots of the bleak view on the future of industrial towns can be traced back to Bell's (1973) influential work on post-industrial society, where he predicted the transformation to more highly developed societies in which employment in manufacturing would decline while professional, technical and other service occupations would increase. Post-industrial urban paradigms, such as the informational city (Castells, 1989), the global city (Sassen, 1991), the cultural city (Scott, 1997), and the creative city (Landry, 2000; Florida, 2003), to name just a few, have painted a rather gloomy picture of traditional industrial activities, celebrating service-based economic activities in cities in one form or the other. Those paradigms were widely used to "prove" that culture-led development (Bailey et al., 2004) or the development of specialised services, amenities and knowledge-based institutions (Clark et al., 2002), can encourage economic and demographic growth in urban environments. Some research went further and tried to prove that post-industrial, service-based structures are associated with people being "happier", having a better quality of life and greater personal well-being (Mellander et al., 2012).

The literature originating from this realm discusses how towns can transform, revitalise or gain functions, which is often biased towards the creative economy (Lorentzen and Heur, 2012). Industrial SMSTs are rarely presented outside of the context of shrinkage and are almost never represented by a wider and more comprehensive array of socioeconomic indicators. Nonetheless, industrial SMSTs are an important part of urban systems. One in five people in Europe lives in an industrial SMST (Koceva et al., 2016). It is estimated that 27% of the EU population lives in SMSTs (Servillo et al., 2017), and according to an SMST-employment study in six European countries, industrial employment remains an important component of the local economy since it is "overrepresented" in SMSTs compared to the national averages (Servillo et al., 2014).

Research linking the size of cities with economic success is also important in understanding why industrial SMSTs are perceived as inherently austere. Urban economists consider that increased city size is correlated with more dynamic productivity rates and stronger economic growth (Duranton, 2015). Frick and Rodríguez-Pose (2018) confirmed that in high-income countries, city size promotes better economic growth, while in developing countries the causality is reversed. The reasons for linking city size with better economic performance in high-income countries can be found in studies of economic diversity and knowledge flows, where larger cities have advantages. Larger cities "exhibit large concentrations and diversity of high human capital and skills and as such act as the 'magnets' towards which both international and interregional flows of capital and labour gravitate" (Dijkstra et al., 2013, p. 336). There is, however, evidence that smaller towns can also generate diversity despite lower concentrations of people and firms, by relying on other factors stemming from the closer social structure of smaller towns (Meili and Shearmur, 2019).

Considering the more economic aspects of urban growth, we should mention the debates about the relationships between industrial specialisation and the economic performance of cities. Storper (2013) argues that the driving force behind the economic growth of cities is specialisation, and that the recent inter-urban divergence is because some cities became specialised into knowledge intensive sectors. Other cities (mostly industrial ones, specialising in labour-intensive manufacturing) lack resilience and are lagging behind (Kemeny and Storper, 2015). There is also research on UK cities, however, that contradicts these notions. For example, Martin et al. (2016) found that employment growth is only marginally linked with sectoral specialisation, and they call for a better explanation of "city-specific" effects. A study of Czech micro-regions showed that manufacturing correlates with higher economic performance but also with higher regional vulnerability, and that in industrial areas, specialisation is still important for better economic performance (Ženka et al., 2015).

According to Fol and Cunningham-Sabot (2010), poorer socioeconomic performance in industrial towns is assumed. They write that "these cities [small cities], with few resources in the areas of research, education and qualified employment, and sometimes underserved by transport infrastructures, are unable to keep pace with competition from the large cities", particularly exposing those small cities with a "reliance on a single industry … or even one large company" (2010, p. 13). The ESPON project, focusing on SMSTs in Europe (population between 5,000 and 50,000), has shown that traditional industrial towns face a problematic future, as a higher proportion of employment in industrial activities is associated with poorer job growth (Servillo et al., 2014). The results from this study also show that industrial SMSTs have larger unemployment rates compared to SMSTs with jobs in the service sector. According to Hamdouch et al. (2017), the majority of industrial SMSTs have had lower employment growth rates since 2000.

Recently, some alternative responses have emerged with a more positive stance towards industry in towns and cities. Some authors have focused on de-industrialised cities and towns and the negative effects of their tertiarisation on socioeconomic polarisation (Beatty and Fothergill, 2017; Gornig and Goebel, 2018). There is also limited evidence that older industrial cities were more resilient to the recent economic crisis (Plöger and Kohlhaas-Weber, 2014; Ženka, et. al., 2019), contesting prior research that traditional industrial cities are less resilient (Kemeny and Storper, 2015). Such research is important because it shows that tertiarisation and the demise of industry in cities and regions in parts of Europe only made matters worse. National urban policies are arguably tailor-made for larger urban conurbations with service-oriented economies, rather than for smaller towns with a pronounced industrial profile. Therefore, it is important to know if industrial SMSTs are truly in a disadvantaged position, and in what ways it might be expressed through their socioeconomic indicators.

The above-mentioned research literature concerns only partial aspects of the socioeconomic performance of SMSTs in Europe – but available studies of the socioeconomic performance of concrete national urban systems are even rarer. A typology of small towns in the Czech Republic demonstrated how towns with an industrial economic profile performed according to basic sustainable development indicators (Vaishar et al., 2016). The results indicated that industrial towns have higher unemployment rates and face population decline. This research is limited, however, since towns are compared using only three indicators: population growth, tertiary educational attainment and unemployment. Other similar research was conducted in Switzerland, where types of SMSTs were evaluated by socioeconomic indicators (Meili and Mayer, 2017). Two industrial types – high-tech and low-tech towns – typically exhibit lower population growth rates in contrast to service-economy or residential towns, but some show better economic performance. Other research involving industry in SMSTs is oriented towards their role within the urban system (Cox and Longlands, 2016), such as the borrowed size concept (Meijers et al., 2016), and do not try to find relationships between industry and socioeconomic performance.

In sum, these studies show that we have a rather limited (and possibly) biased knowledge of the socioeconomic performance of industrial SMSTs, and that we do not know how specific aspects such as economy, employment, demography, living environment and voting behaviours, are expressed within them.

3. Key features of industrial small and medium-sized towns in Slovenia

Industrial SMSTs are a hallmark of the Slovenian urban system and are shaped by two distinct processes: (i) the long-standing policies of polycentric spatial development, and (ii) socialist industrialisation. Both are connected with egalitarianism as a dominant socio-cultural concept. To understand the context of this research and its results, brief overviews of egalitarianism, polycentrism and socialist industrialisation are necessary.

3.1 Egalitarianism

The "egalitarian syndrome" is a preference for an equal distribution of earnings without taking into account one's position in the social division of labour (Županov, 1970). The effect of the egalitarian syndrome is especially significant for smaller communities (Gavrilets, 2012), which is why it is particularly useful for understanding the structural (im) balances between SMSTs. Egalitarianism as a dominant social value today, prevails not only among the majority of the Slovenian population but also among the ex-Yugoslav population (Burić and Štulhofer, 2016). Županov (1970) argued that the germ of the egalitarian syndrome in Yugoslavia should be sought in agrarian societies, characterised by scarcity and low levels of economic development. Hafner-Fink (2006), on the other hand, mentions at least two important sources of egalitarianism in Slovenia: the Communist ideology and the Christian religion (more precisely, the Roman Catholic tradition). Despite the opposite trends in some post-socialist contexts in Central and Eastern Europe that have introduced the neoliberal agenda more openly (Sýkora and Bouzarovski, 2012), egalitarian values in Slovenia have been growing since the beginning of the 1990s (Vehovar and Tiran, 2017). This explains to a large extent the high ranking of Slovenia among the most equal European countries, according to the income and wealth gap, together with Nordic and some Central and Eastern European countries, such as the Czech Republic and Slovakia (OECD, 2017a).

Egalitarianism as a dominant socio-cultural concept possibly influenced the long-standing policy focus on ensuring balanced regional development and suggesting the presence of multiple growth poles in Slovenia (Banerjee and Jesenko, 2014). Egalitarianism on a spatial level was reflected by polycentric policies in times of socialism to create conditions for the more uniform economic and social development of all parts of Slovenia, as well as to provide a uniform allocation of working places and social infrastructure. Even though political, economic and social transitions after the collapse of the Eastern Bloc brought a new planning orientation, the polycentric arrangement in Slovenia still remained understood as the reestablishment of approximately the same access to services and social infrastructure, the opportunity to enable autonomy of decision making, and the management of certain administrative units and the development of local identity (Drozg, 2012). This is especially true for smaller and closed industrial communities with low mobility, which is characteristic of Slovenia.

3.2 Polycentric spatial development and socialist industrialisation

The primary trait of the Slovenian urban system is the dominance of smaller towns (Sýkora and Mulíček, 2017), due to the traditionally dispersed settlement system and polycentric policies during the socialist and post-socialist eras because of the "egalitarian syndrome". The introduction of a communal system in the 1960s strongly favoured the development of smaller towns, which were seen as an extension of state power and were developed with jobs, public services and financial subsidies (Nared, 2018). This was seen as a step towards better social and territorial justice and had strong ideological connotations. Around 13–15 regional centres were somewhat neglected, especially after the 1990s when a new local self-government reform was adopted. This policy recognised only two spatial levels of government: the local (municipal) and state levels, whereas the regional level of government was only administrative. This exacerbated the unevenness of the Slovenian urban system, which is reflected in the lack of regional capitals or medium-sized towns with populations above 60,000, and a strong presence of small towns below 20,000 inhabitants that typically display an "oversupply" of public services and functions in comparison to medium-sized towns (Nared et al., 2017). There are only two large towns with 100,000 inhabitants or more (Ljubljana and Maribor). Contemporary polycentrism policies continue to pursue the principle of balanced spatial development, which might explain why Slovenia is one of the most polycentric European countries (Meijers, 2008). Moreover, some recent spatial studies advocate lesser agglomerative tendencies in Slovenia (Kozina and Bole, 2018), compared to other countries in Central and Eastern Europe (Egedy and Kovács, 2009; Slach et al., 2013) and metropolitan areas in Western Europe (Boix et al., 2015).

Small towns that became municipal centres in the 1970s were further developed with new economic functions – for instance, every town was "equipped" with at least one industrial plant, accompanying apartment buildings built for industrial workers, and basic social infrastructure (Drozg, 2012). Before that, industry was concentrated in medium-sized and large towns. This industrialisation of smaller towns and even rural areas (Zavodnik Lamovšek et al., 2008) became the second trait of the Slovenian urban system. After the transition from a socialist to a market economy, some SMSTs as well as large towns became deindustrialised, but the majority of towns kept their industrial profile (Bole, 2012). SMSTs have 36% industrial workplaces (Bole et al., 2017), which is 7% higher than the national average and 14% higher than the EU-28 average (Eurostat, 2017).

4. Methodology

4.1 Definition of industrial small and medium-sized towns in Slovenia

Although we acknowledge the criticism of population-based definitions because of the arbitrariness of any population threshold (Brenner and Schmid, 2014), delimitations of SMSTs in Slovenia are quite constant in representing towns between 5,000–60,000 inhabitants. Our classification is based on previous research (Bole, 2012; Bole et al., 2015), in which we have used the same population thresholds. This population criterion is also close to the one used in other research, for instance, in the ESPON town study or the Swiss study, where the population criterion for an SMST was from 5,000 to 50,000 inhabitants (Meili and Mayer, 2017; Servillo et al., 2017). The spatial units of analysis are 212 municipalities, which correspond to local administrative units (LAU level 2), according to the Nomenclature of Territorial Units for Statistics (NUTS) of EUROSTAT. With this criterion, we identified 84 small and 16 medium-sized towns with 1,352,000 people, representing 66% of the national population.

If population size is a straightforward criterion that is consistently used in other studies, delimiting industrial towns from non-industrial ones is more difficult, as thresholds are always arbitrary. To select industrial and non-industrial SMSTs, we decided to use the standard deviation grouping technique on the proportion of industrial workplaces. This is a common method and is particularly useful when the purpose is to show deviations from the mean of a data array (Nelson, 1955; Ricketts and Sawhill, 1988), which allows us to make a distinction between "the most" and "the least" industrialised towns. We used 0.5 standard deviations above and below the mean measure, which cuts off SMSTs with more than 42.8% of industrial workplaces and SMSTs with less than 29.8% of industrial workplaces. Our definition of industry includes B (mining and quarrying), C (manufacturing) and F (construction) sectors based on the NACE classification.

To sum up, the two criteria used to define industrial and non-industrial SMSTs are:

1. Population criterion: SMST (population from 5,000 to 60,000); and
2. Industrial criterion: a) industrial SMST (above M + 0.5 SD (42.8%) of industrial workplaces); and b) non-industrial SMST (below M – 0.5 SD (29.8%) of industrial workplaces).

According to these criteria, 23 municipalities represent industrial SMSTs (21 small and two medium-sized towns), 30 municipalities represent non-industrial SMSTs (25 small and five medium-sized towns), while 47 municipalities fall into the "middle category" (38 small and nine medium-sized towns; see Fig. 1). The territorial distribution of industrial SMSTs is not uniform and is scattered across the country, with minor concentration tendencies around two larger towns (Figure 1). There appears to be no general rule for their distribution, however. Industrial SMSTs around Ljubljana are typically peripheral and located in hilly areas, with a strong manufacturing or mining tradition. Those closer to Maribor to the east have better transportation access and industrial activities tied closely to the recent socialist industrialisation.

4.2 Selection of indicators

We selected two types of indicators for the analysis: the structural and the socioeconomic indicators. The first type of indicator represents general economic structure and measures selected characteristics of the economic base, with a focus on its competitiveness – such as technology intensity, investment, and growth. They are added for contextual purposes to better understand and describe the conditions in SMSTs. The second type of indicators are

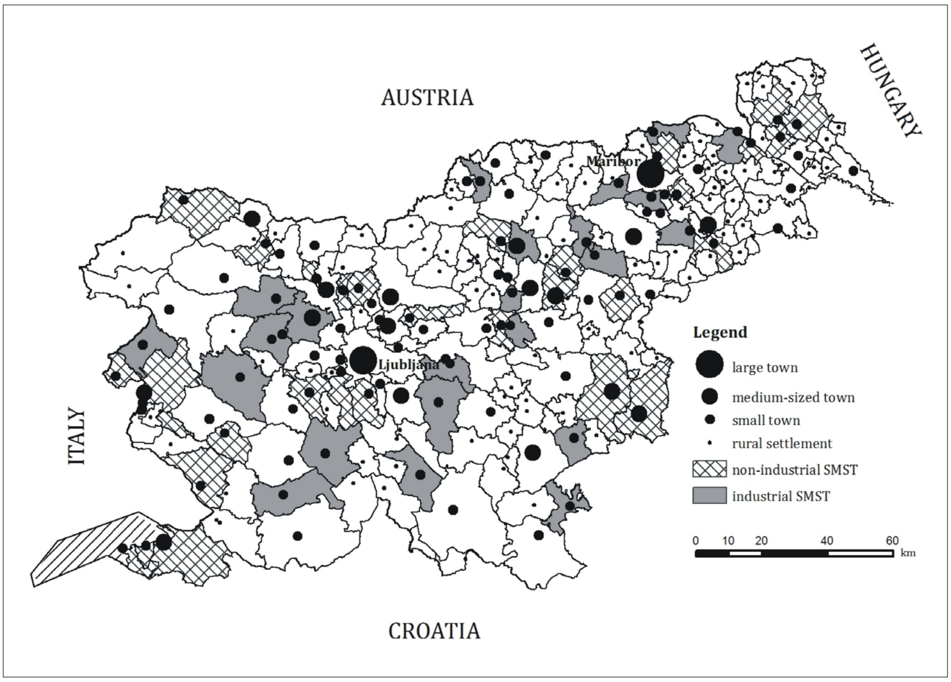


Fig. 1: Map of industrial and non-industrial SMSTs in Slovenia
Source: authors' elaboration

socioeconomic indicators and are central to this research, since they are needed to compare the performance of industrial and non-industrial SMSTs. They are further divided into four dimensions: employment, demography, living environment and voting behaviour. Employment and demographic characteristics are the most straightforward and frequently measured dimensions of socioeconomic performance in the area of research (Wirth et al., 2016; Vaishar et al., 2016; Meili and Mayer, 2017). We tried to include a wider array of both types of indicators, but we were limited by the availability of data collected at town level. Employment indicators are comparable to the above-mentioned research (average income, unemployment, share of commuters and foreign workforce), with an additional indicator of the share of long-term unemployment, which can lead to a culture of unemployment and urban poverty (Engbersen et al., 2006). Demographic indicators are also standard: total population, ageing index and population growth in several time periods after 1991 (independence of Slovenia), to better indicate periods of population growth or decline.

In contrast to other studies, which limited socioeconomic indicators to demographic and economic variables, we included two additional dimensions. Living environment, encompassing the relevant housing, spatial and social conditions of the municipality, was added, as it is an important aspect of a town's success or attractiveness (Buch et al., 2014; Hospers, 2014) and parallels the emergence of policy approaches for small towns, which go beyond economic growth and include or even focus on quality of life and the environment (Knox and Mayer, 2013; Pink and Servon, 2013; Wirth et al., 2016). We also hypothesised a political dimension as relevant from our research perspective, as an indirect indicator of socioeconomic performance. Some scholars have argued that political orientation of a certain place is strongly linked or even driven by their vulnerability and relative economic performance (Rodríguez-Pose, 2018), while there is plenty of evidence that economic deprivation, insecurity, grievance and decline of a place can lead to decreasing voter turnout (Blais, 2006), and the emergence of and support for new populist and radical parties and movements (Inglehart and Norris, 2016; Rooduijn et al., 2017; Dijkstra et al., 2019). Therefore, we included voting behaviour indicators in the analysis, using voter turnout and support for radical political parties in the 2018 parliamentary election. Radical left and radical right parties were defined based on previous studies (Burgoon et al., 2019) and expert surveys of party programmes (Polk et al., 2017): the radical left party is The Left; radical right parties are the Slovenian Democratic Party and the Slovenian National Party.

The selected indicators (see Tab. 1) represent each respective dimension, complement each other (within and across dimensions), and can also partly be found in other similar studies in this research area of analysing the socioeconomic performance of spatial structures (Andreoni and Galmarini, 2016; Vaishar et al., 2016; Meili and Mayer, 2017). All the data were retrieved from the Statistical Office of the Republic of Slovenia, and public records such as the National Institute of Public Health, the Slovenian Intellectual Property Office and the State Election Commission, and are valid for 2015, 2016 or 2018 or refer to a selected period (e.g. 1991–2016): these are the 'Sources' for the data presented in Table 1.

4.3 Methods

To assess differences in socioeconomic factors between industrial and non-industrial SMSTs, we studied 22 variables representing the four dimensions of socioeconomic structure and an additional 11 variables describing the general economic structure (Tab. 1). We conducted Mann-Whitney tests for the first research objective to find differences in socioeconomic aspects between industrial and non-industrial SMSTs. This test is the nonparametric equivalent to the independent samples t-test, which determines whether there is a statistically significant difference between the means in two unrelated groups – in our case between industrial and non-industrial towns.

			Industrial SMSTs (N = 23)				Non-industrial SMSTs (N = 30)			
			Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Structural indicators		Share of employment in the industrial sector	53.81	8.98	43.00	77.90	21.84	5.81	5.70	29.40
		Share of medium-tech companies	1.26	0.46	0.42	2.40	0.71	0.29	0.00	1.23
		Share of high-tech companies	0.18	0.22	0.00	0.89	0.16	0.22	0.00	0.89
		Share of medium- and high-tech companies	1.44	0.57	0.42	2.61	0.87	0.43	0.00	1.96
		Share of people employed in medium- and high-tech companies	9.51	10.69	0.00	37.37	2.45	2.44	0.00	7.99
		Share of medium-sized and big companies	1.47	0.53	0.64	2.75	0.91	0.45	0.22	2.26
		Share of people employed in medium-sized and big companies	55.33	11.12	37.63	81.02	35.10	18.56	0.00	57.87
		Investment index per capita	2.37	1.50	0.52	6.13	1.97	1.79	0.40	9.81
		Share of high-growth companies	0.27	0.23	0.00	0.85	0.26	0.24	0.00	0.97
		Number vof patents 1991–2016 per 1000 inhabitants	0.0023	0.0021	0.0050	0.0096	0.0015	0.0010	0.0000	0.0053
		Value added per employee (net)	37,630	7,185	26,398	52,212	37,715	7,542	25,856	52,924
Socioeconomic indicators	Employment	Average income (gross)	1,420	127	1,180	1,695	1,450	210	1,157	2,348
		Share of unemployed	11.26	3.36	5.20	17.60	12.04	4.03	5.90	20.70
		Share of long-term unemployed	5.78	2.07	2.10	10.30	6.18	2.56	2.50	11.80
		Share of commuters	56.77	13.78	26.90	78.00	64.23	15.79	31.50	86.30
		Share of foreign workforce	5.91	3.39	1.10	16.53	6.66	3.74	1.00	15.24
	Demography	Population	10,409	6,394	5,007	32,747	13,872	12,018	5,138	51,045
		Population growth 1991–2016	0.04	0.12	-0.18	0.34	0.09	0.18	-0.16	0.59
		Population growth 1991–2000	0.01	0.04	-0.05	0.09	0.03	0.07	-0.06	0.23
		Population growth 2000–2010	0.02	0.06	-0.10	0.15	0.05	0.08	-0.06	0.27
		Population growth 2010–2016	0.00	0.03	-0.08	0.06	0.00	0.037	-0.07	0.11
		Ageing index	120.51	26.09	67.50	171.70	134.64	33.17	77.90	215.80
	Living environment	Average useful floor space (m^2) per dweller	28.08	1.74	25.20	31.00	29.36	2.58	25.50	36.60
		Finished dwellings 2007–2016 per 1000 inhabitants	15.35	6.74	4.60	27.30	13.15	4.68	3.70	23.70
		Share of dwellings without appropriate basic infrastructure	4.87	2.52	1.30	13.00	5.22	3.42	1.90	15.20
		Share of dwellings built before 1946	21.69	10.64	4.84	57.24	22.96	7.66	7.27	43.22
		Share of brownfields	0.0007	0.0011	0.0000	0.0041	0.0006	0.0010	0.0000	0.0047
		Days of sick leave per employee	14.55	2.35	9.18	18.59	13.55	2.52	9.59	19.28
		Mortality rate	1,033.63	186.42	753.05	1,378.01	1,023.68	185.60	711.88	1,352.50
		Convicted adults and minors 2006–2015 per 1000 inhabitants	3.37	1.51	1.15	6.09	3.43	1.67	1.13	8.33
	Voting behaviour	Voter turnout on parliamentary election	0.53	0.04	0.47	0.61	0.52	0.05	0.42	0.61
		Share of vote for radical right parties	0.34	0.07	0.16	0.45	0.30	0.08	0.17	0.47
		Share of vote for radical left parties	0.07	0.02	0.04	0.13	0.08	0.03	0.03	0.16

Tab. 1: Descriptive statistics of the variables used. Source: authors' calculations based on the data from Statistical Office of the Republic of Slovenia, National Institute of Public Health, the Slovenian Intellectual Property Office and the State Election Commission

To answer the second research objective on the association between industry and socioeconomic performance, we conducted a correlation analysis, using Pearson's coefficient (*r*). Some variables were not normally distributed according to the Kolmogorov-Smirnov test and the Q-Q plot. We transformed the data by applying square, square root, reciprocal, or log functions. For the variables share of high-tech companies, share of people employed in medium and high-tech companies, and share of degraded urban areas, the transformations were not successful and were excluded from the initial analysis. For these indicators, a Spearman's rho coefficient was calculated as a non-parametric counterpart to Pearson's *r*.

5. Results

5.1 Significant differences between industrial and non-industrial SMSTs

As seen from the descriptive statistics in Table 1, differences in the means of indicators are quite subtle. To test if the differences between industrial and non-industrial SMSTs in Slovenia are statistically significant we conducted Mann-Whitney tests. The results are statistically significant ($p < 0.05$) only for the following indicators:

- Share of employment in the industrial sector (U = 0.00, z = − 6.19, p = 0.000, r = − 0.85);
- Share of medium-tech companies (U = 98.00, z = − 4.43, p = 0.000, r = − 0.61);
- Share of medium- and high-tech companies (U = 136.50, z = − 3.74, p = 0.000, r = − 0.51);
- Share of medium-sized and big companies (U = 133.00, z = − 3.81, p = 0.000, r = − 0.52);
- Share of people employed in medium-sized and big companies (U = 113.00, z = − 4.17, p = 0.000, r = − 0.57);
- Share of commuters (U = 229.50, z = − 2.07, p = 0.038, r = − 0.28).

The statistical tests reveal that differences between industrial and non-industrial SMSTs are in most cases not significant. Statistically significant differences relate mainly to the structural indicators. For instance, it is obvious that industrial SMSTs have a greater share of larger and medium-tech companies since Slovenian industrial enterprises are based on large, export-orientated companies formed in the socialist era and later transformed in the post-socialist era. The differences in structural indicators explain the average picture of Slovenian industry: industrial towns have larger medium to high-tech companies, while the opposite is true for non-industrial towns, with companies mainly in the service sector.

The only significantly different socio-economic indicator is the share of commuters (r = − 0.28), i.e. in industrial towns the share of commuters is lower. This confirms an initial finding that industry depends on local workers and reflects a more "closed" labour market, which was also found in the Swiss case, where it was established that these types of towns are more isolated from larger neighbouring centres and might be too far away from them to be able to "borrow size" (Kaufman and Meili, 2019; Meili and Mayer, 2017). In Slovenian case, this "closed" labour market of industrial towns is probably also due to their geographic location in peripheral areas. We might speculate that, in Slovenia, a more peripheral location enabled those towns to continue with industrial development, since there was no option for workers to commute daily to larger services-oriented towns. In a way, peripheral location was responsible for those industrial towns to be able to better adapt to various restructuring events and shocks. For instance, the case of Jutland – an industrial, successful and peripheral region in Denmark – showcased how entrepreneurs were required to be more technologically advanced, innovative and internally organised to compete with the economies of metropolitan areas (Hansen, 1991).

No other socioeconomic indicator was statistically significantly different, leading to the conclusion that there are no major differences in socioeconomic performance between industrial and non-industrial SMSTs in Slovenia. These findings contradict some other studies, which state that industrial towns face poorer socioeconomic development with regard to unemployment (Hamdouch et al., 2017), population decline and educational structure (Vaishar et al., 2016), or demographic and economic decline (Fol and Cunningham-Sabot, 2010).

5.2 Relationship between industry and the socioeconomic indicators of SMSTs

Since the socioeconomic differences between industrial and non-industrial SMSTs are subtle, we tried to establish if there is any correlation between industry and other dimensions of socioeconomic performance in all SMSTs in Slovenia. This is especially important because the presence of industry in previous research is associated with poorer job growth (Servillo et al., 2014), demographic shrinkage (Wolff and Wiechmann, 2018), unsustainable development (Vaishar et al., 2016) and unemployment (Hamdouch et al., 2017).

The correlation between industry and general economic structure indicators (Tab. 2) show that a greater presence of industrial activity is positively related to larger and medium-tech companies. This is a legacy of the socialist industrialisation, which favoured large labour-intensive industrial plants. Despite the fact that the current economic base is mostly medium-tech (automotive, electrical appliance, pharmaceutical and metal products industries), it shows some significant innovative potential due to a higher concentration of patents, which indicates positive transformative capacities (Kozina and Bole, 2018).

The correlation analysis between industrial employment and socioeconomic performance returned similar results to the Mann-Whitney tests. Industry is negatively associated with the commuting ratio, which reaffirms the notion of industrial areas representing more closed and vulnerable societies that may additionally increase intolerance. This notion is also reflected in the positive correlation between industrial employment and support for radical right parties. This could relate to increasing levels of economic insecurity or even fear in the context of post-industrialisation and (hyper)globalisation, which contributed to the decline of many industrial areas in Western societies, making the electorate susceptible to campaigns of populist and radical parties (Rydgren, 2012; Inglehart and Norris, 2016; Obschonka et al., 2018). In Slovenia there is another possible explanation connected with this association: industrial SMSTs have smaller populations, and right wing parties in Slovenia have historically performed better in smaller towns (Tiran, 2015).

Industry is also negatively associated with the average useful floor space per dweller. Because a significant share of their housing stock originates from the (pre)socialist era, when the construction of working colonies (earlier) and multi-storey blocks with smaller flats (later), was popular,

Indicator	Share of employment in industry
Structural indicators	
Share of medium-tech companies	0.456**
Share of medium- and high-tech companies	0.401**
Share of medium-sized and big companies	0.502**
Share of people employed in medium-sized and big companies	0.588**
Number of patents 1991–2016 per 1000 inhabitants	0.239*
Socioeconomic indicators	
Employment: Share of commuters	– 0.208*
Demography: Ageing index	– 0.221*
Living environment: Average useful floor space (m^2) per dweller	– 0.286**
Voting behaviour: Share of vote for radical right parties on parliamentary election	0.220*

*Tab. 2: Correlations between industrial employment and socioeconomic indicators in Slovenian SMSTs (significance < 0.05 and 0.01 only). Notes: N = 100; *p < 0.05 (2-tailed); **p < 0.01 (2-tailed)*
Source: authors' calculation

industrial towns have a lower housing standard from this perspective today. The dwellings still have a smaller surface area, which is expected since traditional workers' apartments were built under different circumstances and building criteria. Approximately 20% of these apartments were built before the Second World War.

Unexpectedly, industry is negatively related to the ageing index, implying that a better age structure of industrial SMSTs, in comparison to non-industrial SMSTs, means that industrial towns have a somewhat better demographic outlook. This triggers interesting research questions and policy implications.

This correlation analysis reconfirms that industrial SMSTs are not necessarily disadvantaged concerning their socioeconomic performance. Moreover, the presence of industry in Slovenian SMSTs is not associated with poor overall performance, as was the case in other research presented in the earlier theoretical background.

6. Discussion

The main principles appearing from our results are twofold. First, there are very few statistically significant differences in socioeconomic structure between industrial and non-industrial towns in Slovenia. Of 22 socioeconomic variables, only one (share of commuters) differs significantly. Second, the association between industry and other socioeconomic variables is very subtle with few significant and generally weak correlation coefficients. Our results demonstrate several opposing views with respect to previous research. Below, we discuss the potential reasons for this apparent mismatch. We start with locally-specific explanations and discuss them with respect to the distinctive socioeconomic trajectories of Slovenia. We follow up with discussing the post-industrial transformation in Slovenia, which might have influenced the results. We finish with discussing this study in comparison with other studies and by assessing some of the limitations of this analysis.

6.1 The specific economic trajectory of Slovenia

It has to be stressed that Slovenia has had some very specific economic policies, which might contribute to the lack of significant differences between industrial and non-industrial SMSTs. In contrast to other Central and Eastern European countries, where new industrial development was spurred by foreign industrial investments (Pavlinek, 2004; Novotná and Novotný, 2019), the present-day industrial development in Slovenia is mostly based on endogenous development of companies that managed to transform from former 'socialist-style' factories into global ventures (Bole et al., 2019). The economy of Slovenia is considered to be very export-orientated (41% of GDP in 2014), one of the highest in the OECD (OECD, 2017b). It is interesting to note that according to research on the recent economic recession, Slovenian towns with an export-oriented economic base were more resilient (Lapuh, 2018). Industrial SMSTs generally belong to this category and many of them were either unaffected by the recession or recovered more rapidly, which might also explain why industrial SMSTs do not underperform compared to non-industrial ones. If Slovenian industrial towns were less export-oriented, they would perhaps exhibit poorer socioeconomic indicators due to lower levels of adaptation and resilience dynamics.

The small town of Idrija is an example of such an export-oriented town, because it was transformed from a former mercury mining town to a major and globally important supplier in the automotive industry (Urbanc et al., 2012). Many other successful Slovenian industrial towns specialised into niche manufacturing sectors, such as electrical components manufacturing, the chemical industry … and are labelled as "single-industry towns" or "post-socialist champions" (Bole et. al., 2019, p. 77). But it would be premature to say that industrial specialisation leads to better performance, as is the case in Czech microregions (Ženka et al., 2015), especially since successful single-industrial towns in Slovenia are actively developing new paths from older industrial traditions.

There are some interesting research findings, which indicate the positive influence of industrial culture in smaller and older industrial cities through neo-industrialisation strategies of flexible specialisation, the knowledge economy and the fostering of the "pioneering spirit" (Görmar and Harfst, 2019; Harfst et al., 2018; Pipan, 2018). Industrial towns proved very resilient to recent economic shocks because they were able to adapt in what Pike at al. (2010, p. 62) call the "renewal of a pre-conceived and previously successful development path". They are using old industrial paths to create new ones: either directly in a process called "layering" as found in Czech microregions, where an original industrial specialisation adds new layers through an implantation of export-oriented industry (Ženka et al., 2019); or indirectly through industry-related activities (industrial heritage tourism, education based on industrial knowledge and skills, etc.).

6.2 Specific post-industrial transformation in Slovenia

One process that could influence our results is the absence of the so-called "failed tertiarisation" effect in Slovenia. Some authors suggest that urban shrinkage and poor socioeconomic performance is a problem of failed post-industrial transformations or tertiarisation and not of industry as such (Bartholomae et al., 2017). Gornig and Goebel (2018) explain how tertiarisation left deep scars on cities by forsaking certain achievements from the industrial age, such as collective wage setting and the welfare state. The shift to the service sector also brought increasing social polarisation linked to policies deregulating the labour market. Beatty and Fothergill (2017, p. 177) describe how deindustrialised regions in the UK have been hit by social problems, and even call for "a rebalancing of the UK economy in favour of industry". Although there are deindustrialised towns in Slovenia, we must not forget that the embedded egalitarianism of the society managed to maintain its welfare state. Consequently, Slovenia has one of the lowest wage and wealth gaps in Europe (OECD, 2017a). Perhaps this is the reason that failed tertiarisation effect was not felt to the same extent as some other countries, which can explain weak socioeconomic differences between industrial and non-industrial SMSTs.

Perhaps we should also consider the proposition that there are macroregional differences in Europe and that towns in Central and Eastern Europe develop differently to those in the West. This could also explain our results. Krzysztofik et al. (2016) stipulated that post-industrialism, understood as industrial change, is accompanied by deindustrialisation and urban shrinkage, but simultaneously, at least in Central Europe, re-industrialisation is taking place. Re-industrialisation in certain regions of the Czech Republic, Slovakia and Poland (Krzysztofik et al., 2019), as well as in Croatia (Lončar and Braičić, 2016), is not only a consequence of newly-established plants from abroad but also due to the expansion and modernisation of traditional industry in towns (Industry 4.0). A modern post-industrial region can simultaneously experience processes of re-industrialisation, industrial stabilisation or deindustrialisation. Analogically, towns can experience urban growth and better socioeconomic performance (re-industrialisation) or urban shrinkage (deindustrialisation). We cannot claim that the case of Slovenia represents a standard situation across the whole of Europe, or even East Central Europe. The above-mentioned examples, however, could potentially lead to a conclusion that there are some common patterns of adaptation dynamics, such as re-industrialisation, at least in certain regions of Central and Eastern Europe, and that this is the reason why the socioeconomic situation in Slovenian industrial towns cannot be compared to Switzerland or other countries with a longer capitalist tradition. Post-socialist countries have reintegrated differently to the global economic and spatial structures, and present different current and future development trajectories (Novotný et al., 2016).

6.3 Limitations and future research orientations

As well, there are other possibilities why the results of this study differ significantly from previous research. When we investigated whether there are statistically significant differences between the most and the least industrial towns, deindustrialised towns were generally not included in the analysis, since they did not meet the required 0.5 SD threshold of the share of industrial workplaces. Deindustrialised towns have below average industrial employment and were thus not a part of the industrial towns group, although cognitively they are considered as "industrial". This engenders more research for those shrinking deindustrialised towns faced with the failed tertiarisation effect, and for research demonstrating the heterogeneity and variety of industrial towns. We agree with those authors emphasising the evolutionary perspective on reindustrialisation in Europe, showing the importance of adaptive capabilities according to context- and place-specific structures (Wink et al., 2015).

Additionally, we used statistical analysis to detect differences between two types of smaller towns and a correlational analysis to detect patterns of association in any statistical relationship, whether causal or not, between industrial employment and other socioeconomic indicators. We offered a descriptive snapshot of socioeconomic analysis, but not causality – from our results we know that industrial employment interacts with certain variables, such as the share of votes for radical right parties, but it would be premature to say that industry "causes" populist and radical movements. To delve further into causalities, directionality and other processes (for instance industrial specialisation versus diversification in socioeconomic performance), we would need better sets of data combined with more complex statistical methods, such as multi-level models.

Another potential reason for the different results of this study compared to others could be in differences in data and methodologies. Although we have established that similar research on a national level is extremely limited, we should also acknowledge their methodological heterogeneity. For example, the Czech example (Vaishar et al., 2016) considers towns with population thresholds from 3,000 to 15,000 people, while the Swiss (Meili and Mayer, 2017) and the European study (Servillo et al., 2017) have thresholds similar to ours. In the European study (Servillo et. al. 2014), the selection of towns was predetermined and based on 31 case study towns across Europe, while other studies included SMSTs in the entire national urban system. Methodologically, there are important differences as well, from data collection to analytical procedures. We believe it is important to conduct more unbiased, cross-national and methodologically comparative research on the socioeconomic performance of industrial towns to understand them, and avoid the residents' fear of being left behind and of having no future (Rodríguez-Pose, 2018), which might lead to proneness to populism and political radicalisation (Dijkstra et al., 2019).

7. Conclusions

This paper attempted to test the socioeconomic performance of industrial SMSTs in comparison to their non-industrial counterparts, and to see if the presence of industry has adverse effects on employment, demography, the living environment and voting behaviours. The results, based on multiple and diverse indicators, do not confirm the adverse effect of industry on socioeconomic performance. In fact, only minor differences between industrial and non-industrial SMSTs exist, pertaining mainly to employment and the living environment (slightly better in non-industrial SMSTs). This finding does not reflect mainstream literature on post-industrial discourse, which clearly favours the development of a service-based economy, often as the only way forward for industrial towns and regions. Our theoretical suggestion is that industrial SMSTs should not be viewed too simplistically as some sort of remnant of the industrial past. The sheer fact that SMSTs in Europe exhibit above-average industrial employment compared to national averages, should render them an independent subject of further research and strategic policy-making. No European country, however, has an exclusive policy directed specifically to SMST development (Atkinson, 2017), let alone to that of industrial SMSTs. Local policies in SMSTs are found to have a limited impact on the local economy since they lack expertise and seem to be too small-scale to influence economic development – but they do have more control over land-use planning and the general attractiveness of towns (Kaufman and Meili, 2019).

Ferm and Jones (2017) have argued that cities need to plan for new industry if they are to be economically and socially resilient, sustainable and vibrant. If industrial activities are not planned, there is always a danger that unforeseen or ad hoc industrial development might bring further environmental concerns and have adverse consequences on the socioeconomic well-being of SMSTs. This is important for Slovenian industrial SMSTs because they exhibit slightly worse housing standards. These less favourable living environment conditions indicate that policies on industrial SMSTs should focus on enabling a better quality of life, strengthening (industrial) town identity with local sports and cultural activities – all those factors are important elements of retaining people and fostering diversity (Meili and Shearmur, 2019) that could also attract a younger population and the (higher income) high-tech sector.

We can only agree with Rodríguez-Pose (2018), who is proposing a shift towards more place-sensitive development policies in "places that don't matter", instead of uncritically embracing the idealistic culture-led discourse with no support from the local communities. Instead, we propose the re-orientation of the research and policy fields towards addressing the real socioeconomic issues of industrial SMSTs, such as a lower quality of the living environment and rise of radicalism. It would be best to focus policy making on the advantages and untapped potential of industrial SMSTs – over larger and more service-oriented urban environments.

Acknowledgements

The paper was written as a part of a JPI Urban Europe project: BRIGHT FUTURE. This project has received funding from the European Union's Horizon 2020 research and innovation programme (grant No. 693443) and the Slovenian Research Agency (grant H6-8284). The authors acknowledge the financial support from the Slovenian Research Agency research core funding Geography of Slovenia (P6-0101) project.

References:

ANDREONI, V., GALMARINI, S. (2016): Mapping socioeconomic well-being across EU regions. International Journal of Social Economics, 4(3): 226–243.

ATKINSON, R. (2017): Policies for Small and Medium-Sized Towns: European, National and Local Approaches. Tijdschrift Voor Economische En Sociale Geografie, 108(4): 472–487.

BAILEY, C., MILES, S., STARK, P. (2004): Culture-led urban regeneration and the revitalisation of identities in Newcastle, Gateshead and the North East of England. International Journal of Cultural Policy, 10: 47–65.

BANERJEE, B., JESENKO, M. (2015): Economic Growth and Regional Disparities in Slovenia. Regional Studies, 49: 1722–1745.

BARTHOLOMAE, F., WOONNAM, C., SCHOENBERG, A. (2017): Urban shrinkage and resurgence in Germany. Urban Studies, 54(12): 2701–2718.

BEATTY, C., FOTHERGILL, S. (2017): The impact on welfare and public finances of job loss in industrial Britain. Regional Studies, Regional Science, 4(1): 161–180.

BELL, D. (1973): The coming of post-industrial society: a venture in social forecasting. New York, Basic Books.

BLAIS, A. (2006): What affects voter turnout? Annual Review of Political Science, 9(1): 111 – 125.

BOIX, R., HERVÁS-OLIVER, J. L., DE MIGUEL-MOLINA, B. (2015): Micro-Geographies of Creative Industries Clusters in Europe: From Hot Spots to Assemblages: Micro-Geographies of Creative Industries Clusters. Papers in Regional Science, 94(4): 753–72.

BOLE, D. (2012): Socio-economic characteristics of the Slovene urban system. Geografski Vestnik, 84(1): 141–149.

BOLE, D., KOZINA, J. (2018): Locals' narratives: case study town of Velenje, Slovenia. BRIGHT FUTURE project report T3.3 [online]. [cit. 17.12.2018]. Available at: https://giam.zrc-sazu.si/sites/default/files/t3.3_report_velenje_final_en.pdf

BOLE, D., KOZINA, J., TIRAN, J. (2017): National analysis of Slovenian small and medium-sized industrial towns. BRIGHT FUTURE project report [online]. [cit. 12.03.2018]. ZRC SAZU, Ljubljana. Available at: https://giam.zrc-sazu.si/sites/default/files/wp2_analiza_si_v3.pdf

BOLE, D., KOZINA, J., TIRAN, J. (2019): The variety of industrial towns in Slovenia: a typology of their economic performance. Bulletin of Geography. Socio-Economic Series, 46(46): 71–83.

BOLE, D., NARED, J., ZORN, M. (2015): Small urban centers in the Alps and their development issues. In: Zhelezov, G. [ed.]: Sustainable development of mountain regions (pp. 265–279). Cham, Springer.

BRENNER, N., SCHMID, C. (2014): The 'Urban Age' in Question. International Journal of Urban and Regional Research, 38(3): 731–755.

BUCH, T., HAMANN, S., NIEBUHR, A., ROSSEN, A. (2014): What Makes Cities Attractive? The Determinants of Urban Labour Migration in Germany. Urban Studies, 51(9): 1960–1978.

BURGOON, B., VAN NOORT, S., ROODUIJN, M., UNDERHILL, G. (2019): Positional Deprivation and Support for Radical Right and Radical Left Parties. Economic Policy, 34(97): 49–93.

BURIĆ, I., ŠTULHOFER, A. (2016): In search of the egalitarian syndrome: cultural inertia in Croatia? Financial Theory and Practice. Reviewed Scientific Journal, 40(4): 361–382.

CASTELLS, M. (1989): The Informational City. Information Technology, Economic Restructuring, and the Urban-Regional Process. Oxford, Blackwell.

CLARK, T. N., LLOYD, R., WONG, K. K., JAIN, P. (2002): Amenities Drive Urban Growth. Journal of Urban Affairs, 24: 493–515.

COMBES, P.-P., DURANTON, G., GOBILLON, L., PUGA, D., ROUX, S. (2012): The Productivity Advantages of Large Cities: Distinguishing Agglomeration From Firm Selection. Econometrica, 80: 2543–2594.

COX, E., LONGLANDS, S. (2016): City systems: The role of small and medium-sized towns and cities in growing the northern powerhouse. Manchester, Institute for Public Policy Research.

DAVIES, R. (2015): Industry 4.0. Digitalisation for productivity and growth. European Parliamentary Research Service, PE 568.337: 10.

DIJKSTRA, L., GARCILAZO, E., McCANN, P. (2013): The Economic Performance of European Cities and City Regions: Myths and Realities. European Planning Studies, 21(3): 334–354.

DIJKSTRA, L., POELMAN, H., RODRÍGUEZ-POSE, A. (2019): The geography of EU discontent. Regional Studies (online first). doi: 10.1080/00343404.2019.1654603

DROZG, V. (2012): Polycentric Urban System Between State Regulation and Market Economy – The Case of Slovenia. In: Csapo, T., Balogh, H. [eds.]: Development of the Settlement Network in the Central European Countries (pp. 3–12). Berlin / Heidelberg, Springer.

DURANTON, G. (2015): Growing through cities in developing countries. World Bank Research Observer, 30: 39–73.

EGEDY, T., KOVÁCS, Z. (2009): The capacity and potentials of Budapest to attract creative economy. Hungarian Geographical Bulletin, 58(4): 281–294.

ENGBERSEN, G., SCHUYT, K., TIMMER, J., VAN WAARDEN, F. (2006): Cultures of Unemployment: A Comparative Look at Long-Term Unemployment and Urban Poverty. Amsterdam, University Press, Amsterdam.

EUROSTAT (2017): Employment by A*10 industry breakdowns [online]. [cit. 23.01.2019]. Available at: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

FERM, J., JONES, E. (2017): Beyond the post-industrial city: Valuing and planning for industry in London. Urban Studies, 54(14): 3380–3398.

FLORIDA, R. L. (2003): The Rise of the Creative Class. New York, Basic Books.

FOL, S., CUNNINGHAM-SABOT, E. (2010): Déclin urbain et shrinking cities : Une évaluation critique des approches de la décroissance urbaine. Annales de Geographie, 119(674): 359–383.

FRICK, S. A., RODRÍGUEZ-POSE, A. (2018): Big or Small Cities? On city size and economic growth. Growth and Change, 49: 4–32.

GAVRILETS, S. (2012): On the Evolutionary Origins of the Egalitarian Syndrome. Proceedings of the National Academy of Sciences of the United States of America, 109(35): 14069–14074.

GÖRMAR, F., HARFST, J. (2019): Path Renewal or Path Dependence? The Role of Industrial Culture in Regional Restructuring. Urban Science, 3(4): 106.

GORNIG, M., GOEBEL, J. (2018): Deindustrialisation and the polarisation of household incomes: The example of urban agglomerations in Germany. Urban Studies, 55(4): 790–806.

HAFNER-FINK, M. (2006): Values of the Slovenian Population: Local and Collective or Global and Individual? In: Ramet, S. P., Fink-Hafner, D. [eds.]: Democratic Transition in Slovenia: Value Transformation, Education, and Media (pp. 127–147). College Station: Texas, A&M University Press.

HAMDOUCH, A., DEMAZIERE, C., BANOVAC, K. (2017): The Socio-Economic Profiles of Small and Medium-Sized Towns: Insights from European Case Studies. Tijdschrift Voor Economische En Sociale Geografie, 108(4): 456–471.

HANSEN, N. (1991). Factories in Danish Fields: How High-Wage, Flexible Production has Succeeded in Peripheral Jutland. International Regional Science Review, 14(2): 109–132.

HARFST, J., WUST, A., NADLER, R. (2018): Conceptualizing industrial culture. GeoScape, 12(1): 1–9.

HOSPERS, J. (2014): Policy Responses to Urban Shrinkage: From Growth Thinking to Civic Engagement. European Planning Studies, 22(7): 1507–1523.

INGLEHART, R., NORRIS, P. (2016): Trump, Brexit, and the Rise of Populism: Economic Have-nots and Cultural Backlash. HKS Working Paper No. RWP16-026.

KAUFMANN, D., MEILI, R. (2019): Leaves in the wind? Local policies of small and medium-sized towns in metropolitan regions. European Planning Studies, 27(1): 21–41.

KEMENY, T., STORPER, M. (2015): Is Specialization Good for Regional Economic Development? Regional Studies, 49(6): 1003–1018.

KNOX, P., MAYER, H. [eds.] (2013): Small town sustainability: Economic, social, and environmental innovation. Berlin, Walter de Gruyter.

KOCEVA, M. M., BRANDMÜLLER, T., LUPU, I., ÖNNERFORS, Å., CORSELLI-NORDBLAD, L., COYETTE, C., JOHANSSON, A., STRANDELL, H., WOLFF, P. [eds.] (2016): Urban Europe: statistics on cities, towns and suburbs. Luxembourg: Publications Office of the European Union.

KOZINA, J., BOLE, D. (2018): The impact of territorial policies on the distribution of the creative economy: tracking spatial patterns of innovation in Slovenia. Hungarian Geographical Bulletin, 67(3): 259–273.

KRZYSZTOFIK, R., TKOCZ, M., SPÓRNA, T., KANTOR-PIETRAGA, I. (2016): Some dilemmas of post-industrialism in a region of traditional industry: The case of the Katowice conurbation, Poland. Moravian Geographical Reports, 24(1): 42–54.

KRZYSZTOFIK, R., KANTOR-PIETRAGA, I., KŁOSOWSKI, F. (2019): Between Industrialism and Postindustrialism—the Case of Small Towns in a Large Urban Region: The Katowice Conurbation, Poland. Urban Science, 3(3): 68.

LANDRY, C. (2000): The Creative City: A toolkit for urban innovators. London, Earthscan.

LAPUH, L. (2018): Socio-economic characteristics of resilient localities – experiences from Slovenia. Regional Studies, Regional Science, 5(1): 149–156.

LONČAR, J., BRAIČIĆ, Z. (2016): Industrial restructuring and downsizing: Case study of Central Croatia. Acta Geographica Slovenica, 56(2): 209–220.

LORENTZEN, A., VAN HEUR, B. [eds.] (2012): Cultural Political Economy of Small Cities. Oxon, Routledge.

MARTIN, R., SUNLEY, P. TYLER, GARDINER, B. (2016): Divergent cities in post-industrial Britain. Introduction: deindustrialisation, post-industrialisation and divergent city growth paths. Cambridge Journal of Regions, Economy and Society, 9: 269–299.

MARTINEZ-FERNANDEZ, C., AUDIRAC, I., FOL, S., CUNNINGHAM-SABOT, E. (2012): Shrinking Cities: Urban Challenges of Globalization. International Journal of Urban and Regional Research, 36(2): 213–225.

MEIJERS, E. J. (2008): Measuring Polycentricity and its Promises. European Planning Studies, 16(9): 1313–1323.

MEIJERS, E. J., BURGER, M. J., HOOGERBRUGGE, M. M. (2016): Borrowing size in networks of cities: City size, network connectivity and metropolitan functions in Europe. Papers in Regional Science, 95: 181–198.

MEILI, R., MAYER, H. (2017): Small and medium-sized towns in Switzerland: Economic heterogeneity, socioeconomic performance and linkages. Erdkunde, 71(4): 313–332.

MEILI, R., SHEARMUR, R. (2019): Diverse diversities – Open innovation in small towns and rural areas. Growth and Change, 50(2): 492–514.

MELLANDER, C., FLORIDA, R., RENTFROW, J. (2012): The creative class, post-industrialism and the happiness of nations. Cambridge Journal of Regions, Economy and Society, 5(1): 31–43.

NARED, J. (2018): Local Self-government Reforms in Slovenia: Discourse on Centrality and Peripherality. In: Pelc, S., Koderman, M. [eds.]: Nature, Tourism and Ethnicity as Drivers of (De)Marginalization (pp. 243–256). Cham, Springer.

NARED, J., BOLE, D., VALJAVEC, M. B., CIGLIČ, R., GOLUŽA, M., KOZINA, J., RAZPOTNIK VISKOVIĆ, N., REPOLUSK, P., RUS, P., TIRAN, J., ISTENIČ, M. Č. (2017): Central settlements in Slovenia in 2016. Acta Geographica Slovenica, 57(2): 7–32.

NARED, J., ERHARTIČ, B., RAZPOTNIK VISKOVIĆ, N. (2013): Including development topics in a cultural heritage management plan: Mercury heritage in Idrija. Acta Geographica Slovenica, 53(2): 394–402.

NELSON, H. J. (1955): A Service Classification of American Cities. Economic Geography 31(3): 189–210.

NOVOTNÁ, J., NOVOTNÝ, L. (2019): Industrial clusters in a post-socialist country: The case of the wine industry in Slovakia. Moravian Geographical Reports, 27(2): 62–78.

NOVOTNÝ, J., BLAŽEK, J., KVĚTOŇ, V. (2016): The anatomy of difference: comprehending the evolutionary dynamics of economic and spatial structure in the Austrian and Czech economies. European Planning Studies, 24(4): 788–808.

OBSCHONKA, M., STUETZER, M., RENTFROW, P. J., LEE, N., POTTER, J., GOSLING, S. D. (2018): Fear, populism, and the geopolitical landscape: the "sleeper effect" of neurotic personality traits on regional voting behavior in the 2016 Brexit and Trump elections. Social Psychological and Personality Science, 9(3): 285–298.

OECD (2017a): Understanding the Socio-Economic Divide in Europe [online]. [cit. 13.04.2018]. Available at: https://www.oecd.org/els/soc/cope-divide-europe-2017-background-report.pdf

OECD (2017b): Slovenia: trade and investment statistical note [online]. [cit. 17.12.2018]. Available at: http://www.oecd.org/investment/SLOVENIA-trade-investment-statistical-country-note.pdf

PAVLINEK, P. (2004): Regional development implications of foreign direct investment in Central Europe. European Urban and Regional Studies, 11(1): 47–70.

PINK, S., SERVON, L. J. (2013): Sensory Global Towns: An Experiential Approach to the Growth of the Slow City Movement. Environment and Planning A: Economy and Space, 45(2): 451–466.

PIKE, A., DAWLEY, S., TOMANEY, J. (2010). Resilience, adaptation and adaptability. Cambridge Journal of Regions, Economy and Society, 3(1): 59–70.

PIPAN, T. (2018): Neo-industrialization models and industrial culture of small towns. GeoScape, 12(1): 10–16.

PLÖGER, J., KOHLHAAS-WEBER, I. (2014): Shock-proof cities? The impact of and responses to the recent financial and economic crisis in older industrial cities. Journal of Urban Regeneration and Renewal, 7: 136–149.

POLK, J., ROVNY, J., BAKKER, R., EDWARDS, E., HOOGHE, L., JOLLY, S., KOEDAM, J., KOSTELKA, F., MARKS, G., SCHUMACHER, G., STEENBERGEN, M., VACHUDOVA, M., ZILOVIC, M. (2017): Explaining the salience of anti-elitism and reducing political corruption for political parties in Europe with the 2014 Chapel Hill Expert Survey data. Research & Politics, 4(1).

RICKETTS, E. R., SAWHILL, I. V. (1988): Defining and Measuring the Underdass. Journal of Policy Analysis and Management, 7(2): 316–325.

RODRÍGUEZ-POSE, A. (2018): The revenge of the places that don't matter (and what to do about it). Cambridge Journal of Regions, Economy and Society, 11(1): 189–209.

ROODUIJN, M., BURGOON, B., VAN ELSAS, E. J., VAN DE WERFHORST, H. G. (2017): Radical distinction: Support for radical left and radical right parties in Europe. European Union Politics, 18(4): 536–559.

RYDGREN, J. (2012): Class Politics and the Radical Right. London and New York: Routledge.

SASSEN, S. (1991): The Global City. New York, London and Tokyo: Princeton University Press.

SCOTT, A. J. (1997): The Cultural Economy of Cities. International Journal of Urban and Regional Research, 21(2): 323–339.

SERVILLO, L., ATKINSON, R., HAMDOUCH, A. (2017): Small and Medium-Sized Towns in Europe: Conceptual, Methodological and Policy Issues. Tijdschrift Voor Economische En Sociale Geografie, 108(4): 403–423.

SERVILLO, L., ATKINSON, R., SMITH, I., RUSSO, A., SÝKORA, L., DEMAZIČRE, C., HAMDOUCH, A. (2014): TOWN, small and medium sized towns in their functional territorial context. Final ESPON Report. Luxembourg: ESPON.

SLACH, O., KOUTSKY, J., NOVOTNY, J., ŽENKA, J. (2013): Creative industries in the Czech Republic: a spatial perspective. Ekonomie, 16(4): 14–29.

STORPER, M. (2013): The Keys to the City: How Economics, Institutions, Social Interactions and Policies Shape Development. Princeton: Princeton University Press.

SÝKORA, L., BOUZAROVSKI, S. (2012): Multiple Transformations: Conceptualising the Post-communist Urban Transition. Urban Studies, 49(1): 43–60.

SÝKORA, L., MULÍČEK, O. (2017): Territorial Arrangements of Small and Medium-Sized Towns from a Functional-Spatial Perspective. Tijdschrift Voor Economische En Sociale Geografie, 108(4): 438–455.

TIRAN, J. (2015): Urbano proti ruralnemu: (nov) razcep v slovenskem političnem prostoru? Teorija in praksa, 52(1/2): 271–290.

URBANC, M., NARED, J., BOLE, D. (2012): Idrija: A Local Player on the Global Market. In: Häyrynen, S., Turunen, R., Nyman, J. [eds.]: Locality, Memory, Reconstruction: The Cultural Challenges and Possibilities of Former Single-Industry Communities (pp. 101–122). Newcastle: Cambridge Scholars Publishing.

VAISHAR, A., ZAPLETALOVÁ, J., NOVÁKOVÁ, E. (2016): Between Urban and Rural: Sustainability of Small Towns in the Czech Republic. European Countryside, 8(4): 351–372.

VAN WINDEN, W. (2010): Knowledge and the European City. Tijdschrift Voor Economische En Sociale Geografie, 101(1): 100–106.

VEHOVAR, U., TIRAN, J. (2017): Structural and cultural characteristics of Slovenian society and potential for establishment of authoritarian rule. Research in social change, 9(1): 49–68.

WINK, R., KIRCHNER, L., KOCH, F., SPEDA, D. (2016). There are Many Roads to Reindustrialization and Resilience: Place-based Approaches in Three German Urban Regions. European Planning Studies, 24(3): 463–488.

WIRTH, P., ELIS, V., MÜLLER, B., YAMAMOTO, K. (2016): Peripheralisation of small towns in Germany and Japan– Dealing with economic decline and population loss. Journal of Rural Studies, 47: 62–75.

WOLFF, M., WIECHMANN, T. (2018): Urban growth and decline: Europe's shrinking cities in a comparative perspective 1990–2010. European Urban and Regional Studies 25(2): 122–139.

ZAVODNIK LAMOVŠEK, A., DROBNE, S., ŽAUCER, T. (2008): Small and medium-size towns as the basis of polycentric urban development. Geodetski Vestnik, 52(2): 267–289.

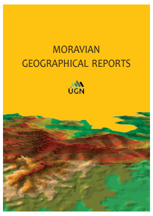
ŽENKA, J., NOVOTNÝ, O. SLACH, KVĚTOŇ, V. (2015): Industrial specialization and economic performance: A case of Czech microregions. Norsk Geografisk Tidsskrift – Norwegian Journal of Geography, 69: 67–79.

ŽENKA, J., SLACH, O., PAVLÍK, A. (2019): Economic resilience of metropolitan, old industrial, and rural regions in two subsequent recessionary shocks. European Planning Studies, 27(11): 2288–2311.

ŽUPANOV, J. (1970): Egalitarizam i industrializam. Sociologija, 12(1): 5–45.

Please cite this article as:

BOLE, D., KOZINA, J., TIRAN, J. (2020): The socioeconomic performance of small and medium-sized industrial towns: Slovenian perspectives. Moravian Geographical Reports, 28(1): 16–28. Doi: https://doi.org/10.2478/mgr-2020-0002



MORAVIAN GEOGRAPHICAL REPORTS

sciendo

The Czech Academy of Sciences, Institute of Geonics
journal homepage: http://www.geonika.cz/mgr.html
doi: https://doi.org/10.2478/mgr-2020-0003

Changes in urban transport behaviours and spatial mobility resulting from the introduction of statutory Sunday retail restrictions: A case study of Lodz, Poland

Marta BOROWSKA-STEFAŃSKA [a], Michał KOWALSKI [a], Szymon WIŚNIEWSKI [a *]

Abstract

The impact of statutory Sunday retail restrictions on the transport behaviours of people living in the Polish post-socialist city of Lodz is investigated in this article. One carrier of information on journeys undertaken in the city is data from induction loops – a part of the city's Intelligent Transportation System (ITS). The second source of data is a two-stage questionnaire survey (concerning trading and non-trading Sundays) of the city's inhabitants, aimed at defining any changes in their transport behaviours with reference to the introduction of retail restrictions. The research was conducted to assess the way in which the new statutory restrictions affect transport behaviour discharged after the political transformation. The results of the research conducted on the transport behaviours of Lodz residents indicate that the majority of their transport behaviours clearly depend on whether a given Sunday is a trading or non-trading day. The traffic load of the urban road network (perceived as the manifestation of residents' spatial mobility) is characterised by a distinct changeability due to the legislative restrictions related to Sunday trading. There is both a time (daily and hourly) differentiation of traffic flows and a spatial changeability of the load in the urban space, when a comparative analysis is conducted of the results of observations made in the weeks preceding trading and non-trading Sundays. The study also demonstrates that the time previously devoted to Sunday shopping is currently spent not only at home, but also allocated to new (and until now unperformed) activities that often require travelling.

Keywords: *spatial mobility, transport behaviour, retail restrictions, Intelligent Transportation Systems, Lodz, Poland*

Article history: *Received 28 June 2019, Accepted 26 February 2020, Published 31 March 2020*

1. Introduction

In geographical and sociological research, mobility is a concept that encompasses both the multi-scale movement of people, goods, capital and information, and the local phenomena related to daily trips and travelling in the public space (Hannam et al., 2006). In this article, we focus on spatial mobility, which Kaufmann (2005) divides into four types: (I) short-term, within a certain distance of home – daily mobility; (II) short-term, outside a certain distance of home – travel (including tourism); (III) long-term, within a certain distance of home – residential change; (IV) long-term, outside a certain distance of home – migration (Borowska-Stefańska and Wiśniewski, 2019; Komornicki, 2011).

In line with this classification, our studies focus mainly on short-term mobility within a certain distance of home. Mobility results from trips taken to fulfil certain needs (Hannam et al., 2006). Numerous studies on transport behaviours indicate the strong position of shopping in the hierarchy of such needs (Carp, 1988; Vilhelmson, 1999; Kraft, 2014). The introduction of legislation with respect to shopping days – such as the Polish Act on retail restrictions on Sundays and public holidays, as well as some other specified days (Item 305 published in the Official Journal of Laws of the Republic of Poland ("Dziennik Ustaw")) in March 2018, has become a barrier restricting the possibilities of fulfilling this particular need.

Existing studies – conducted by various researchers, including economists (Szromnik, 2017), sociologists (Szul, 2015), and geographers (Rochmińska, 2016) – demonstrate that shopping and spending leisure time in trading facilities is an important and popular element of people's Sunday activities. In Poland, the traditional, Catholic image of the weekend (and Sunday in particular)

[a] Institute of the Built Environment and Spatial Policy, Faculty of Geographical Sciences, University of Lodz, Lodz, Poland (*corresponding author: S. Wiśniewski, e-mail: *szymon.wisniewski@geo.uni.lodz.pl*)

has undergone dramatic changes during the period of social, political and economic transformation (Čábyová et al., 2014; Szromnik and Wolanin-Jarosz, 2018). Changes in the job market have brought about alterations to working conditions, including varied forms and rules of employment, which are translated into substantial changes to the ways and standards of social life of both individuals and whole families, including, in particular, the amount and ways of spending free time (Rochmińska, 2011). Therefore, it appears to be quite legitimate to scrutinise the impact that the statutory restrictions have exerted on people's transport behaviours in Poland.

The research reported here focuses on the transport behaviours of residents in a large city, their mobility (expressed by traffic volumes on the road and street network), and the effects of legal regulations related to Sunday trading. The juxtaposition of these three elements allows us to analyse the impact of the legislation – implemented to protect employees' rights to free Sundays by releasing those in the retail trade from their obligation to work on Sundays, and to create equal competition opportunities for the smallest retail shops (which reported the greatest losses when big-box stores appeared on the Polish market) – on social behaviours, whose transformation legislators did not take into account. Such behaviours include those related to transport – understood as a statistically-described set of transport decisions made by a specified population in a given territorial unit, and identified on the basis of a questionnaire survey and traffic load measurements.

The main purpose of this article is to determine the impact of the statutory Sunday retail restrictions on the transport behaviours of people living in a large post-socialist city, and it will be accomplished through the completion of the following detailed objectives:

- The analysis of transport behaviours of residents on trading and non-trading Sundays;
- Identification of the reasons behind any possible changes in transport behaviours related to the Sunday retail restrictions and the extent of their relation with (independence from) the ban;
- Indication of features of temporal and spatial differentiation regarding residents' mobility, the expression of which is the load of the urban road network on non-trading and trading Sundays; and
- Scrutiny of spatial, daily and hourly variability of vehicle numbers within the road and street network reported during weeks with and without trading Sundays, and presented with reference to spatial management.

This paper, which presents mobility during working days and weekends, contains data on weekdays preceding trading and non-trading Sundays, and weekends with or without trading Sundays. The final section of the article focuses on a comparison of transport behaviours among Lodz residents in the said periods, including an attempt to determine – by means of data from induction loops – what impact the implementation of the statutory retail restrictions has had on changes in transport behaviours.

The second part of the article provides a review of the research into and studies on the links between spatial mobility and trade, with a particular focus on post-socialist cities. The third part presents the source materials used in the paper and the research methods applied in the analytic procedures, while the fourth section contains the empirical analysis of changes in transport behaviours among Lodz citizens that have resulted from the introduction of the statutory retail restrictions, which is followed by a scrutiny of the results, a summary of such, as well as conclusions and recommendations for further studies. Due to the fact that the retail restrictions were implemented relatively recently (2018), the resultant changes in spatial mobility constitute a new and significant research issue, which should contribute to the development of scientific research into such issues. In Poland, this research issue is an absolute novelty, since the statutory restrictions were only introduced in 2018, and their effects in various areas will most likely be the subject of further research.

2. Theoretical background

The issue of regulation concerning shop opening hours has been regularly discussed in many European countries over the last two decades. Such discussions have resulted in a softening of the legal restrictions in, for instance, Great Britain, Holland and Germany, but regulations with regard to Sunday trading still vary considerably in different European countries (Dijkgraaf and Gradus, 2006, 2007; Genakos and Danchev, 2015; Kay and Morris, 1987). Currently, numerous countries are holding heated debates on the opening hours of retail shops and other facilities. Some participants advocate for unrestricted competition and greater customer freedom, while others believe that the rights of retail trade employees to free Sundays for relaxation and leisure time must be respected (Temperini and Gregori, 2015). Naturally, Sunday retail restrictions also bring effects and consequences apart from mobility changes. These include their impact on the labour market (Paul, 2015), and the distribution of the lost turnover from non-trading Sundays (Choi and Jeong, 2016). The conclusions to be drawn there are partially related to spatiality, and thus, they may be used to theorise on customers' spatial behaviours.

In general, deregulation of restrictions imposed on shops with regard to business hours translates into an increase in expenses and a drop in the number of small shops (Nooteboom, 1983). The spatial model developed by Morrison and Newman (1983) – which premises that the price of a given good is the resultant of the price itself and additional costs as a result of the time spent by the consumer in purchasing the item – allows us to assume that the sales volume will grow in large stores and diminish in small shops if the opening hours are prolonged, and the effect will be reversed in the case of more substantial legal regulation in the matter. As regards Sunday trading, some researchers believe that competitive pressures may induce excessive opening on Sundays, when high costs would be incurred (naturally followed by price increases; Kay and Morris, 1987). The empirical evidence collected in the United Kingdom, however, shows that this does not occur in practice, and that the deregulation of opening hours of retail facilities leads to a decrease in costs and prices (Gradus, 1996). Although the imposition of Sunday trading restrictions results in a slight drop of net sales (if we take into account the growth observed on other days of the week), and leads to people shopping on alternative days and, partially, also in different places (e.g. small shops: Choi and Jeong, 2016), in their study on changing business hours, Bell et al. (1997) indicate that such restrictions encouraged consumers to shop where stores were clustered, thus reducing their time-based costs.

In Poland, attempts to introduce statutory Sunday retail restrictions have been made on a number of occasions over recent years, for example in 1999 and 2014. The issue resurfaced in 2016 with the submission of a bill initiated by citizens over Sunday retail restrictions (supported by Solidarity, the largest trade union in the country). Consequently, an act on retail restrictions on Sundays and public holidays, as well as certain other days, was introduced in Poland in March, 2018: Dz.U. 2018 item 305, as amended with regard to changes to the provisions of the Entrepreneurs' Law Act and other acts concerning business activity, Dz.U. 2018 item 650). In accordance, the trading ban will be introduced gradually. Shops have been open on two Sundays per month since March 2018 and will be open on only one Sunday from 2019, and from 2020 the ban will include all Sundays apart from seven (three Sundays before holidays, as well as the last Sundays in January, April, June and August: Stelina, 2018). Under the Act, only those retail facilities in which the owner or the owner's household members (the closest family) are directly in charge of handling retail activities, may operate on all Sundays and public holidays. As a result, transport needs with regard to travelling to shopping facilities encountered a major barrier.

The above changes should be perceived through the prism of the characteristics of consumer behaviour – which are quite distinctive in post-socialist countries. Retail in Poland developed on the basis of the pre-requisites typical of free-market countries until the outbreak of World War II. In turn, during the socialist period retail - initially being the domain of mercantilism and co-operatives, continuing pre-war traditions (even in the 1940s, the share of such initiatives was 89% of the whole country's retail: Kaliński, 1968) – was in time subject to quite rapid nationalization under the concept of "battle for trade" promoted by the domestic socialist authorities of that time (the Polish Workers' Party) (Åslund, 1985). As a result, as early as in the 1950s the share of the private sector in retail turnover slumped to a mere 3.2%.

The last decade of socialism, however, did see a very slow transformation of retail in Poland. The share of collectivised retail in the total retail turnover shrank from 98% in 1981 to 95% in 1989, although this hardly changed its monopolist position in the economy (Kaliński, 2015). In the years of the centrally-planned economy in Poland, Chudzyńska (1985) notices that "theoretical models of service localisation assume that a service point of a given function should be located in each settlement unit of the population that is larger or equal to the break-even point for this function" (p. 14). She adds that service points are generally located in places of the highest market accessibility, in which there is a tendency to concentrate service points and consequently form service centres. In practice, however, in socialist times, especially in its last decades, most shops in Poland offering food, chemical and household goods were more and more visibly undersupplied, etc. (Lesiakowski, 2012). In the last decade of socialism, retail trading was primarily based on small shops and simplistic forms of retail outlets (e.g. market stands, stalls and booths), and, less frequently, on department stores.

In the period of political transformation (late 1980s and early 1990s), the Polish economy saw, on the one hand, rapid privatisation due to a number of conditions and crises, and, on the other, the demise of many ill-managed state-owned enterprises. Even though numerous small retail units began to appear on the market (Taylor, 2000; Dzieciuchowicz, 2013), the potential for domestic capital to support the development of large retail facilities remained low on a nation-wide scale. The introduction of a free-market economy and the opening of the domestic market to foreign investors, resulted in a rapid expansion of retail chains in Poland. This transformation put an end to the problems connected with the availability of basic products, which since that time have often been offered in new, modern premises such as supermarkets, hypermarkets and shopping centres (Kaczmarek, 2011; Kowalski, 2018).

The spatial behaviours of Poles was considerably affected by the aforementioned deficiencies, and the low level of organisation of retail clashed with a highly developed form of retail. Consequently, due to the high concentration of retail, these facilities (shopping centres) began to play an increasingly important role in shaping the network of all kinds of relations and connections, integrating many social and economic phenomena which took place in the post-socialistic city (Dinic-Brankovic et al., 2018; Heffner and Twardzik, 2015a) as well as in western countries (Bennison and Davies, 1980; Hopkins, 1991; Lowe, 2005). Over time, and with growing competition, these facilities extended their offer to include services other than retail, which consequently increased their impact as they no longer depended only on the scale of retail concentration but also on certain non-retail attractors (Cudny, 2016). As a result, these facilities have become contemporary temples of consumption (Ritzer, 2005; Xavier, 2018), particularly for post-socialist societies (Rembowska, 2008). Such phenomena bring about, for instance, considerable traffic-generating potential from these places, which, in consequence, translates into the efficiency of the city's transport layout in the areas in which they function (Romanowska and Jamroz, 2015).

Apart from changes in spatial and purchasing behaviours following the transformation of retail in post-socialist countries, particularly in Poland, the socialist system did not reflect "hidden" features of Poles, such as their liking for ownership or independence in everyday life. The political transformations awoke behaviours previously quashed, which were additionally reinforced by accounts of lifestyles abroad shared by the numerous Polish diaspora living mainly in the United States (including transport behaviours: Komornicki, 2003). All this leads to Poles changing their transport choices as they get richer – more and more often choosing a car to fulfil their transport needs (the expression of which is a very rapid increase in car ownership rate) at the expense of public transport or alternative means of personal transport. Additionally, some distinctive factors shaping the car ownership rate in Poland include: the prestige and social position resulting from owning a car (Lijewski, 1998); the relative ease of owning a car when compared to possessing a residential property (Menes, 2001); privatisation and decentralisation of the economy, as well as high indirect labour costs (Komornicki, 2011). Taking into account the historical background of transformations in retail trade and the development of motorisation in post-socialist countries, one must bear in mind that Sunday trading restrictions may have different repercussions there when compared to countries that have enjoyed a free market economy for decades.

3. Data and methods

The first source of information on journeys undertaken within the city is data from induction loops that are part of the Intelligent Transportation Systems (ITS) functioning within the city boundaries of Lodz. The second source is a questionnaire survey conducted in two stages (concerning trading and non-trading Sunday) with the city's inhabitants, aimed at defining changes in their transport behaviour with reference to the introduction of retail restrictions. The results of the questionnaire survey were analysed to determine the extent of their relation with (or independence from) the Sunday shopping ban (using a chi-squared test). The strength of the correlations that occurred depend on the legislative change and were analysed by means of Cramér's V. Another analysis focused on the spatial, daily and hourly variability of vehicle numbers within the road and street network, reported during weeks with and without trading Sundays. This involved calculating changes in traffic volume and the percentage of such changes, traffic distribution during weeks with and without retail restrictions, changes in traffic distribution and median for differences in traffic volume, the standard deviation for differences in traffic distribution, and the rate of variability of differences in traffic volume. The results presented here originate from the two aforementioned sources. Since the two types of data differ substantially (surveys have a declarative nature, while data from induction loops are relatively objective), the third part of the article has been divided into three sections: Subsection 3.1 characterises the survey questionnaire and the respondents; Subsection 3.2 contains a description of data from the induction loops; and Subsection 3.3 refers to the research area, Lodz, a large city in central Poland.

It must be emphasised that the two types of data used in this study – namely the data collected from surveys and those from ITS sensors – are meant to complement, rather than substitute for one another. After all, the questionnaire survey focuses on a specific cohort of respondents whose mobility within the urban area (a manifestation of transport behaviour) was, in all probability, also recorded by the local ITS (just like trips taken by all other residents). It is, however, beyond our possibilities to select and isolate this group (respondents) within the database, since the ITS data from induction loops contains evidence of all motor vehicles (including buses and construction vehicles) that were detected within the city's transport system during the researched period. Induction loops (a measurement component of the ITS) are installed within the road surface and react to the electromagnetic spectrum emitted by objects that travel above them. Unfortunately, the ITS in Lodz does not allow us to classify vehicles. There are ITS systems which do offer this functionality, but unfortunately the solution applied in Lodz is not one of them. Even if it did offer the possibility to recognise public transport vehicles, their timetable is unaffected by trading restrictions, so it would be necessary to measure the number of passengers on board. From our research perspective, however, this is an inconvenience that excludes the possibility of drawing unambiguous conclusions on factors determining the volume and spatial distribution of traffic flows. Nevertheless, if we look at the ITS data through the prism of the survey, we may expand our reasoning with potential co-occurrence of certain regularities which stem from the respondents' answers and objective measurements conducted via the ITS sensors.

3.1 Questionnaire survey and profile of respondents

For the purposes of the study, a two-stage questionnaire survey was conducted. In both of these stages the same dwellings were visited. The first stage was carried out during a week following a non-trading Sunday (November 19–23), and the respondents were asked to refer exclusively to that Sunday (i.e. November 18). The second stage was conducted during a week following a Sunday with no trading restrictions (November 26–30), and the questions again focused only on that previous Sunday (i.e. November 25). Apart from respondent socio-demographic characteristics, the questionnaire contained open-ended and 'semi-open' questions that inquired about the number of trips taken; the reasons why: "if there were no trips", and the time spent at home. Next, the respondent was asked to determine their motivation behind each trip at a specified time, the means of transport they used, including the number of changes of vehicle/transport mode, travel time, the hour of departure and arrival, and the starting point and destination, including any errands and destinations 'en route'. During the second stage, the questionnaire was expanded, with questions referring to the impact of the statutory Sunday trading ban on their shopping habits and time management. Additionally, there was also a question – aimed at respondents who usually did their shopping on Sunday – about how they allocated the free time that would normally be spent in the shops.

The unit of observation in the research was single- or multi-member households, as well as household members of age of 16 or more living in the selected dwellings. The number of household members neither determined nor excluded households from the survey. In the case of multi-member households, the selected respondent was a person currently at home, and if there were more members present, we selected the dweller whose date of birth (day and month) was closest to the date when the survey was conducted. The questionnaire focused on the respondent's traits and behaviours, with some questions also regarding the whole household (e.g. number of household members, average income). In some cases, assistance was provided by the head of the family or a decision-making adult. The applied age limit (16 years of age or older) stems from practices of traffic research in Poland, and is meant to take into account respondents who make relatively 'independent' mobility decisions (with a particular focus on shopping decisions), as these people were expected to fill in the journey log. It was assumed that the transport behaviours of younger users of the urban transport system depended substantially on decisions made by their parents/legal guardians. These youths are persons who have completed the primary level of education (the only obligatory requirement in Poland).

The research was carried out with a selected sample of 465 dwellings from the city of Lodz and had the character of voluntary anonymous research. The sample selection took place in two stages. The first stage involved choosing a 5% sample of primary sampling units, which are census areas or groups of census areas (comprising at least 15 dwellings). The secondary sampling units were dwellings. Three dwellings were selected for the main sample, and three for the reserve sample from each of the previously chosen census areas. 155 census areas (from 3,107, with number of dwellings not smaller than 15), and then 465 dwellings were selected for the research. The selection of surveyed areas (i.e. meeting the requirement of a sufficient number of homes) involved the city as a whole (the entire area was divided into the smallest unit of spatial classification, i.e. a census tract). The selection of homes in individual neighbourhoods (census tracts) was also conducted at random.

The sample was not representative, however, which stemmed mainly from financial limitations. Another obstacle to implement a representative sample was the time allocated for the questionnaire surveys, which had to be conducted promptly after the selected Sundays so that the respondents would provide reliable answers. Being aware of the drawbacks of this approach, the authors followed good research practices in the matter and refrained from applying extensive generalisations, for example to other cities. The implications, then, are that we are dealing with a largely exploratory study.

Consent to take part in the research was more often given by women than men – with women representing nearly 60 per cent of the survey's participants (the feminisation ratio being over 119 women to 100 men), hence women are slightly overrepresented in research output data. Two groups of respondents are clearly prevalent with reference to education: those with a secondary education (almost 45 per cent) and a higher education (nearly 34 per cent). The average age of respondents was 42. The majority of respondents work in professional occupations. The largest group is made up of respondents who work outside their home (79.5 per cent). The most popular sectors among respondents include administration and other services (about 20 per cent each). The majority of persons in employment do not work on Sundays (slightly over 76 per cent). In turn, only a small number of individuals declared that they had to work every Sunday (0.5 per cent; see Tab. 1 for details).

Respondents who took part in the survey represented 2-person (slightly over 31 per cent) and 3-person (almost 28 per cent) households in the majority of cases. With regard to the professional situation, relatively, 2 persons working professionally (nearly 61 per cent) make up the largest number of households. The largest number of respondents declared a net income in the region of 350–460 EUR (with an exchange rate of 4.3 to PLN) per person in the household (slightly over 34 per cent), followed by a group with an income between 230–350 EUR net per person (almost 23 per cent), and then 460–580 EUR (slightly over 20 per cent). The average net income per person in a household is 447 EUR (Tab. 1).

3.2 Data from the ITS (induction loops)

The carrier of information on journeys undertaken within the city is the data from induction loops that are part of the city's Intelligent Transportation System (ITS) in Lodz (Kowalski and Wiśniewski, 2017a; Borowska-Stefańska et al. 2019). Data from a complete two-week period were obtained from the Lodz ITS (the week before a trading Sunday, and the week before a non-trading Sunday), which preceded the Sundays included in the questionnaire survey so as to ensure that any conclusions refer to the same timing.

Relying on data from induction loops imposes certain preliminary assumptions. This is information with an extremely high time accuracy, obtained from a large set of measurement points. Yet it fails to provide any qualitative data; hence the analysis was extended to include the above-mentioned questionnaire survey. Apart from the number of vehicles which passed through the given detector in the analysed time interval, the researcher does not have access to any other direct information. It is only through "superimposing" the network of induction loops on the city's functional and spatial structure that it is possible to make general conclusions about the distribution of potential travel sources and destinations. It is also necessary to assume that no other factors conditioning volumes of traffic on the city's road and street network were subject to any changes in the analysed periods. In brief, it is assumed that changes in the time and spatial structure of vehicle traffic result solely from retail restrictions.

Characterising the general distribution of the system's measurement elements (induction loops), it should be pointed out that they are concentrated mostly in the city centre, and if they do go beyond it, they tend to accompany key transport arteries in the meridional and latitudinal layout. Such a distribution greatly affects any subsequent conclusion-making process on the basis of research results conducted with the given data. There are also many issues the solution for which cannot be based on certain interpolations or extrapolations of the data obtained from ITS measurement tools. Analysing the data from the ITS, one should bear in mind that the spatial mobility of the population recorded in them – i.e. their transport behaviours – is not really "natural", as the ITS alone affects the registered flows by, for instance, favouring tram transport or setting the phase length of traffic lights. This is obviously a natural part of the city's transport system, yet one should take into account that the picture emerging from the analysis of data obtained from the ITS is not only the result of decisions taken by traffic participants.

The functioning of induction loops may be encumbered with all kinds of errors and breakdowns, the result of which may be, for example, flawed results of vehicle count measurements (Li et al., 2014). This is why, after collection from the ITS, data control is necessary as the system alone does not detect such kinds of errors. This basic information on the spatial mobility of the population enables the undertaking of numerous problem analyses. An example of this could be the influence of retail restrictions on the city's transport system. It is possible, however, to present the volume of movement made by vehicles using the monitored sections of the urban road network in the region, where the given city's spatial structure elements occur (Kowalski and Wiśniewski, 2017b): in this case, retail facilities. Data obtained from the city system allows one to pinpoint the 'real' traffic generating potential. Data adopted in this research project by no means replaces information on travel motivations, sources and destinations, collected directly from traffic participants. They only present the load on the network, being, in a way, an expression of the choices made by road users at any given time. Consequently, research of this type is general – or holistic – as it refers to all car movements without indicating any individual dimensions of mobility.

These factors help to explain why it is impossible to depict the traffic generating potential of shopping centres on the scale of the whole city, without the possibility of isolating this part of traffic in traffic flows – connected with transit (including intra-city transit). In this context, the major value of the current research project resides in combining the data on the volume of movements (data from the ITS) in the regions where the given development and (retail) function occurs (data from the Head Office of Geodesy and Cartography), with the results of the conducted questionnaire survey.

3.3 Area under study

As the third most populated urban agglomeration in Poland, Lodz has a demographic structure which places it among both the most feminised and fastest-ageing cities –

Characteristics (N = 465)		Share [%]	Characteristics (N = 465)		Share [%]
Gender	Female	59.8	Possession of a driving licence by respondents	Yes	77.6
	Male	40.2		No	22.4
Education	Primary	0.9	Number of bicycles in the household	0	29.5
	Junior high school	1.1		1	22.4
	Vocational	15.5		2	30.1
	Secondary	44.7		3	11.6
	Post-secondary	4.1		4	5.4
	Higher	33.7		5	0.8
				6+	0.2
Age	17–25	12.0	Number of cars in the household	0	21.3
	26–35	22.4		1	54.0
	36–45	26.9		2	23.2
	46–55	17.4		3	1.5
	56–65	15.1			
	66–75	6.2			
Net income per person in the household per month	< 230 EUR	10.5	Employment	Pupil	1.3
	230–350 EUR	22.6		Student	3.9
	350–460 EUR	34.3		Student working/working casual	2.4
	460–580 EUR	20.4		Work outside home	79.5
	580–700 EUR	6.9		Work at home	1.9
	700–820 EUR	1.9		Pensioner/retired	8.4
	820–940 EUR	1.3		Unemployed	2.2
	940–1,060 EUR	0		Other	0.4
	1,060–1,180 EUR	0.4			
	> 1180 EUR	0.2			
	refusal to answer	1.5			
Household size (number of persons)	1	13.1	Business sector working respondents (N = 390)	Other services	20.6
	2	31.4		Administration	20.3
	3	27.7		Industry	14.6
	4	20.0		Architecture	11.0
	5	5.6		Trade	9.0
	6 or more	2.2		Science	7.9
				Transport	7.4
				Healthcare	4.6
				Culture	2.8
				Other	1.5
				Agriculture	0.3
Number of people working in the household	0	7.5	Working on Sundays (N = 390)	Work every Sunday	0.5
	1	19.4		Work some Sundays	23.1
	2	60.6		No work on Sundays	76.4
	3	9.5			
	4	2.8			
	5	0.2			

Tab. 1: Basic characteristics of the respondents
Source: authors' survey

with a low rate of natural increase (RNI) and a negative net migration rate – resulting in the fact that it is dominated by small households. The majority of its residents used to work for state-run industries (mostly in the textile industry), which led to them being economically weak. Although almost 25 years have passed since the political transformations, the city has only slowly gained economic momentum, with an average income of its citizens still remaining lower than in other large Polish cities. Nevertheless, the improving economic situation in reflected in the retail market (see Tab. 2).

The structure of the city's urban area consists of two distinct zones: outer and inner one, the boundaries of which are delineated by the railway line that rings the city (Lamprecht and Wojnarowska, 2013). The socio-spatial structure of Śródmieście (Downtown) is dominated by the lower class, with minor pockets of middle class (Marcińczak, 2007). Traditionally, Midtown plays a trading role, which is occasionally supplemented by out-of-town shopping centres and numerous supermarkets located in the residential areas. The most significant elements of the outer zone are rapidly developing housing estates built during the 1970s and 1980s, vast and expansive multi-use industrial zones, modern housing developments (Milewska-Osiecka, 2010) and industrial and warehousing zones (see Fig. 1).

The street layout in Śródmieście takes the form of a 19th century grid and becomes gradually less regular the farther you depart from the city centre. Roads in Śródmieście are of low efficiency and capacity, which leads to most of the district's network being greatly overloaded. The main transport axes of the city (grid patterns) are streets and avenues of national and regional roads running longitudinally and latitudinally. Besides the layout of streets in Śródmieście, another factor that determines the district's accessibility is the network of express and motorways which form an unclosed ring road. The spatial structure of the areas located in the immediate vicinity of ITS devices installed on Lodz roads is dominated by transport infrastructure and built-up zones (mostly housing estates, and service and trading facilities: see Fig. 1). Even though mobility in Lodz is not an extensively explored phenomenon and its characteristics can only be found in secondary analyses (Tab. 2), it can be stated that the majority of shopping trips in the city, just like in any other large urban area in Poland, are taken by car (Bartosiewicz and Pielesiak, 2019).

4. Results and discussion

4.1 Mobility conditioning connected with retail

The car ownership rate in Lodz is 55 passenger cars per 100 persons. This indicator includes both vehicles belonging to households and companies. This indicator is predominantly achieved by those surveyed households in which the net income per inhabitant exceeds 460 EUR (values calculated at the EUR-PLN exchange rate of 4.3) – hence considerably exceeding the average household income per person in the region, which is 362 EUR. The highest car ownership rate is observed in those households with a high income (see Tab. 3) and clearly increases with a rise in net income per inhabitant.

Demography and employment		Females	Males	Total		
Number of residents (2017)		375,786	314,636	690,422		
Number of employees (2017)		130,868	116,702	247,570		
Number of employees in retail industry (2017)**		29,460	33,927	63,387		
Number of households (2011)	Total	1 person	2 persons	3 persons	4 persons	5+ persons
	324,892	33.6 %	31.3 %	20.1 %	10.8 %	4.1 %
Retail						
Number of retail facilities (2017)	Shopping centres	Hypermarkets	Supermarkets	Department stores	Seasonal marketplaces	Permanent marketplaces
	13	20	121	5	3	31
Value of retail sales (2017)	Poland			Lodz Voivodeship		
	Total [mill. EUR]		Per capita [EUR]	Total [mill. EUR]		Per capita [EUR]
	188,426.42		4,904.19	9,185.05		3,703.72

Changes of retail sales (YoY)* in Lodz Voivodeship	year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	in total [%]	3.8	2.7	1.4	5.4	12.8	0.3	0.2	– 0.7	4.0	7.8	12.1
	per capita [%]	4.2	3.0	1.7	5.4	13.2	0.7	0.7	– 0.3	4.5	8.3	12.5

Mobility			
Average annual number of trips per resident (2015)	Total	Shopping trips	
	450	40	
Average travel time per trip [mins] (2015)	By car	By public transport	On foot
	26	28	16
Average distance per trip [km] (2015)	By car	By public transport	
	16.5	10.3	

*Tab. 2: Selected demographic and economic data related to retail and mobility in Lodz (Notes: * YoY – the year over year; **retail with repair of motor vehicles; transportation and storage; accommodation and catering; information and communication). Source: authors' elaboration based on the Central Statistical Office (GUS) data*

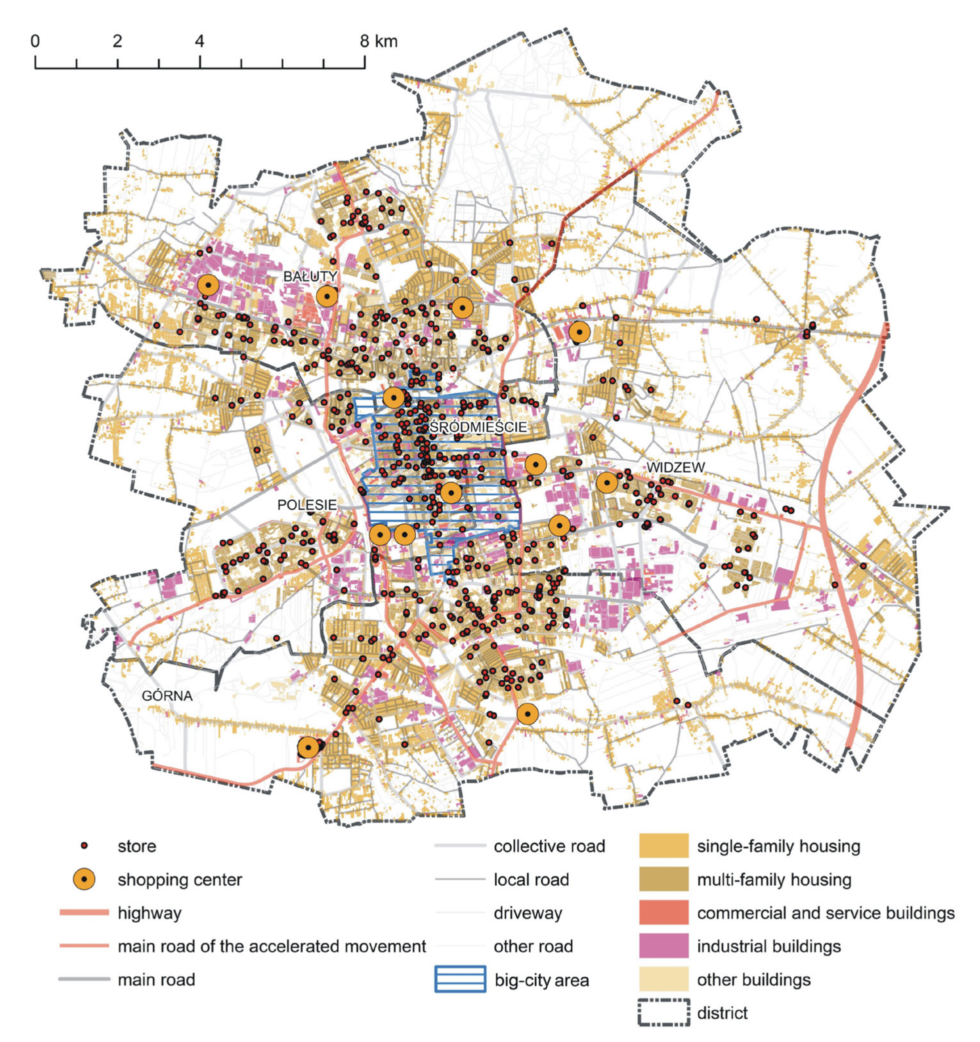


Fig. 1: Distribution of stores and shopping centres against the background of housing development and the road network in Lodz. Source: authors' survey

Net income of a household per inhabitant		Cars per 100 household	Cars per 100 persons	Cars per 100 working persons
PLN	EUR	No.	No.	No.
≤ 1,000	≤ 233	92	27	64
1,001–2,000	234–465	99	33	54
2,001–3,000	466–698	23	51	63
> 3,000	> 699	104	54	63

Tab. 3: Number of cars in households. Source: authors' survey

The majority of respondents declare that they adjusted their shopping needs to Saturday due to the Sunday trading ban – or they claim that they did not do any shopping on Sunday in any case, which is why they do not feel restricted by the ban. A large group of respondents altered their Sunday shopping to one of the weekdays (Fig. 2). Most people pointed to other kinds of impact of the ban on their purchasing behaviours, indicating that they go to bars and restaurants as it is impossible to do grocery shopping on a non-trading Sunday.

Table 4 shows the detailed distribution of declarations concerning the impact of the Sunday trading ban on ways of doing shopping. Research participants who declared that the ban on Sunday trading made them organise their shopping at a different time, were later asked to indicate how they used the time on Sunday which they would have spent on shopping, if there was no trading ban. The results show that more than half of them spent this time on activities which require travelling (Fig. 3).

There is a lot of research concerning shopping facilities in post-socialist cities as places to spend leisure time (Majchrzak, 2007; Novák and Sykora, 2007; Humphrey and Skvirskaja, 2009). Rochmińska (2011) analysed customers at the shopping centres in Lodz, demonstrating that, irrespective of gender, their presence in such facilities is a way of spending free time for 22.6 per cent of the customers, mostly young people. At the same time, she showed that whether they spent their free time in retail

Impact of the trading ban		Groups of households according to net income per inhabitant* [in %]			
		≤ 233 EUR	234–465 EUR	466–698 EUR	> 699 EUR
Nothing has changed – did not do any shopping on Sunday anyway	in total	33	36	20	46
	men	38	49	27	55
	women	28	27	17	38
Nothing has changed – still does shopping on Sunday but in shops in which the trading ban does not apply (small family-run shops)	in total	6	9	6	4
	men	8	9	4	n.a.
	women	4	8	6	8
Now does shopping on Saturday	in total	33	32	44	25
	men	21	22	33	27
	women	44	39	50	23
Now does shopping in the week	in total	16	20	23	17
	men	21	17	24	9
	women	12	23	22	23
Does not do any shopping at all	in total	12	3	5	n.a.
	men	13	3	9	n.a.
	women	12	3	2	n.a.
Other	in total	0	0	2	8

Tab. 4: The declared impact of the trading ban on shopping behaviour according to gender and income per person in the household
Source: authors' survey
*Note: *In Poland, the average income per capita amounts to approx. € 370 (Polish Central Statistical Office, 2017)*

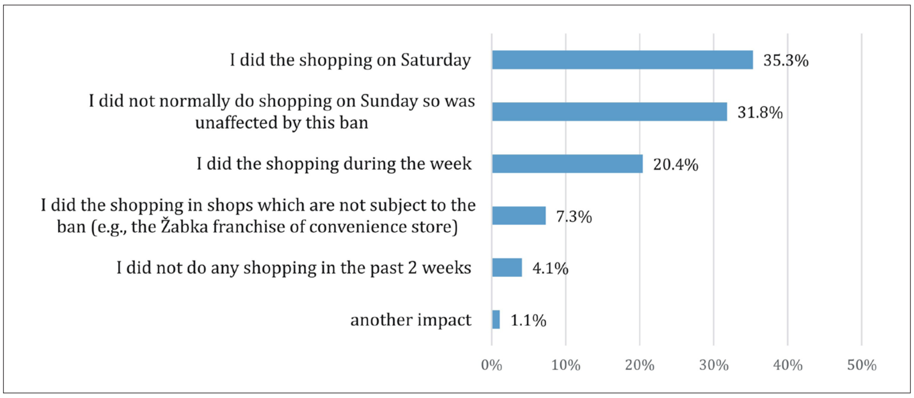


Fig. 2: Impact of Sunday retail restrictions on shopping habits
Source: authors' survey

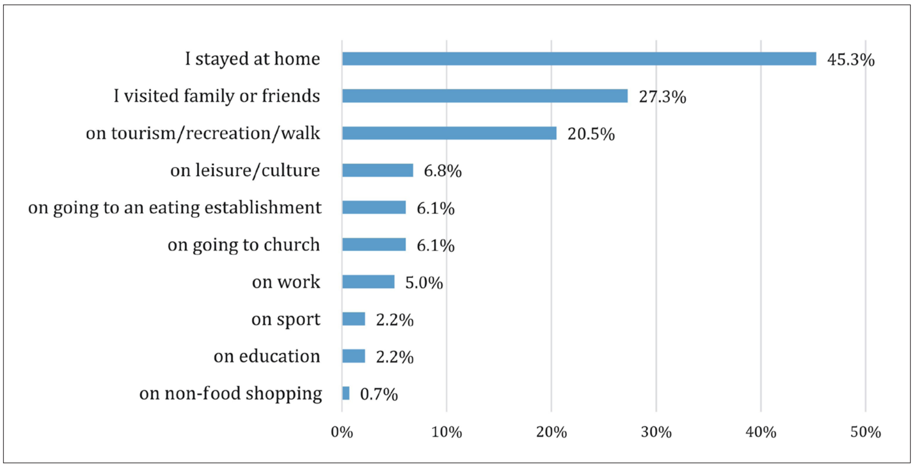


Fig. 3: The use of free time generated as a result of the Sunday trading ban
Source: authors' survey

facilities depended largely on their own assessment of their material status. As many as 33.2 per cent spent their time in this and not in any other fashion on Sundays. Our research shows that the majority of respondents (over 64 per cent) stated that they did not feel any impact of the ban on trading on the way they spent their free time at the weekend. Over 23.2 per cent of respondents see the positive impact of the introduction of the ban on Sunday trading, whereas 12% said the ban on Sunday shopping adversely affected the way they organising their leisure time. This is also confirmed by the calculated chi-square statistic – where the introduction of retail restrictions had an impact on motivations, numbers, modal division and duration of trips. It must be stated, however, that the influence is slight for each of these elements, with the highest association for trip duration (see Tab. 5).

The results concerning travel motivation point out that respondents tend to spend this day visiting their family and friends, regardless of whether the Sunday is subject to the ban on trading or not. Nevertheless, respondents see their family and friends more often on non-trading Sundays. In addition, respondents undertake activities connected with tourism and recreation (including walks), culture and leisure, eating out and engaging in sport with greater frequency on non-trading Sundays. On trading Sundays, the respondents did their shopping more often, which seems to be obvious. In this respect, the greatest changes in travel motivation concern shopping other than for food. This shows that the shops which can be open (run by the owner or the owner's family) offering these types of products on non-trading Sunday are not an attractive destination. This may be due to the fact that people are more willing to do shopping of this kind (e.g. in the category of fashion, electronics, white and brown goods, etc.) in places where there is a considerable concentration of facilities offering such products (e.g. in shopping centres), which under the new act are closed on Sundays.

Interestingly, the share of journeys to church is observed to be actually lower on non-trading Sundays. Generally speaking, Polish society stands out among many other societies which went through the period of socialism due to the fact that a vast majority of Poles declare themselves to be believers, predominantly Christians (87.58 per cent Catholics, 2.41 per cent atheists, 0.41 per cent Orthodox, 0.36 per cent Jehovah's Witnesses, 0.18 per cent Protestants, 7.1 per cent refused to make any declarations with regard to belonging to a religious organisation) (GUS). Consequently, the doctrines of these churches require the Sabbath day (or Sunday) to keep it holy. This is why the Catholic Church in Poland supported the act banning Sunday trading. It turns out, however, that inhabitants went to church more often on trading Sundays, possibly combining their shopping trips with going to church.

Changes in the duration time of the afore-mentioned activities on trading and non-trading Sundays are small and are within standard errors. The largest number of activities took from 30 minutes to 1 hour, activities requiring an hour to accomplish represented 20 per cent, whereas activities lasting less than half an hour represented slightly over 17 per cent. More than 55 per cent of respondents made one journey, 13 per cent 2, and over 3 per cent 4 trips on a Sunday with the ban on trading. More than 27 per cent of respondents did not travel on a non-trading Sunday, pointing to their lack of need to go out as the main reason for this state of affairs (Fig. 4).

It transpires, however, that despite a relatively large number of people who made at least one journey during a non-trading Sunday, the overwhelming majority spent over 10 hours at home (slightly over 96 per cent). Two groups of about two per cent of respondents stayed at home less than 5 hours and from 5 to 10 hours each.

Even though habits related to means of transport do not change on trading and non-trading Sundays, their percentage does differ slightly. On trading Sundays, the respondents are more eager to walk and travel by car as passengers, and on non-trading Sundays, they use public transport more frequently (see Tab. 5).

The research results show that journeys undertaken on a trading Sunday are much longer than those on a Sunday with restricted trading. The average time of all trips on a trading Sunday is 37 minutes (30-minute trips dominate), where the average duration of the first or the only journey is 43 minutes, the second – 33 minutes, the third – 42 minutes, the fourth – 30 minutes. In the case of non-trading Sundays the average time for the first or the only journey is 38 minutes, the second – 27 minutes, the third – 19 minutes; the fourth – 14 minutes (see Tab. 5). Analysis of the type and place of activity for the inhabitants of individual districts clearly shows that their general

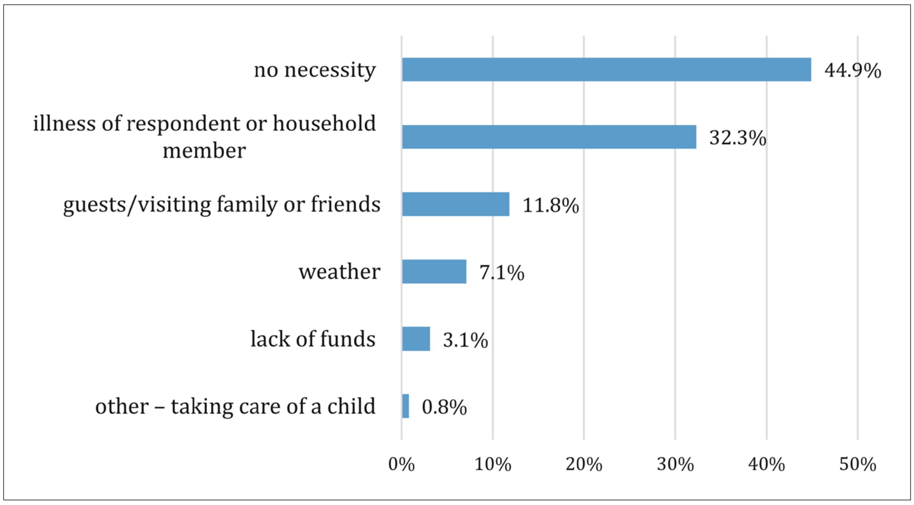


Fig. 4: Reasons for staying at home on non-trading Sunday
Source: authors' survey

												Sig.	Critical value	$\chi 2$	Cramer's V
Trip motivation	Visiting friends, family	Tourism/ recreation/ walking	Church	Entertain-ment/ culture	Eating out	Workplace	Grocery shopping	Sport	Education	Shopping (other than grocery)	Others	0.01	23.209	143.686	0.017
Trading Sunday	28.1%	19.8%	22.3%	4.1%	1.7%	6.6%	21.5%	0%	1.7%	19.8%	7.4%				
Non-trading Sunday	37%	31.7%	16.9%	13.3%	8.6%	6.5%	6.2%	4.1%	1.5%	0.9%	2.4%				
Modal division	Walking	Car (driver)	Car (passenger)	Bus	Tram	Bicycle	Train	Plane	Minibus	Motorbike/ scooter	Others	0.01	23.209	43.398	0.2145
Trading Sunday	62.8%	29.8%	29.8%	7.4%	2.5%	2.5%	0%	0%	0%	0%	0%				
Non-trading Sunday	55.9%	30.2%	18.6%	14.5%	7.4%	3.6%	2.1%	0.6%	0.3%	0.3%	0.3%				
Activity duration	0–30 min	30–60 min	1–2 hrs	2–3 hrs	3–4 hrs	4–5 hrs	5–6 hrs	6–7 hrs	7–8 hrs	Over 8 hrs		0.01	21.666	14.556	
Trading Sunday	17.4%	27.1%	20.0%	14.8%	9.7%	3.9%	0.6%	1.9%	3.2%	1.3%					
Non-trading Sunday	16.3%	24.1%	23.4%	13.5%	6.0%	5.0%	3.2%	1.6%	3.9%	3%					
One-way trip duration	0–15 min	15–30 min	30–60 min	1–2 hrs	2–3 hrs	3–4 hrs	Over 4 hrs					0.01	16.812	100.312	0.3782
Trading Sunday	8.7%	50.9%	30.4%	8.2%	0.6%	0.6%	0.6%								
Non-trading Sunday	39.2%	30.9%	18.7%	9%	1.4%	0.5%	0.5%								
No. of trips	None	One	Two	Three	Four							0.01	13.277	29.815	0.2062
Trading Sunday	27.3%	55.3%	13.3%	3.2%	0.9%										
Non-trading Sunday	48.7%	38.2%	10.2%	2.1%	0.8%										
Activity* by district	Bałuty	Górna	Polesie	Śródmieście	Widzew							0.01	13.277	2.898	
Trading Sunday	49.1%	55.0%	47.4%	65.5%	47.1%										
Non-trading Sunday	69.2%	79.4%	66.7%	61.9%	95.6%										
Leisure time at home	Up to 5 hrs	5–10 hrs	Over 10 hrs									0.01	9.210	4.754	
Trading Sunday	1.7%	1.9%	96.3%												
Non-trading Sunday	0.4%	0.4%	99.2%												

Tab. 5: Changes in people's transport behaviours resulting from the introduction of the Sunday retail restrictions and the extent of their correlation with the implemented ban
Source: authors' survey
*Note: *Activity is understood as taking at least one trip a day*

mobility is restricted to the immediate vicinity of their places of residence. The vast majority of respondents did not cross the boundary of their district in order to shop for food, engage in some recreational activity or fulfil spiritual needs. The largest mobility, i.e. travelling outside their district, was observed in the case of non-food shopping and visiting family and friends, in which case the percentage of journeys outside the city was clearly higher.

4.2 ITS research

The outcomes presented above were juxtaposed with empirical data from the ITS: as mentioned above, however, the information contained in both databases does not correspond directly one to the other: see Tab. 6). As a result, it seems that the heavier traffic observed on the Saturdays preceding the Sundays with the ban on trading, is confirmed by the questionnaire survey results (an increase of over 11 percent in traffic volume was observed on Saturdays preceding Sundays with the trading ban. In addition, it is interesting to observe the difference between just after 6 p.m. and 9 p.m. on Saturdays. It appears that the high value of the aforementioned difference reveals that some customers realised quite late that the access to retail would be restricted for the following 24 hours and made a last-minute decision to shop on Saturday evening. It should be noticed that the greatest role in this respect is represented by the ITS data obtained at the beginning of the year, which is the period when the act on the trading ban came into force. It is necessary, however, to confirm this conclusion in subsequent survey research (there was no question concerning the time of doing shopping on Saturday in the research presented here). When we assume other mobility-motivating factors to be permanent, it is worth noticing that Sunday retail restrictions had an impact on the distinctly noticeable increase in vehicle traffic during the working week. The said increase was not compensated for by a lower number of vehicles recorded by detectors on Sunday (Tab. 6).

The spatial distribution of changes in the load on the road network shows unambiguously that on Saturdays preceding non-trading Sundays traffic is heavier in the vast majority of measurement points (Fig. 6). The aforementioned increases are particularly visible both in the vicinity of shopping centres and along those roads acting as the main axes connecting them with housing areas (and at the same time, being part of the basic transport layout).

	MON	TUE	WED	THU	FRI	SAT	SUN
Traffic in a week without retail restrictions [veh.]	7,084,840	7,093,999	7,235,917	7,303,608	7,543,059	5,917,129	5,026,990
Traffic in a week with retail restrictions [veh.]	7,407,257	7,505,784	7,641,739	7,731,889	7,875,149	6,590,186	4,865,094
Change of traffic volume [vehicles]	322,417	411,785	405,822	428,281	332,090	673,057	– 161,896
Percentage of change of traffic volume [%]	4.55	5.80	5.61	5.86	4.40	11.37	3.22
Traffic distribution in a week without retail restrictions [%]	15.01	15.03	15.33	15.47	15.98	12.53	10.65
Traffic distribution in a week with retail restrictions [%]	14.93	15.13	15.40	15.58	15.87	13.28	9.81
Change of traffic distribution [pp]	– 0.08	0.10	0.07	0.11	– 0.11	0.75	– 0.84
Percentage of change of traffic distribution [%]	0.53	0.66	0.48	0.72	0.67	5.96	7.92

Tab. 6: Time and spatial differentiation of residents' mobility, the expression of which is the load of the urban road network during trading and non-trading Sundays
Source: authors' survey

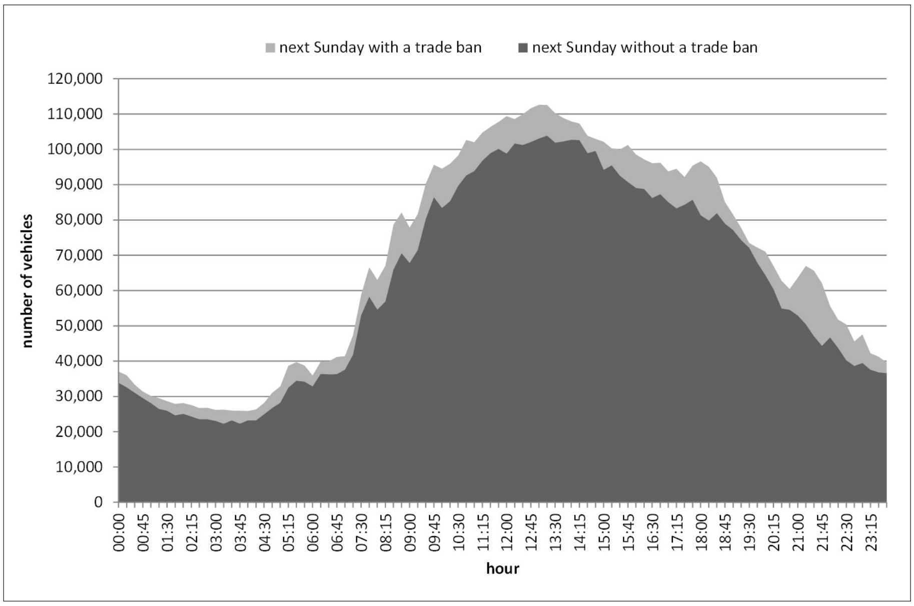


Fig. 5: The number of vehicles on Saturdays before Sundays with and without the ban on trading
Source: authors' survey

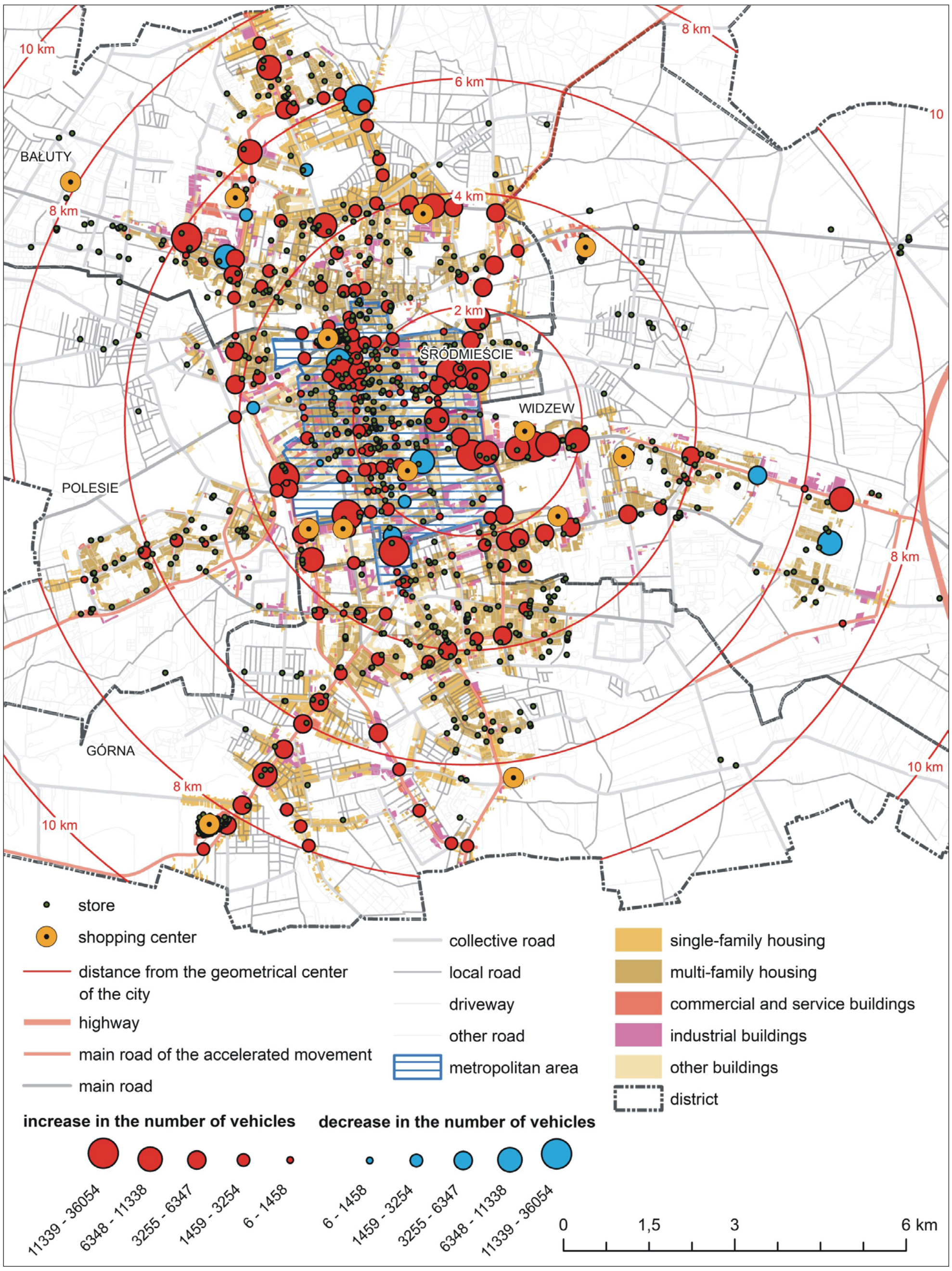


Fig. 6: Changes in the load on the road network between Saturdays before Sundays with and without the ban on trading against the background of development type (increases and decreases in relation to a trading Sunday; average 24-hour changes). Source: authors' survey

Changes in the traffic volume on the road network between trading and non-trading Sundays indicate that the actual differences for the benefit of trading Sundays are visible in the opening hours of most shopping facilities (Fig. 7). It is intriguing that the aforementioned differences are much smaller than those observed on Saturdays despite the fact that some people reschedule shopping previously done on Sunday either to weekdays or Saturdays.

One reason for this state of affairs may be the fact that despite Sunday restrictions on trade, most inhabitants did not change the frequency of their journeys, only shifting their destination from shopping centres to other forms of outdoor activities. The spatial distribution of changes in the load on the road network on Sundays may be some confirmation of the questionnaire survey results. A greater load is observed along the arteries connecting the city with its surroundings (showing outward journeys to visit family and friends). Changes are smaller on the roads within the city centre (which is a district located centrally and traditionally considered a trading area), and there are more observations indicating drops in the load in relation to trading Sundays (Fig. 8).

The research also aimed to check if the restriction on Sunday trading had a major impact on the load on the road network on weekdays. Due to the complexity of daily city mobility on a weekday and much heavier traffic in this period, however, it is not possible to show the aforementioned relations either on the basis of the comparative method used earlier or more advanced attempts to capture this phenomenon. Sunday retail restrictions contribute to an increase in car traffic both at weekends (Fig. 9) and during the week as a whole (Fig. 10).

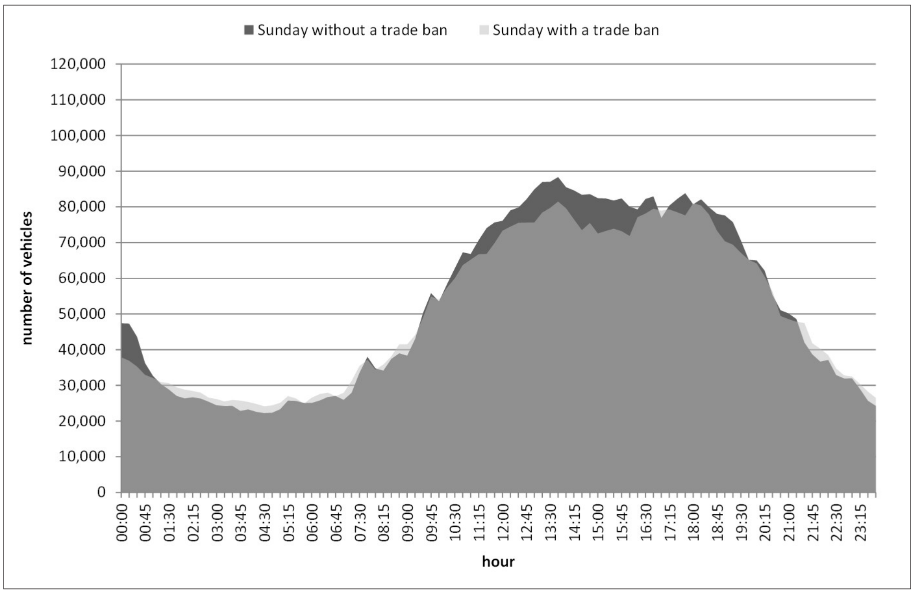


Fig. 7: The number of vehicles on Sundays with and without the ban on trading
Source: authors' survey

The fact that people avoided shopping on non-working days, which refers to Sundays in particular, stems from long-held practices, habits, and social norms, according to which Sunday is a statutory holiday (Čábyová et al., 2014; Szromnik, 2017). Its traditional Christian image (Siguaw and Simpson, 1997) changed substantially during the period of socio-economic and political transformation (Čábyová et al., 2014; Szromnik and Wolanin-Jarosz, 2018), and, in consequence, people began to spend their leisure time differently (Rochmińska, 2011). Those persons professionally active – younger employees in particular – only had free time on non-working days, which limited the scope for this type of activity to weekends (de Pourbaix, 2010). As a result, there was a shift in the weekly schedule regarding various activities related to culture, education, recreation, socialising with friends and family, as well as shopping and visiting retail facilities (Bywalec, 2017).

Such a shift does not apply exclusively to Poland, as various studies have shown that people in many other countries have similar preferences (Zhong et al., 2008; Agarwal, 2004). Undoubtedly, the 2018 introduction of the Sunday retail restrictions has led to a change in the model of behaviour (Jękot, 2018; Stelina, 2018), confirmed by our research. There are, however, quite diverse opinions on the impact of said restrictions. Some believe them to have had beneficial effects – people can rest and spend more time with their families; while others (mostly young people) claim that they have been deprived of the possibility to do their weekend shopping in a relaxed and unhurried fashion (Szromnik, 2017). In September 2016, the Public Opinion Research Centre carried out a survey on a representative sample of 981 adult Polish citizens. The results showed that the majority did their shopping on Sundays (79%) (CBOS, 2016). This was influenced by such factors as age, employment status, city size and religiousness (Adamiec and Grodzka, 2017; Szromnik, 2017). The phenomenon of Sunday shopping, which was mainly done by younger people, is also confirmed by other researchers (Williamson et al., 2006). The process of explaining the changes to the weekly shopping cycle can also be facilitated by analysis of the first and last days of the 'working week' – i.e. just after and before the weekend (Perchla-Włosik, 2010). Not only have the implemented restrictions contributed to changes in the weekly shopping cycles (which – in the case of our research – is confirmed by the results of the survey and data from induction loops), but they have also influenced shifts in motivations, numbers, modal division, and duration of trips.

5. Conclusions and policy implications

The realisation of the main research objectives of this project allowed us to draw significant conclusions which are likely to supplement existing knowledge of the relations between customer behaviours and transport behaviours. The methodological approach employed takes into account questionnaire surveys and the objectivised ITS measurements, and focuses on an exceptional research area (a city which for years functioned under a socialist regime) and thus renders the results relatively unique in nature.

The main conclusion to be drawn from this study of the impact of the statutory Sunday retail restrictions on the transport behaviours of people living in the large Polish city of Lodz, is that the introduction of restrictions on retail facilities results in a considerable increase in mobility (number of trips) of residents on working days, which is not reflected by a proportionate drop on non-trading weekends (Sundays in particular). This is confirmed by analyses of citizen transport behaviours conducted on trading and non-trading Sundays, and by research on the time and spatial differentiation of their mobility, the expression of which is the load on the urban road network (including daily and hourly changes of differences in vehicle numbers on the urban road and street network).

Data from the ITS concerning volumes of road traffic measured by means of induction loops is of considerable value in research into changes in transport behaviour – despite the many aforementioned difficulties. The overall results may be presented because of the analysis made on their basis connected with comparison of traffic volumes in the space of a diversified functional and spatial structure, but these results have great cognitive value when combined with research aimed at characterising transport system participants and their destinations.

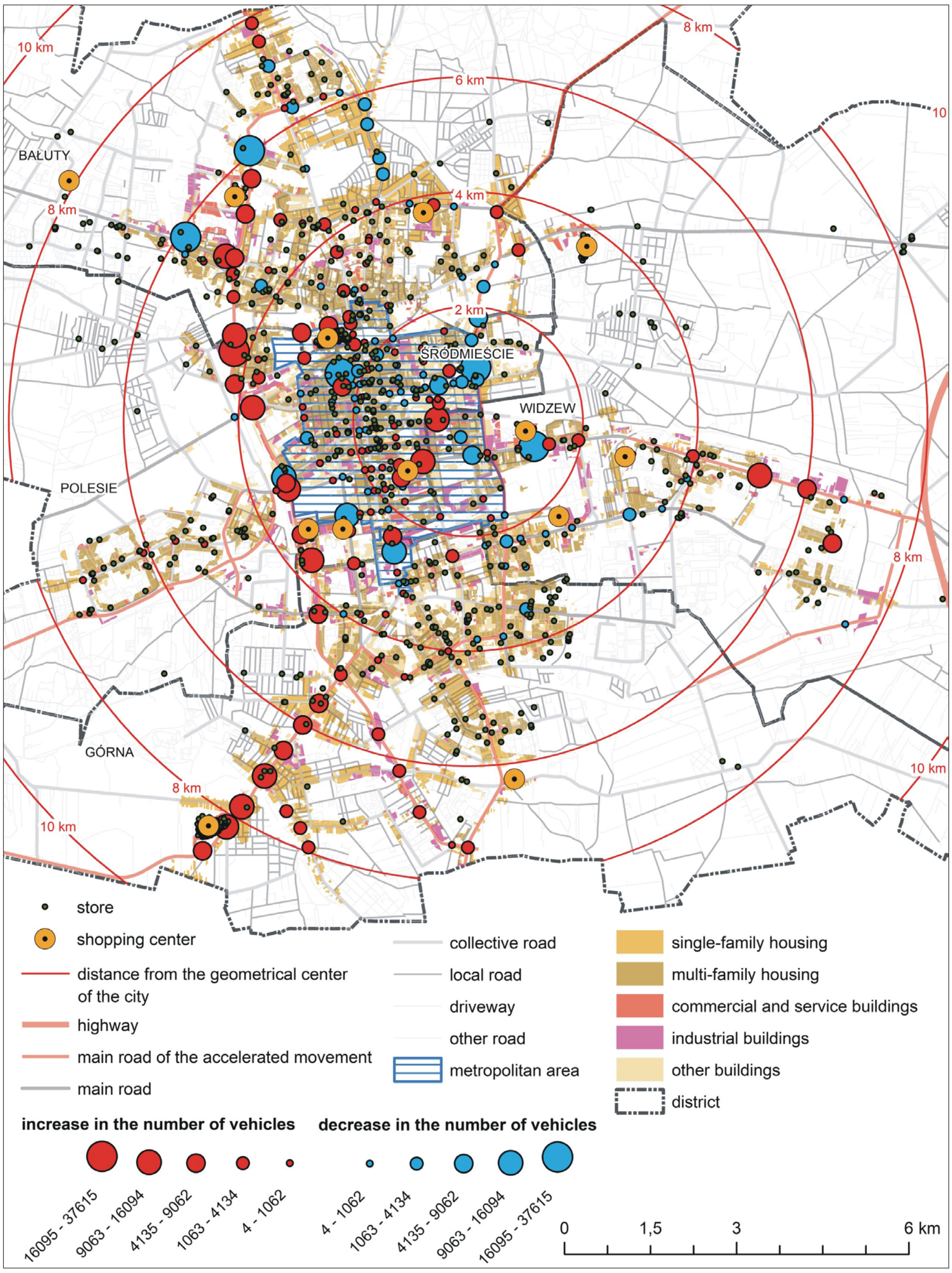


Fig. 8: Changes in the load on the road network between trading and non-trading Sundays with and without the ban on trading against the background of land cover and development type (increases and decreases in relation to trading Sunday) (average 24-hour changes). Source: authors' survey

A closer correlation between the data obtained via the survey and from the ITS would be possible if we retrieved information recorded by ITS cameras, which could recognise licence plates and 'track' vehicles within the area covered by the ITS. For such a purpose, however, we would have to obtain information on the number plate of the vehicle driven by a given respondent, which is against privacy laws. Another issue would be the fact that some urban areas are not covered by the ITS system.

The results of the first specific objective, related to the analysis of residents' transport behaviours on trading and non-trading Sundays, shows that those shopping needs which could not be fulfilled on a Sunday are now satisfied on the remaining days of the week and, consequently, mobility shifts to those days when trading is allowed. In addition, the time previously devoted to Sunday shopping is used by the inhabitants not only to stay at home but also to undertake new (not accomplished earlier) activities which required travelling. Additionally, the modal division of means of transport used for this purpose points to the more frequent use of the car (as driver) and less frequent use of the possibilities offered by non-mechanised transport.

The study of factors responsible for possible changes in residents' transport behaviours related to the introduction of Sunday trading restrictions and the degree of their correlation (independence) with the implemented ban (the second specific research objective), shows that such changes actually occurred (especially with regard to travel motivations, modal division and duration of journeys, and mobility). Another phenomenon discovered in relation to these features is a statistically significant correlation regarding trade in general, although this correlation can be described as weak.

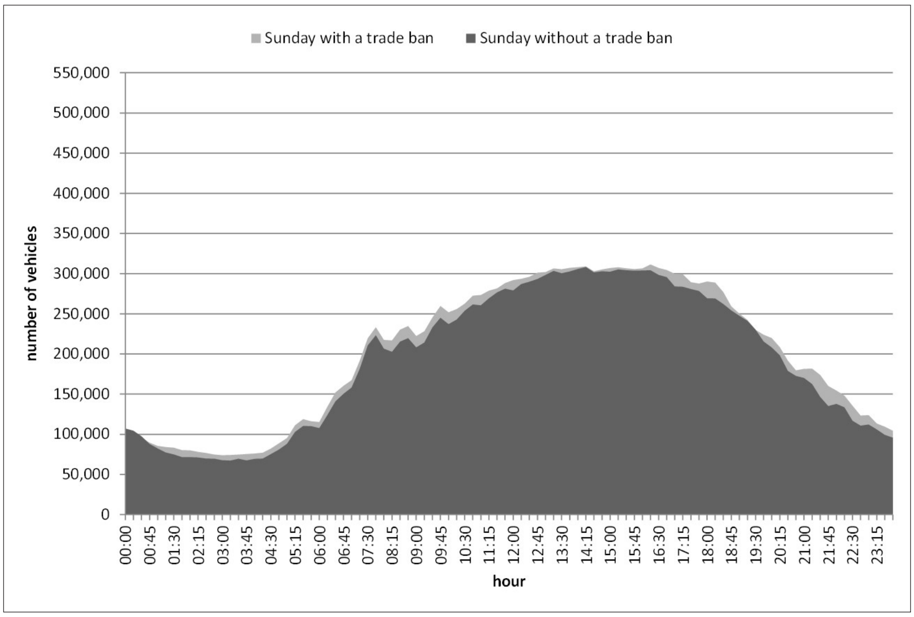


Fig. 9: The number of vehicles at the weekend with and without the trading ban
Source: authors' survey

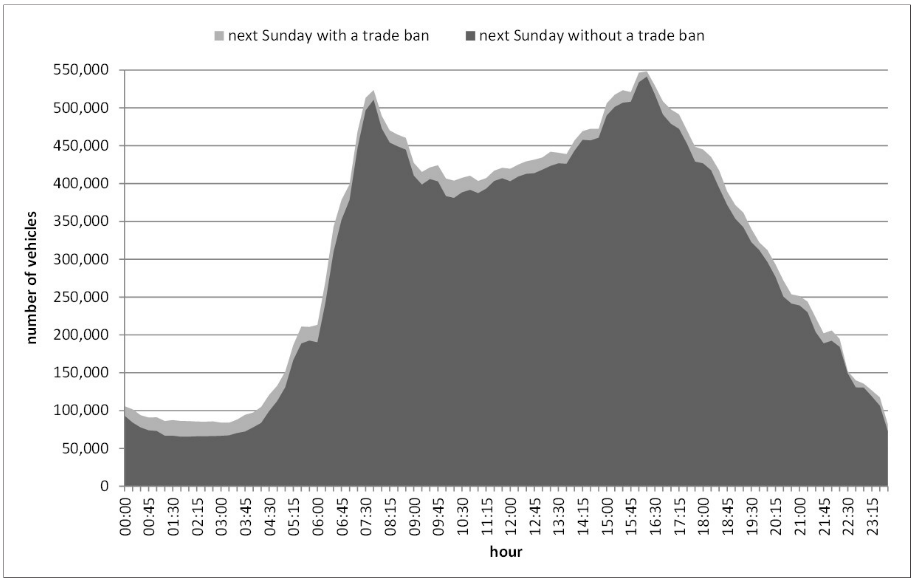


Fig. 10: The cumulated number of vehicles on Mondays, Tuesdays, Wednesdays and Thursdays before Sundays with and without the trading ban. Source: authors' survey

The analysis of the spatiotemporal features of residents' mobility, which is driven by the load of the urban road network on Sundays with and without trading restrictions (our third specific objective), indicates that changeability in the matter is clearly noticeable, and insufficiently diverse.

Changes in time are mostly distinguishable on Saturdays and Sundays (even though increased traffic flows were recorded on all days of the week with trading restrictions), and changes in space (the fourth specific research objective) mainly refer to the areas in the vicinity of shopping centres and main sections of the street and road infrastructure that serve the traffic entering and leaving the city.

Apart from the conclusions resulting from the major aims of this work, the research also established (and partly confirmed other research results in academia) that in Lodz (as a post-socialist city):

- Sunday is mainly used as a day of passive rest at home;
- Non-trading Sundays foster the undertaking of recreation and sports as well as cultural and leisure activities;
- The aforementioned activities replace Sunday shopping, while also influencing any decisions over attending church;
- Inhabitants are generally willing to travel longer distances to do non-food shopping than they are for food shopping; and
- During trading Sundays it is women rather than men who go out, and additionally women do shopping more often.

This research was conducted in the first year of the imposition of the partial ban on Sunday trading. It seems that changes in the demand for transport which took place in this period, may still need to undergo further transformations due to: firstly, achieving a better balance where the retail and transport systems meet; and secondly, owing to the gradual increased restriction on Sunday trading.

Research into people's transport behaviours and spatial mobility is important for a number of reasons. It returns invaluable analytical materials that allow us to recognise and describe principles governing traffic and its modelling; it provides data for studying trends and any corresponding necessity for changes in the researched territories; and for preparing insightful reports, projects and evaluations of the effectiveness of individual constituents and devices of the transport system. It also facilitates analyses of traffic as a sociological phenomenon. The results can be directly translated into transport studies (which take into account spatial management, transportation schedules, mobility plans, and industrial strategies and policies), traffic models (particularly those related to the incorporation of retail facilities in urban space), the designs of roads, carparks and junctions (which are capable of taking traffic for precisely specified purposes), and strategies of traffic organisation and traffic light management (varied traffic signal timing adjusted to trading and non-trading days).

The results also facilitate the monitoring of the effectiveness of implemented transport policies, preparation of feasibility studies, economic analyses, environmental studies, and traffic safety reports, commercial applications of traffic data, design and supervision of traffic management systems, and implementation of electro-mobility (choosing locations for charging points, delineating the boundaries of zero-emission zones, etc.). This research project, based on a questionnaire survey, automated data from various types of sensors and detectors, and image analysis, applied to determine the impact of the legislation that does not refer directly to transport laws and regulations, also returns wide ranging implications for both national and local, urban transport policies, the purpose of which is to generate transport behaviours that are concordant with, for instance, the principles of sustainable mobility. The results of this study can also be utilised by lawmakers as material facilitating verification and validation of the premises behind the introduction of laws and regulations.

Acknowledgements

This article is based on the results of the research project No. 2018/02/X/HS4/00093 financed by the National Science Centre Poland, and the research project No. 2019/33/N/HS4/01733 financed by the National Science Centre Poland.

References:

Act on Retail restrictions on Sundays and Public Holidays as well as Some Other Specified Days (Item 305 published in the Official Journal of Laws of the Republic of Poland ("Dziennik Ustaw")).

ADAMIEC, J., GRODZKA, D. (2017): Społeczne uwarunkowania handlu w niedziele. Infos, 1(224): 1–4.

AGARWAL, A. (2004): A comparison of weekend and weekday travel behavior characteristics in urban areas. MS Thesis, Department of Civil and Environmental Engineering, University of South Florida.

ÅSLUND, A. (1985): The Development of the Private Sector in Poland. In: Åslund, A. [ed.]: Private Enterprise in Eastern Europe (pp. 19–117). London, Palgrave Macmillan.

BARTOSIEWICZ, B., PIELESIAK, I. (2019): Spatial patterns of travel behaviour in Poland. Travel Behaviour and Society, 15: 113–122.

BELL, R., DAVIES, R., HOWARD, E. (1997): The changing structure of food retailing in Europe: the implications for strategy. Long range planning, 30(6): 853–861.

BENNISON, D. J., DAVIES, R. L. (1980): The impact of town centre shopping schemes in Britain: Their impact on traditional retail environments. Progress in Planning 14(3): 1–104.

BOROWSKA-STEFAŃSKA, M., KOWALSKI, M., WIŚNIEWSKI, S. (2019): Wewnętrzna samochodowa dostępność transportowa Łodzi w świetle pomiarów z Inteligentnych Systemów Transportowych. Prace Geograficzne, 159: 7–24.

BOROWSKA-STEFAŃSKA, M., WIŚNIEWSKI, S. (2019): Mobilność codzienna osób starszych w Łodzi. Łódź, Wydawnictwo Uniwersytetu Łódzkiego.

BYWALEC, C. [ed.] (2017): Gospodarstwo domowe – Ekonomika, Finanse, Konsumpcja. Kraków, Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie.

ČÁBYOVÁ, L., FAŠIANG, T., KOLLÁROVÁ, D., MUŽÍKOVÁ, D. (2014): Sunday christian significance and the saints days shopping behaviour. European Journal of Science and Theology, 10(1): 43–54.

CARP, F. M. (1988): Significance of mobility for the well-being of the elderly. Transportation in an aging society: Improving mobility and safety of older persons, 2: 1–20.

CBOS (2016): Komunikat z badań, Zakaz handlu w niedzielę, Warszawa.

CHOI, Y. J., JEONG, J. (2016): Effects of the Sunday shopping restriction in Korea. Contemporary Economic Policy, 34(1): 203–215.

CHUDZYŃSKA, I. [ed.] (1985): Struktura przestrzenna handlu detalicznego w Warszawie. Wrocław, Zakład Narodowy im. Ossolińskich.

CUDNY, W. (2016): Manufaktura in Łódź, Poland: An example of a festival marketplace. Norsk Geografisk Tidsskrift, 70(5): 276–291.

DE POURBAIX, P. (2010): Proces zakupowy młodych nabywców. Zeszyty Naukowe Uniwersytetu Szczecińskiego Ekonomiczne Problemy Usług, 54: 263–270.

DIJKGRAAF, E., GRADUS, R. (2006): Deregulating Sunday Shop Policies. Tinbergen Institute Discussion Paper, 06-003/3, Tinbergen Institute, Amsterdam and Rotterdam [online]. [cit. 24.10.2019]. Available at: http://hdl.handle.net/10419/86473

DIJKGRAAF, E., GRADUS, R. (2007): Explaining Sunday shop policies. De Economist, 155(2): 207–219.

DINIC-BRANKOVIC, M., DJEKIC, J., MITKOVIC, M., MITKOVIC, P., MARKOVIC-BRANKOVIC, J. (2018): Postsocialist Restructuring of City Subcenters and the Role of Shopping Centers in Nis Serbia. Journal of Urban Planning and Development, 144(2): 4018009.

DZIECIUCHOWICZ, J. (2013). Handel w przestrzeni wielkomiejskiej. Przykład Łodzi, Łódź. Łódź University Press.

GENAKOS, C., DANCHEV, S. (2015): Evaluating the Impact of Sunday Trading Deregulation. CEP Discussion Paper, 1336: 1–22.

GRADUS, R. (1996): The economic effects of extending shop opening hours. Journal of Economics, 64(3): 247–263.

HANNAM, K., SHELLER, M., URRY, J. (2006): Editorial: Mobilities, immobilities and moorings. Mobilities, 1(1): 1–22.

HEFFNER, K., TWARDZIK, M. (2015): The impact of shopping centers in rural areas and small towns in the outer metropolitan zone (the example of the Silesian Voivodeship). European Countryside, 7(2): 87–100.

HOPKINS, J. S. P. (1991): West Edmonton Mall as a centre for social interaction. The Canadian Geographer, 35(3): 268–279.

HUMPHREY, C., SKVIRSKAJA, V. (2009): Trading places: Post-socialist container markets and the city. Focaal, 55: 61–73.

JĘKOT, A. (2018): Ograniczenie i zakaz handlu w niedziele w opinii konsumentów. Zeszyty Naukowe Wyższej Szkoły Ekonomiczno-Społecznej w Ostrołęce, 30: 9–22.

KACZMAREK, T. (2011): Handel detaliczny w rozwoju funkcjonalnym i przestrzennym miast w Polsce. Rozwój Regionalny i Polityka Regionalna, 15: 67–83.

KALIŃSKI, J. (1968): Handel wewnętrzny w Polsce w latach 1944–1946. Przegląd Historyczny (1): 67–91.

KALIŃSKI, J. (2015): Etatyzacja gospodarki w okresie rządów komunistycznych w Polsce. Kwartalnik Kolegium Ekonomiczno-Społecznego Studia i Prace, 24(4): 177–201.

KAUFMANN V. (2005): Re-Thinking mobility, Ashgate, Aldershot.

KAY, J. A., MORRIS, C. N. (1987): The economic efficiency of Sunday trading restrictions. The Journal of Industrial Economics, 36(2): 113–129.

KOMORNICKI, T. [ed.] (2003): Przestrzenne zróżnicowanie międzynarodowych powiązań społeczno-gospodarczych w Polsce. Prace Geograficzne Nr. 190. Warszawa, IGiPZ PAN.

KOMORNICKI, T. (2011): Przemiany mobilności codziennej Polaków na tle rozwoju motoryzacji. Prace Geograficne Nr. 227. Warszawa, IGiPZ PAN.

KOWALSKI M., WIŚNIEWSKI, S. (2017b): Natężenie ruchu a zagospodarowanie Łodzi – zarys problematyki w świetle danych z Obszarowego Systemu Sterowania Ruchem. Prace Komisji Geografii Komunikacji PTG, 20(4): 20–36.

KOWALSKI, M. (2018): Торгові центри в просторі польських міст. Містобудування та територіальне планування, 66: 265–286.

KOWALSKI, M., WIŚNIEWSKI, S. (2017a): Centrum handlowe jako czynnik ruchotwórczy w transporcie samochodowym – przykład Portu Łódź. Przegląd Geograficzny, 89(4): 617–639.

KRAFT, S. (2014): Daily spatial mobility and transport behaviour in the Czech Republic: Pilot study in the Písek and Bytřice and Pernštejnem regions. Human Geographies: Journal of Studies and Research in Human Geography, 8(2): 51–67.

LAMPRECHT, M., WOJNAROWSKA, A. (2013): The structure of urban space in Łódź. In: Habrel, M., Wojnarowska, A. [eds.]: Lviv and Łódź at the turn of 20th century. Spatial development and functional structure of urban space (pp. 165–191). Łódź, Łódź University Press.

LESIAKOWSKI, K. (2012): Zaopatrzenie mieszkańców Łodzi w artykuły codziennego użytku w latach 1980–1983. Przegląd Nauk Historycznych, 11(1): 101–128.

LI, J., VAN ZUYLEN, H. J., WEI, G. (2014): Loop detector data error diagnosing and interpolating with probe vehicle data. Paper presented at 93rd Annual Meeting Transportation Research Board, Washington 12–16.01.2014 [online]. [cit. 24.10.2019]. Available at: http://resolver.tudelft.nl/uuid:02bc7359-7136-4844-8691-f95436e7340c

LIJEWSKI, T. (1998): Rozmieszczenie ruchu drogowego w Polsce. Prace Komisji Geografii Komunikacji PTG, 4: 57–66.

LOWE, M. (2005): The regional shopping centre in the inner city: a study of retail-led urban regeneration. Urban Studies, 42(3): 449–470.

MAJCHRZAK, K. (2007): Centrum handlowe jako atrakcja turystyczna ery postturystyki na przykładzie Starego Browaru w Poznaniu. Ekonomiczne Problemy Turystyki, 9: 181–184.

MARCIŃCZAK, S. (2007): The socio-spatial structure of postsocialist Łódź, Poland. Results of national census 2002. Bulletin of Geography. Socio-economic Series, 8: 65–82.

MENES, E. (2001): Społeczno - ekonomiczne aspekty rozwoju motoryzacji indywidualnej w Polsce. Przegląd Komunikacyjny, 1: 1–6.

MILEWSKA-OSIECKA, K. [ed.] (2010): Budownictwo mieszkaniowe aglomeracji łódzkiej (zróżnicowanie I struktura przestrzenna po roku 1994). Łódź, Wydawnictwo Uniwersytetu Łódzkiego.

MORRISON, S. A., NEWMAN, R. J. (1983): Hours of Operation Restrictions and Competition among Retail Firms. Economic Inquiry, 21: 107–114.

NOOTEBOOM, B. (1983): Trading Hours and Economy of Scale in Retailing. European Small Business Review, 1: 57–62.

NOVÁK, J., SÝKORA, L. (2007): A city in motion: time-space activity and mobility patterns of suburban inhabitants and the structuration of the spatial organization of the Prague metropolitan area. Geografiska Annaler: Series B Human Geography, 89(2): 147–168.

PAUL, A. (2015): After work shopping? Employment effects of a deregulation of shop opening hours in the German retail sector. European Economic Review, 80: 329–353.

PERCHLA-WŁOSIK, A. (2010): Czas wolny jako wyraz zachowań konsumenckich młodych Polaków Ujęcie socjokulturowe. Zeszyty Naukowe Uniwersytetu Szczecińskiego Ekonomiczne Problemy Usług, 54: 113–122.

REMBOWSKA, K. (2008): Kulturowy aspekt przemian rynku usług. Space - Society – Economy, 8: 5–15.

RITZER, G. (2005): Enchanting a disenchanted world: revolutionizing the means of consumption. Thousand Oaks, London, New Delhi, Pine Forge Press.

ROCHMIŃSKA, A. (2011): Centra handlowe – miejsca spędzania czasu wolnego przez łodzian. Acta Universitatis Lodziensis Folia Geographica Socio-Oeconomica, 11: 1–12.

ROCHMIŃSKA, A. (2016): Shopping centres as the subject of polish geographical research. Geographia Polonica 89(4): 521–535.

ROMANOWSKA, A., JAMROZ, K. (2015): Wielkopowierzchniowe obiekty handlowe: zwykłe generatory ruchu czy źródła problemów transportowych?. Transport miejski i regionalny, 2: 4–13.

SIGUAW, J. A., SIMPSON, P. M. (1997): Effects of religiousness on Sunday shopping and outshopping behaviours: a study of shopper attitudes and behaviours in the American South. The International Review of Retail, Distribution and Consumer Research, 7(1): 23–40.

STELINA, J. (2018): Legal restrictions on work on Sundays and festive days in Poland. Istorie, Cultura, Cetatenie in Uniunea Europeana, 11(1): 105–114.

SZROMNIK, A. (2017): Handel i zakupy w niedzielę w opinii społecznej – studium porównawcze (cz. I). Handel Wewnętrzny, 368(3/2): 409–422.

SZROMNIK, A., WOLANIN-JAROSZ, E. (2018): Social acceptance of retailing on Sunday in Poland – results of surveys. In: Mihalčová, B. et al. [eds.]: Production Management and Business Development (pp. 221–226). London, Taylor & Francis.

SZUL, E. (2015): Obrazowanie współczesnego konsumenta – ujęcie socjologiczne. Nierówności Społeczne a Wzrost Gospodarczy, 42: 20–31

TAYLOR, Z. (2000): Przekształcenia sieci handlu detalicznego i gastronomii w okresie transformacji społeczno-gospodarczej Polski, Wrocław, Wydawnictwo Continuo.

TEMPERINI, V., GREGORI, G. L. (2015): The impact of the liberalisation of opening hours on small retail enterprises. International Journal of Sales, Retailing & Marketing, 4(5): 47–59.

VILHELMSON, B. (1999): Daily mobility and the use of time for different activities. The case of Sweden. GeoJournal, 48(3): 177–185.

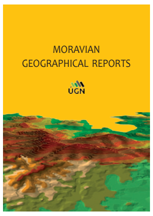
WILLIAMSON, B., HARGREAVES, J., BOND, J., LAY, H. (2006): The economic costs and benefits of easing Sunday shopping restrictions on large stores in England and Wales. A report for the Department of Trade and Industry [online]. [cit. 24.10.2019]. Available at: www.gov.uk

XAVIER, M. (2018): Dreaming in the temples of consumption: shopping malls and department stores dreams. In: Xavier, M. [eds.]: Subjectivity, the Unconscious and Consumerism (pp. 289-319). Cham, Palgrave Macmillan.

ZHONG, M., HUNT, J. D., LU, X. (2008): Studying differences of household weekday and weekend activities: a duration perspective. Transportation Research Record, 2054: 28–36.

Please cite this article as:

BOROWSKA-STEFAŃSKA, M., KOWALSKI, M., WIŚNIEWSKI, S. (2020): Changes in urban transport behaviours and spatial mobility resulting from the introduction of statutory Sunday retail restrictions: A case study of Lodz, Poland. Moravian Geographical Reports, 28(1): 29–47. Doi: https://doi.org/10.2478/mgr-2020-0003



MORAVIAN GEOGRAPHICAL REPORTS

sciendo

The Czech Academy of Sciences, Institute of Geonics
journal homepage: http://www.geonika.cz/mgr.html
doi: https://doi.org/10.2478/mgr-2020-0004

Using local climate zones to compare remotely sensed surface temperatures in temperate cities and hot desert cities

Cathy FRICKE [a], Rita PONGRÁCZ [b *], Tamás GÁL [a], Stevan SAVIĆ [c], János UNGER [a]

Abstract

Urban and rural thermal properties mainly depend on surface cover features as well as vegetation cover. Surface classification using the local climate zone (LCZ) system provides an appropriate approach for distinguishing urban and rural areas, as well as comparing the surface urban heat island (SUHI) of climatically different regions. Our goal is to compare the SUHI effects of two Central European cities (Szeged, Hungary and Novi Sad, Serbia) with a temperate climate (Köppen-Geiger's Cfa), and a city (Beer Sheva, Israel) with a hot desert (BWh) climate. LCZ classification is completed using WUDAPT (World Urban Database and Access Portal Tools) methodology and the thermal differences are analysed on the basis of the land surface temperature data of the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor, derived on clear days over a four-year period. This intra-climate region comparison shows the difference between the SUHI effects of Szeged and Novi Sad in spring and autumn. As the pattern of NDVI (Normalised Difference Vegetation Index) indicates, the vegetation coverage of the surrounding rural areas is an important modifying factor of the diurnal SUHI effect, and can change the sign of the urban-rural thermal difference. According to the inter-climate comparison, the urban-rural thermal contrast is the strongest during daytime in summer with an opposite sign in each season.

Key words: *satellite images, surface temperature, local climate zones, temperate and hot desert cities, Hungary, Serbia, Israel*

Article history: *Received 10 August 2019, Accepted 10 February 2020, Published 31 March 2020*

1. Introduction

Urban areas substantially modify the radiative, thermal, moisture and aerodynamic conditions with more vegetation and less artificial surfaces on the local scale and mesoscale (Oke et al., 2017), creating a so-called urban climate different from the surrounding area. These modified features are also different within the city, depending on the characteristics of the built-up areas and anthropogenic activities (intra-urban differences). One of the most common phenomena associated with cities is the urban heat island (UHI) effect, which can be detected in near-surface air (T_a), as well as in surface temperature (T_s) (surface UHI, SUHI: e.g. Rasul et al., 2017). This can be easily quantified as the temperature difference between urban and rural areas, although the terminology of these areas is not straightforward in the literature (e.g. Stewart, 2007). In the case of T_s, several remotely sensed land cover products (Imhoff et al., 2010; Pongrácz et al., 2010; Zhou et al., 2013b; Mathew et al., 2018) and even night-time light data (Clinton and Gong, 2013; Fu and Weng, 2018) have been used to determine the boundary between urban and rural polygons.

2. Theoretical background

The concept of local climate zones (LCZs) has become a widely-used, universal framework, which is applicable for representing the lack of homogeneity of surface structures and land cover characteristics, even on the intra-urban scale, and therefore it can underlie the delineation of urban and rural areas. Its first formulation was released in Stewart (2009), and in its final form in Stewart and Oke (2012). It consists of 10 built-up and 7 land cover classes. Originally,

[a] Department of Climatology and Landscape Ecology, University of Szeged, Szeged, Hungary
[b] Department of Meteorology, Eötvös Loránd University, Budapest, Hungary (*corresponding author: R. Pongrácz, e-mail: *rita.pongracz@ttk.elte.hu*)
[c] Climatology and Hydrology Research Centre, Faculty of Sciences, University of Novi Sad, Novi Sad, Serbia

this surface classification scheme was designed for the description of the surroundings of T_a measurement sites, but nowadays it has several applications. The first published study about an extension of LCZ beyond its primary functions, was in the mapping of zones in the urban area of a medium-sized Central European city (Novi Sad, Serbia), in order to recommend representative station sites for an urban climate monitoring network (Unger et al., 2011). The applied mapping process was relatively simple, as it was based on only the visual inspection of aerial images and the authors' local knowledge.

Some time later, Bechtel and Daneke (2012), Bechtel et al. (2015) and Lelovics et al. (2014), developed more objective LCZ mapping methods; then, others followed them with the elaboration and comparison of different mapping approaches (e.g. Geletič and Lehnert, 2016; Quan et al., 2017; Wang et al., 2018b; Hidalgo et al., 2019; Mushore et al., 2019). Today, the LCZ-system is used worldwide, and the recent comparisons of thermal features in neighbourhoods with different built-up area characteristics, revealed definite T_a-differences between the zones; thus they confirmed the usefulness of the scheme (e.g. Stewart et al., 2014; Unger et al., 2015; Leconte et al., 2015, 2017; Skarbit et al., 2017; Kotharkar and Bagade, 2018; Shi et al., 2018; Yang et al., 2018).

Besides these studies directed at T_a characteristics, the mapping of LCZs has expanded the application possibilities of the zones (Geletič et al., 2016). For instance, in recent years the scheme also provided a basis for some inter-LCZ thermal comparisons, using surface temperatures derived from remotely-sensed measurements. Some of these comparisons use airborne or high-resolution remote sensing data, but these are essentially case studies with small datasets. In comparison, Skarbit et al. (2015) applied high resolution T_s data acquired by an airborne small-format digital imaging system, measured on an August night in Szeged, Hungary. Bartesaghi Koc et al. (2018) used LiDAR-derived parameters to evaluate the quality of LCZ classifications by a comparison of mean values of T_s.

Nassar et al. (2016) investigated the LCZ–T_s relationship, applying Moderate Resolution Imaging Spectroradiometer (MODIS) 8-day composites from a year-long period, supplemented with nine Landsat scenes in Dubai (United Arab Emirates). Their analysis targetted the effects of different urban zones with varying structures, cover types and proximity to the ocean, urban cooling and heating in a city with dry desert climate. Wang et al. (2018a) also studied this relationship in arid cities in the south-western United States (Phoenix and Las Vegas), based on two night-time and two daytime ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) images from the warmer part of the year (May, August). They concluded that this type of analysis of LCZs provides valuable information about the distributions of land surface temperatures at the neighbourhood scale. Mushore et al. (2019) used cloud-free Landsat 8 imagery and WUDAPT methodology to monitor T_s patterns in Zimbabwe – on three cool days and three hot days. A study from the wet subtropical Yangtze River Delta (China) mega-region has to be mentioned: it acquired T_s from 13 Landsat and ASTER images (Cai et al., 2018). Their results also confirm that T_s is generally consistent with those LCZs showing higher T_s values in built-up LCZs.

Gémes et al. (2016) examined the seasonal development of urban T_s in the same study area using 7 Landsat thermal images, during a period of 30 years and 7 images within a year. Also in Central Europe, Geletič et al. (2016) studied Prague and Brno (Czech Republic) using 8 Landsat and 8 ASTER thermal images, eight images for each city, which were obtained in the warmer months of the year. Summarising their results, the variation of T_s is generally consistent with the LCZ classes as they have a higher temperature observed in built-up area classes. Recently, Geletič et al. (2019) performed an inter- and intra-zonal investigation of three Central-European cities (Prague, Brno and Novi Sad) and they also analysed the role of the vegetation in the T_s pattern. The results show that the character of the vegetation has well-marked effect on the intra-zonal seasonal variability of T_s.

Up to the present, most of the thorough longer-term investigations based on a continuous dataset have focused on the T_s-differences of urban-rural areas, defined by different subjective techniques, and they do not apply LCZ mapping for characterisation and separation in and around urban areas. For instance, Zhou et al. (2013b) systematically analysed the daytime SUHI of European cities using MODIS-Aqua imagery between 2006 and 2011. They calculated the SUHI as the difference between the mean T_s of urban and rural clusters as defined by CORINE land cover data. They showed that the SUHI of many city clusters was higher in spring than in autumn. This result is considered a consequence of a phase shift between the astronomical and meteorological seasonality of T_s in the urban area and its surroundings. According to further sensitivity simulations in London (Zhou et al., 2016), this hysteresis can be explained by the region-specific seasonal variation of solar radiation.

Peng et al. (2012) selected 419 large cities to quantify inter-city differences and explore the global drivers of SUHI. They used MODIS-Aqua T_s data during the 2003–2008 period to report that cities with a more seasonal greening contrast between urban and suburban areas have a more pronounced seasonal SUHI effect. They also analysed the relationship between diurnal and nocturnal SUHI, and no correlation was found between them, which can be explained by the fact that driving mechanisms during the day are different from those at night.

Several Central European cities (i.e. Belgrade, Munich, Vienna, Milan, Warsaw, Zagreb and Budapest) were investigated by Pongrácz et al. (2010), between 2001 and 2003 using MODIS T_s and land cover products. According to the measurements in most of the examined cities, the nocturnal SUHI intensity was near-permanent (2–3 °C) between spring and autumn. The maximum intensity of SUHI occurred in daytime in summer, and the monthly mean intensity changed in a range from 1 °C to 6 °C. Tran et al. (2006) focused on eight Asian megacities that are located in both temperate and tropical climates. The most severe SUHI intensity (12 °C) was observed in Tokyo within a period of three years. Zhou et al. (2013a) evaluated the diurnal variation of SUHI in Beijing on the basis of four typical 24-hour daily cycles in 2005, using MODIS data as well as in situ measurements. In addition to the temporal cycle, they also analysed the spatial extension of the SUHI in Beijing.

From the research studies cited above, it can be concluded that there is a shortage of LCZ–T_s relationship investigations that are based on a large number of thermal images, enabling detailed diurnal and seasonal analysis. In this paper we intend to reveal the urban-rural and intra-urban surface thermal reactions, and their differences (ΔT_s) between Central European cities (Szeged, Hungary and Novi Sad, Serbia) with a warm and humid temperate climate

(Köppen type Cfa), as well as a city with a hot desert climate (Beer Sheva, Israel) (Köppen type BWh), based on a 4-year series of satellite data. Hence, the general aim is to depict the diurnal and seasonal evaluation of mean ΔT_s values based on the cloud-free thermal pictures of MODIS in the period of 2014–2018.

Our specific objectives are to:

i. map LCZ patterns by city based on Landsat images;
ii. reveal the differences in the distribution of LCZs by climatic region;
iii. separate the 'urban' and 'rural' areas containing 1-km tiles according to the MODIS grid;
iv. determine the clearly distinguishable (representative) LCZ cells within the urban areas;
v. collect MODIS thermal images with clear conditions and separate them according to season (winter and summer), as well as night and day;
vi. compare the obtained mean seasonal and diurnal urban-rural T_s differences between the Cfa and BWh climatic regions (Szeged, Novi Sad vs. Beer Sheva); and
vii. compare the obtained mean seasonal and diurnal T_s differences of specific LCZs and rural areas between the Cfa and BWh climatic regions (Szeged, Novi Sad vs. Beer Sheva).

3. Data and methods

Figure 1 illustrates the locations of the studied cities and the general characteristics (aridity, vegetation) of their regions based on a colour Google Maps image.

Szeged (Hungary) and Novi Sad (Serbia) are located on the Great Hungarian (or Pannonian) Plain in Central Europe (see Fig. 1a). They have similar geographical and climatic environments: both of them can be found on mostly flat terrains and are in Köppen's climatic region Cfa characterised by a warm and humid temperate climate, with a relatively warm summer and no distinguishable dry season (Beck et al., 2018). Szeged has a densely-built midrise core of the city that becomes more open towards the suburban areas (Fig. 1b). The north-eastern part of the city consists of blocks of flats, while the suburbs are characterised by warehouses and detached houses with gardens. The neighbouring rural area is used for cultivating wheat, maize and other crops, but a few scattered trees are also found there (Skarbit et al., 2017). The central area of Novi Sad is densely built and wide avenues connect different areas of the city, which can be mainly characterised by midrise and low-rise built-up types (Fig. 1c). Warehouses and industrial zones are located in the northern suburban areas. The city surroundings are predominantly characterised by arable land, as well as dense and scattered tree areas (Unger et al., 2011).

Beer Sheva is the largest city in the Negev desert of southern Israel. In contrast to the previous two cities, it has a hot arid climate with Mediterranean influences (Köppen type BWh: Beck et al., 2018). It is one of the fastest growing cities in Israel; the development of its present cityscape has occurred only in the last century (Fig. 1d). The historical city centre, built in the late Ottoman era, has been surrounded by several new urban neighbourhoods built in recent decades. The new part of Beer Sheva consists of 17 residential districts, as well as a university campus, hospitals, information technology and biotechnological centres. Its rural surroundings are dry and bare, occasionally with some vegetated patches. Table 1 summarises the main climatic and geographical features of the studied cities.

Considering that the mapping method of Bechtel et al. (2015) uses open-access software and remotely sensed data, which has a homogeneous fine scale coverage, we applied this globally comprehensive classification method in this paper. This method is also applied in the worldwide WUDAPT (World Urban Database and Access Portal Tools) project (www.wudapt.org; Bechtel et al., 2019), as it provides a simple and objective workflow for LCZ mapping. Two freely accessible software programs are required (i.e. Google Earth and SAGA-GIS) to process all the 11 spectral bands of the Landsat 8 satellite imagery as input data. The multi-temporal, highest quality level (Level-1) Precision

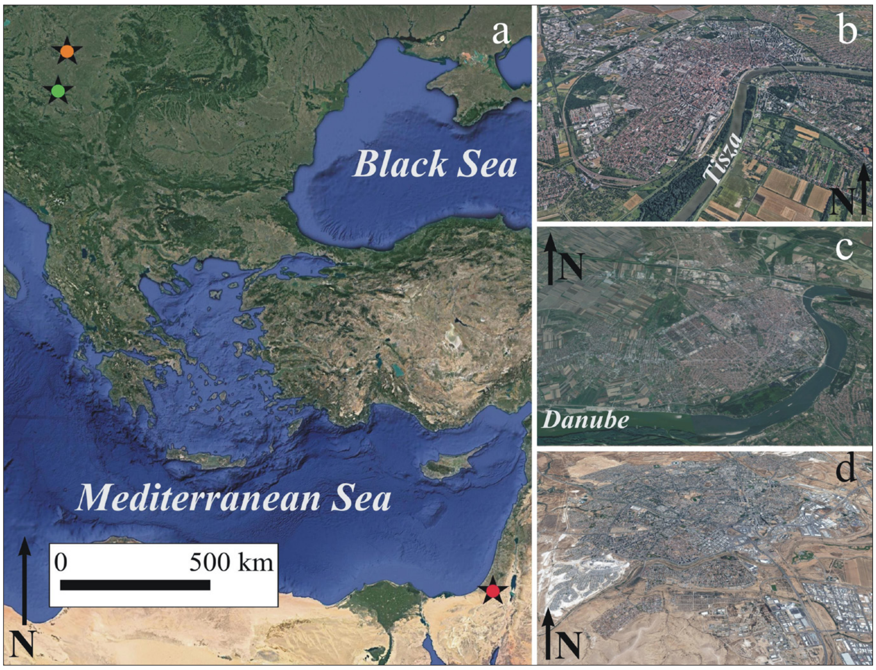


Fig. 1: (a) Locations of the studied cities (stars: Szeged – orange; Novi Sad – green; Beer Sheva – red) and their aerial views: (b) Szeged, (c) Novi Sad and (d) Beer Sheva. Source: https://www.google.com/maps

Features	Szeged	Novi Sad	Beer Sheva
mean annual temperature (°C)	11.9	12.2	20.4
the highest mean monthly temperature (°C)	22.7	23.0	27.5
the lowest mean monthly temperature	0.4	0.8	12.6
mean annual amount of precipitation (mm)	508	620	194
geographical coordinates	46.25°N, 20.15°E	45.25°N, 19.85°E	31.25°N, 34.80°E
urban area (km^2)	40	102	110
altitude (m a.s.l)	80	86	260
population	161,879 (2017)	265,387 (2012)	193,440 (2009)

Tab. 1: Some climatic and geographical features of the studied cities
Sources: climate; 1986–2015 (Harris et al., 2014); geography; United Nations (2019)

Terrain data of the OLI (Operational Land Imager) and the TIRS (Thermal Infrared Sensor) instruments was retrieved from the Earth Explorer user interface of the U.S. Geological Survey. Cloud-free Landsat 8 images were selected for each city, which were taken in three different sections in the year (Szeged: 24.06.2017, 27.08.2017, 30.10.2017; Novi Sad: 04.03.2017, 24.06.2017, 30.10.2017; Beer Sheva: 17.09.2017, 19.10.2017, 07.01.2018) to represent the intra-annual changes. Although the high resolution Landsat 8 images (30–100 m) are ideal for the mapping, we need to resample the images to a common resolution (100 m) in SAGA-GIS, which is acceptable for monitoring local patterns. Due to the annual course of surface properties, satellite images from different seasons are used for the LCZ mapping.

The first part of the process is to define the sample areas of the LCZ classes (training area polygons) and the region of interest (ROI) in Google Earth, called the training area (see Fig. 2). Each training area needs to be at least a 500 m × 500 m polygon with homogeneous structure, and the ROI must be a square-shaped polygon that covers the urban site, including the agglomeration and its surrounding natural environment. These delineated training area polygons and ROI are retained in a kml format file. In SAGA-GIS we perform the vector and raster processing using this kml file and Landsat 8 multispectral satellite images. A random forest classification algorithm performs the automated classification of Landsat images using the training polygons as learning areas within the ROI. If the classification does not take place properly, we have to improve the training areas and repeat the workflow. In the end, we perform a majority filtering that scans the neighbouring pixels within a given distance of a central pixel according to the size of the filter radius. If a particular LCZ class is in the majority in this examined field, all pixels are changed to that LCZ class. In this paper the selected size of the radius was 3 pixels; because this reduces noise, however, it does not perform unreasonable generalisation. The result of this workflow is a final LCZ map with reduced noise due to the filter.

To analyse the thermal properties of the urban area over the four-year period (2014–2018), we used derived Version 6 products (MOD11A1 and MYD11A1) from the measurements of the MODIS sensor, which can be found on the Terra and Aqua satellites. As parts of the American National Aeronautics and Space Administration's (NASA) Earth Observing System, these solar-synchronous satellites (i.e. Terra and Aqua) carry out the tasks of providing data from different spheres of the Earth including the land surface, biosphere, hydrosphere, cryosphere and atmosphere. The MODIS sensor measures radiation in 36 electromagnetic spectral bands with different spatial resolutions (250 m, 500 m, 1000 m) (NASA, 2006).

In this paper, we use T_s – derived from the raw MODIS radiation data – calculated from bands 3–7, 13 and 16–19 for retrieving emissivity, band 26 for cirrus cloud detection, and bands 20, 22, 23, 29, 31 and 32 for correction for atmospheric parameters (Wan and Dozier, 1996; Wan and Snyder, 1999). T_s is retrieved by a generalised split-window algorithm. The quality of the data is improved by the optimisation of the algorithm coefficient to the viewing angle.

In addition, the method is less sensitive to uncertainty in emissivity over wide ranges of surface and atmospheric conditions. According to validations with in situ measurements, the MODIS T_s product accuracy is better than 1 °C over land (Wan et al., 2004; Wan and Dozier, 1996). Moreover, the quality assessment of Version 5 T_s by Wan (2008) and Wan and Li (2008) reported root mean square differences of less than 0.5 °C across 39 tested cases. The satellites can provide a total of four images per day for each city – hence, in this way we can consider two images for daytime and two images for night-time during 24 hours for the examined areas. The horizontal resolution of the thermal infrared measurements is 1 km, which is

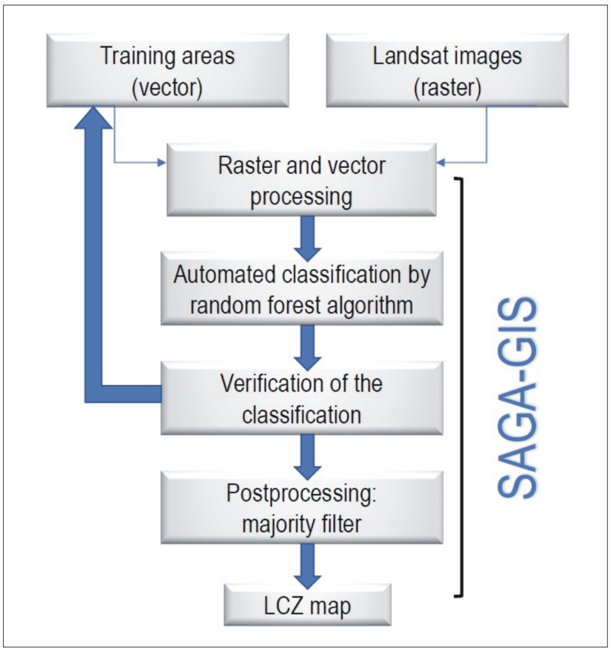


Fig. 2: The processing scheme of LCZ mapping
Source: authors, based on Bechtel et al., 2015

appropriate in recognising the overall thermal pattern of the studied areas. More information about the specifications of the sensor is provided in Table 2.

Since an anticyclonic weather situation, with clear sky and low air movement, is the ideal weather condition to examine local-scale thermal features, we selected all clear days between the summer of 2014 and the spring of 2018. Considering the whole urban and rural area around the cities, we neglected all the days when any cloudy tile (cell) was detected (see Fig. 4 for their numbers by season and city).

One of our goals is to reveal the thermal differences between urban and rural areas. To complete a comprehensive study, it is especially important to define urban and rural areas as precisely as possible. In this study, we obtained the fractions of individual LCZ classes for each MODIS tile using the QGIS and based on these ratios we evaluated the building surface fraction of each cell. So, we consider 'urban' tiles that:

i. include at least 50% of built-up LCZ; and
ii. the cells form a coherent area (polygon) in order to neglect the effect of smaller, separated built-up patches near the suburban area; and
iii. to avoid the overspreading of the urban areas over the sparsely-built regions around the most urbanised areas, urban cells must be located within the administrative border of the city.

The specification of a representative rural area was a more complex challenge. In more detailed research, Pongrácz et al. (2010) divided the urban and rural areas by the MODIS land cover product based on information about the elevation and radiation features of the surface. The urban area consisted of pixels with urban land cover within 15 km of the city centre, while the rural area is located in a radius belt of 15–25 km around the city centre. The pixels with hills were eliminated in the examined area.

Since we also require an area without any significant effects of built-up areas, water bodies or substantial topography, cells with a height difference above 200 m compared to the urban polygon or being covered by more than 1% of water, must be eliminated. Additionally, rural areas are defined as (i) mostly uninhabited, and (ii) being located at least 2 km from the urban boundary. Hence, the rural areas form a belt of equal area around the urban area, similarly to previous works (e.g. Peng et al., 2012; Zhou et al., 2013b). The rural tiles (iii) must contain less than 1% of the total building surface fraction (TBSF) in order to avoid the effects of small towns and villages around delineated urban areas. As the building surface fraction (BSF) (Stewart and Oke, 2012) varies according to LCZ class, different ratios of LCZ class were allowed in rural tiles (Tab. 3). For example, when a tile contains LCZ 9, which has a minimum of 10% BSF, we eliminate this from the rural area, if the tile contains more than 10% of LCZ 9 due to it exceeding 1% TBSF of the entire tile. As an LCZ class shows higher BSF, we obviously take into account a smaller fraction of a tile.

Focusing on the thermal features of the individual urban LCZs, the investigation of representative areas of LCZ classes is required. For this purpose we selected MODIS tiles which have more than 55% coverage of a particular LCZ class. As a following step, mean T_s differences between the selected LCZs and rural areas were calculated for each cloud-free day and night, using the MOD11A1 and MYD11A1 images indicated above.

The satellite-derived T_s data series enable us to reveal the spatial and temporal features of the surface thermal features in the three target cities. First, we calculate the T_s mean values of the separated urban and rural areas for daytime (based on forenoon and afternoon MODIS images), and night-time (based on night and dawn images), in the case of each city. Then, we compute the mean diurnal and nocturnal T_s differences between urban and rural areas (SUHI intensity or $\Delta T_{s(u-r)}$). To retrieve the differences in thermal reactions caused by urban effects in the same and quite different climatic regions, the mean diurnal and nocturnal SUHI intensities between Szeged, Novi Sad (both Cfa) and Beer Sheva (BWh) were compared by season, and then the obtained differences are analysed and explained.

In addition we calculated the difference between the mean T_s of tiles with the same LCZ classes and the mean T_s of the rural area, as determined previously. The comparisons of the cities are presented in box-percentile plots (Esty and Banfield, 2003), which provide representative visualisations by showing the entire range and the distribution of the

Sensor	MODIS	
satellite	Terra	Aqua
name of the product	MOD11A1	MYD11A1
equatorial crossing times	10:30 a.m. (descending)	1:30 p.m. (ascending)
acquisition times (UTC)	9–10 a.m. and 8–9 p.m.	2–3 a.m. and 12–13 p.m.
height	~705 km	

Tab. 2: Technical features of the MODIS sensor
Source: after Wan and Snyder (1999)

LCZ classes	BSF (%)	Maximum TBSF (%)
compact midrise (2)/low-rise (3)	40–70	2.5
open-set midrise (5)/low-rise (6)	20–40	5
large low-rise (8)	30–50	3
sparsely built (9)	10–20	10

Tab. 3: Building surface fraction (BSF) of the built LCZ classes and the maximum possible value of the total building surface fraction (TBSF) of the cells considered as rural. Source: after Stewart and Oke, 2012

seasonal T_s differences. The boxes spread from minimum to maximum and the width contains detailed information about the distribution. The white lines – within the box – indicate the 25th percentile or lower quartile (near the bottom), the 50th percentile or median (in the middle) and the 75th percentile or upper quartile (near the top) value, therefore the area between the two quartiles represents half of all cases. The median has an advantage compared to the mean, namely, it is less affected by the extreme values. The black point – within the box – indicates the mean value of the T_s differences in each season. The numbers located near the horizontal axis of the diagram indicate the number of cases considered in the individual box above.

4. Results and discussion

Figures 3a–3c present the obtained LCZ maps for Szeged, Novi Sad and Beer Sheva (hereinafter Sz, NS and BS), respectively. First of all, we can notice that three LCZ classes are absent in the urban areas: LCZ 1 (compact high-rise); LCZ 4 (open high-rise); and LCZ 7 (lightweight low-rise). In the case of NS and Sz, the administrative border – indicated with a black line – is located relatively distant from the city centre and encloses a large green area beside the built-up area (Figures 3a, b). In comparison to these cities, BS's border is located nearby the mostly built-up core of the city (Fig. 3c). In addition, the administrative border separates broad, mostly sparsely-built (LCZ 9) regions from the central part of NS (to the south of the Danube) and BS (to the east of the city). Compact midrise classes (LCZ 2) are located in three different parts of the city in NS, LCZ 2 is situated in the city centre of Sz, whereas this zone is completely missing in BS. While the LCZ 3 (compact low-rise) and LCZ 5 (open midrise) classes are located north and south of the city centre in Sz, these LCZ classes are located near the city centre as well as in isolated patches at a greater distance from the centre both in NS and BS. The most common classes around the central built-up area in Sz and NS are the open low-rise (LCZ 6) and sparsely built (LCZ 9) types, whereas these classes appear much less frequently within BS. There are also differences in the location of the large low-rise (LCZ 8) class, as the north-western part of Sz includes the LCZ 8 class, while this class is found in separated patches in NS (mostly in the northern half of the city) and in BS (in the southern part of the city). Heavy industry (LCZ 10) appears in both Central European cities and is associated with petroleum production and refining. It is located closer to the city centre and covers a larger area, however, in NS than in Sz.

The dominant land cover types around the two Central European cities are low plants with some dense and scattered trees (Figs. 3a, b). Some parts of the low plant areas temporarily change to bare soil within the year because of their agricultural use; thus, these two categories are merged into LCZ D. Since multiple satellite images from different dates are used to determine the different LCZs, the merging of the two zones simplifies the classification. In contrast, around BS, beside the scattered trees and low plants, the other dominant land cover is sand because of the semi-arid environment (Fig. 3c). As a result for further investigations, Figure 3 also shows the delineated urban polygons and the separated rural tiles for each city determined by the selection procedure described above.

We selected tiles that are covered by particular LCZ classes over more than 55% of the tile area, and assigned them with the numbers of the majority LCZ class in each urban area. These selected tiles were taken into consideration in the analysis of intra-urban and inter-urban thermal differences of the zones. Where there is no zonal number within the delineated urban area (Fig. 3), neither of the LCZ classes reached 55% coverage. Table 4 summarises the numbers of the selected urban tiles by zone and the numbers of the tiles in the rural areas assigned in and around the cities.

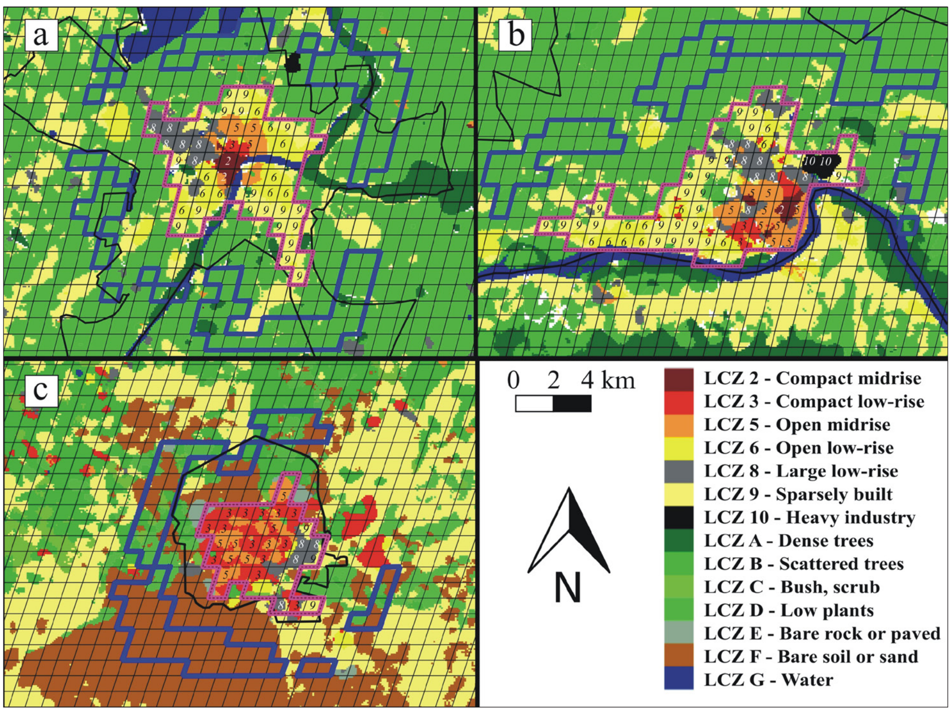


Fig. 3: LCZ maps shown on the MODIS grid covering the study areas: administrative city borders (black line); delineated urban polygons (purple line); and rural (blue line) areas in and around (a) Szeged, (b) Novi Sad and (c) Beer Sheva (the selected LCZ tiles are marked by zone number)
Source: authors' elaboration

City	LCZ class (with more than 55% area coverage)							Rural
	2	3	5	6	8	9	10	
Szeged	2	1	3	10	6	18	0	84
Novi Sad	1	2	9	10	8	23	2	69
Beer Sheva	0	14	7	0	4	3	0	66

Tab. 4: Numbers of the selected urban cells dominated by certain LCZs and rural cells by city
Source: authors' elaboration

The seasonal urban-rural T_s differences ($\Delta T_{s(u-r)}$) in Szeged (Sz), Novi Sad (NS) and Beer Sheva (BS) that were detected on clear days in daytime are shown in Figure 4. In Sz and in BS the largest absolute T_s difference values were detected in summer. In Sz the difference increases from winter to summer, then decreases in autumn. There is no substantial annual variation – the seasonal medians fluctuate between 0.3–1.3 °C – and the surface of the urban area is warmer than the rural area producing a recognisable SUHI effect in Sz. The medians of the $\Delta T_{s(u-r)}$ have opposite sign throughout the year in BS, implying that the rural areas around BS are much warmer compared to the urban areas, therefore, the surface of the built-up area in BS acts as an urban cool island. This cooling effect of the delineated urban area is moderated (– 1.9 °C median) in winter and it increases throughout the year – $\Delta T_{s(u-r)}$ reaches even – 6.5 °C in summer and autumn on certain days. This opposite behaviour ensues from the fact that sand or dry bare soil is heated up more intensively by the stronger incoming solar radiation than in the Central European region, which is covered mostly with vegetation. In addition, in Central Europe the higher soil moisture content also helps to decrease T_s more effectively compared to BS.

Similar results were reported in cities surrounded by desert, such as Jeddah in Saudi-Arabia and Mosul in Iraq (Peng et al., 2012). Negative daytime SUHI intensity contributes to the oasis effect (Oke, 1987; Georgescu et al., 2011) caused by the residential and agricultural irrigation within the urban area. Georgescu et al. (2011) simulated this influence with the Weather Research and Forecasting (WRF) regional climate model over Phoenix, Arizona. They concluded that besides the oasis effect, landscape and soil moisture conditions also explain the daytime cooling of urban areas. Observations from the United States also demonstrate the dependence of seasonal SUHI on biomes and environmental factors (Imhoff et al., 2010). The diurnal variation of thermal properties is discussed on the micro-scale by Zhan et al. (2012).

NS can be characterised by a high annual variation between the seasons. The sign of $\Delta T_{s(u-r)}$ is mainly negative in all seasons except in summer, when a higher positive maximum of the median (2.1 °C) is observed than in Sz. In summer, NS shows a larger fluctuation (from – 1.7 °C to 4.7 °C) in Ts differences, and the resulting SUHI effect of NS is mostly stronger (1–3.5 °C) compared to Sz (0.7–1.7 °C). Moreover, a clear deviation was observed in spring: the surface of the urban area was considerably cooler (by 2.9 °C on average and mostly 2.3–3.9 °C) in general than the rural area. In absolute terms, greater diurnal differences occur in spring (even 6 °C) than in summer (4.7 °C), when the urban area is heated by strong shortwave radiation causing a SUHI effect.

To reveal the reason for prominently negative $\Delta T_{s(u-r)}$ values in NS, average spring NDVI (Normalised Difference Vegetation Index) values were calculated for each MODIS tile. The NDVI values shown in Figure 5 enable us to analyse the differences in the spatial distribution of the vegetation in the urban and the rural areas in both cities. Figure 5a demonstrates that the rural area is characterised by higher NDVI values compared to the urban area in the

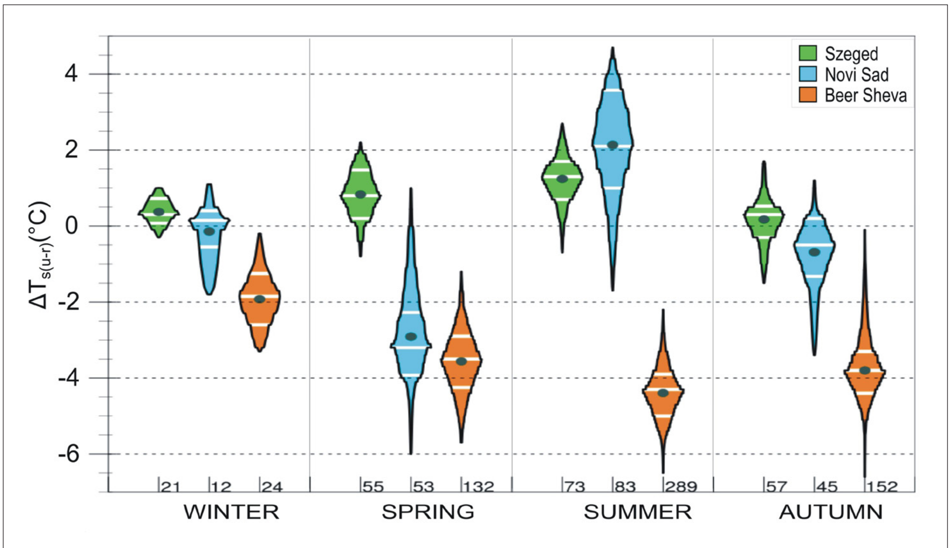


Fig. 4: Intra- (Cfa) and inter-climatic (Cfa vs. BWh) comparison of the diurnal urban-rural surface temperature differences ($\Delta T_{s(u-r)}$) by season (Szeged, Novi Sad vs. Beer Sheva, clear days, 01.06.2014–31.05.2018). Note: small numbers at the bottom of diagram = total numbers of selected satellite images by season in the studied cities
Source: authors' elaboration

case of Sz. Figure 5b shows relatively low NDVI values in the rural area around NS, while the urban area has a similar pattern to Sz – the lowest mean NDVI values are detected in the most densely built-up areas (LCZs 2 and 3). In the surroundings of NS, the agricultural areas are mostly bare from autumn to spring (after the harvest and before the subsequent harvest), which leads to a rapid warm-up of the fields covered by dark soil in the morning, meanwhile the rural area around Sz is still covered by crops (as a result of the autumn sowing). Consequently, the rural areas of NS result in higher T_s values in spring than the rural areas of Sz.

According to the previous research of Savić et al. (2018) on the T_s-LCZ connection in the urban and the surrounding area of NS, during the vegetation period higher T_s values were detected in spring and autumn in the area covered with LCZ D compared to the built-up zones. The rural areas around NS and Sz are typically agricultural areas. The arable lands around NS are covered mostly by dark chernozem soil (with low albedo), while the soil around Sz although of a similar texture, it additionally contains a certain fraction of sand, which makes it less dark, resulting in somewhat higher albedo.

In winter, there is no substantial thermal difference between Sz and NS as the medians of $\Delta T_{s(u\text{-}r)}$ are around 0 °C in both cities, with the least variation among the seasons. Finally, in autumn, the rural areas of NS are slightly warmer than the urban areas as the box extends between – 1.3 °C and 0.1 °C, meanwhile in Sz the distribution of $\Delta T_{s(u\text{–}r)}$ is slightly more symmetrical with a small positive (0.3 °C) median value.

Similarly, different SUHI effects were detected in many European cities in spite of the same background temperature in spring and in autumn (Zhou et al., 2013b; Zhou et al., 2016). This phenomenon is considered to be the result of different (astronomical and meteorological) seasonality in the urban and rural temperature, which can lead to differences in phenological phases.

The nocturnal urban-rural T_s differences (Fig. 6) clearly show less variability in the Central European cities, which is expected in an urban environment located in a moderate climate (e.g. Pongrácz et al., 2010). Generally, the urban areas are slightly warmer in the Central European cities than the corresponding rural areas. Meanwhile, in BS the mean seasonal $\Delta T_{s(u\text{–}r)}$ values change between 0.2 °C and 0.5 °C throughout the year, which implies almost no thermal difference on average between the urban and rural areas; nevertheless, the rural area around BS is occasionally more than 2 °C warmer than the urban area in summer. The mean seasonal $\Delta T_{s(u\text{–}r)}$ of Sz reaches a maximum in summer, and then it decreases towards winter, while NS has a maximum in spring, which slightly exceeds the mean

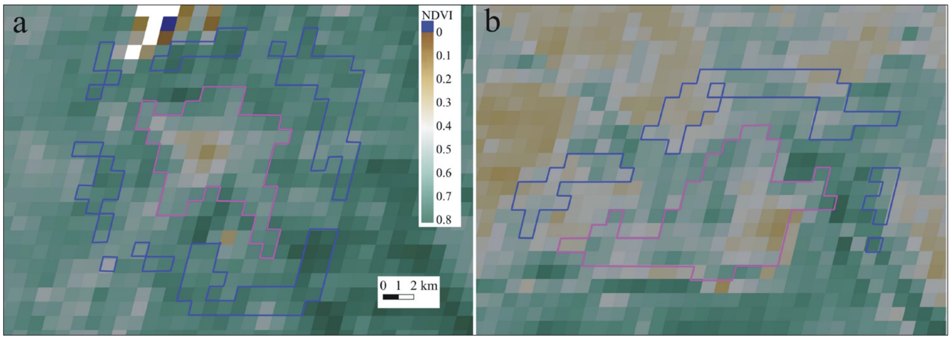


Fig. 5: Distribution of mean spring NDVI in and around (a) Szeged and (b) Novi Sad (2014–2018)
Source: authors' elaboration

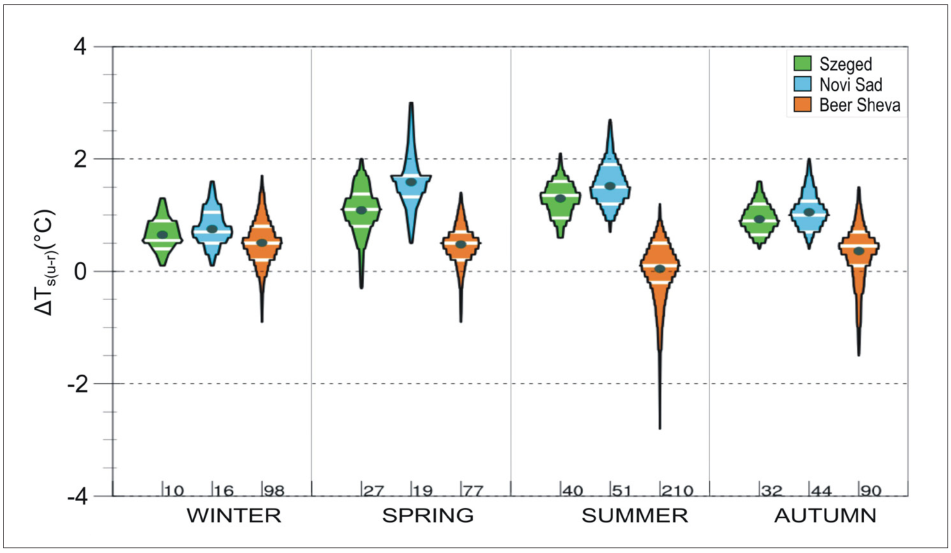


Fig. 6: Intra- (Cfa) and inter-climatic (Cfa vs. BWh) comparison of the nocturnal urban-rural surface temperature differences ($\Delta T_{s(u\text{–}r)}$) by season (Szeged, Novi Sad vs. Beer Sheva, clear nights, 01.06.2014–31.05.2018). Note: small numbers at the bottom of diagram = total number of selected satellite images by season in the studied cities
Source: authors' elaboration

$\Delta T_{s(u-r)}$ in summer. Furthermore, a clear difference can be recognised between the two Central European cities in spring: NS shows slightly higher T_s differences (mainly 1.4–1.7 °C) compared to Sz (mainly 0.8–1.4 °C). The medians of $\Delta T_{s(u-r)}$ range between 0.6–1.6 °C, thus T_s values in both urban areas are typically higher than in the corresponding rural areas.

The diurnal mean LCZ-rural T_s differences compared for Sz, NS and BS measured on cloud-free days in two thermally extreme seasons (winter and summer), are presented in Figure 7. In winter the medians of the LCZs have no outstanding spatial variability considering the three cities together (Fig. 7a). Regarding the LCZ classes, there is no substantial difference between the two Central European cities. Sz and NS have similar medians: $\Delta T_{s(LCZ\text{-}r)}$ of Sz fluctuates between 0.3 °C and 0.7 °C within the urban area, while the medians in NS are between 0 °C and 0.5 °C. In NS the diurnal $\Delta T_{s(LCZ\text{-}r)}$ fluctuates over a larger range, and lower (occasionally negative) differences occur between the LCZs and the rural area compared to Sz. For instance, the $\Delta T_{s(LCZ3\text{-}r)}$ in Sz changes between – 0.6 °C and 1.7 °C, while the diurnal ΔT_s values in NS are observed between – 2.3 °C and 2.5 °C during the examined period. In BS, areas dominantly covered by LCZs 2 and 6 are not found, therefore they are absent from both Figures 7a and 7b. All of the LCZs are cooler in winter than the rural areas but there is no considerable discrepancy between them in their thermal reactions: the median of T_s difference was 1.6 °C for LCZs 3 and 9, meanwhile it was around 2 °C for LCZs 5 and 8.

In Sz and in NS the diurnal mean $\Delta T_{s(LCZ\text{-}r)}$ values measured in summer generally fluctuate in a wider range than in winter (Fig. 7b). Due to the increased solar irradiation, the thermal differences between the LCZs are more conspicuous in the Central European cities. The strongest SUHI effect is detected in NS as the mean T_s differences of NS exceed the means of Sz considering each zone. The highest medians of the differences were observed between the most densely built-up class (LCZ 2) and the rural areas, both in Sz (3.3 °C) and in NS (4.5 °C). In Sz LCZ 2 is mainly warmer 2.2–4.4 °C than the surrounding rural area, while in NS this ΔT_s changes mostly between 2.6 °C and 6.5 °C. Additionally, the difference reaches even 8 °C on certain days. In summer the medians of the diurnal $\Delta T_{s(LCZ\text{-}r)}$ of Sz show a slight decrease moving from LCZ 2 (3.3 °C) to LCZ 9 (0.6 °C), except LCZ 8, where the median of $\Delta T_{s(LCZ\text{-}r)}$ has a second maximum (2.2 °C). It shows consistency with the decreasing SUHI effect toward the border of the urban area as the T_s difference decreases proportionally with built-up area density. These results show good agreement with other studies (e.g. Thomas, et al., 2014; Mushore et al., 2019) suggesting that the most intense SUHI can be recorded in LCZ 2, while the weakest SUHI effect was detected in LCZ 9 in all seasons. In Sz and in NS, the sparsely-built (LCZ 9) zones show lower T_s compared to the rural areas, because of the higher ratio of vegetation, which has a cooling effect due to evaporation (Odindi et al., 2015; Stabler et al., 2015).

In BS all the zones are colder than the rural area in summer similarly to winter, but the absolute LCZ-rural ΔT_s differences are greater in this season. The mean summer T_s values in LCZs 5 and 8 are around 5 °C lower than the rural values, which is beneficial for the population of the city. For LCZ 5 the largest absolute T_s difference is 7 °C, while for LCZ 8 the difference reaches 7.5 °C.

The nocturnal mean T_s differences between LCZs and the rural area that were measured on cloud-free days of winter and summer sorted by city, are shown in Figure 8. In winter (Fig. 8a), considering the Central European cities, the nocturnal T_s differences follow a similar pattern to the diurnal T_s-differences: the medians in Sz fluctuate mainly between 0.4 °C and 1.1 °C, and the medians in NS vary in the range of 0.4–1.9 °C with a slightly descending order from LCZ 2 to LCZ 9. In BS a weak SUHI was detected during winter nights: LCZs 3 and 5 are mainly 0.2–1 °C warmer than the rural area around BS. In LCZs 8 and 9 there are no considerable thermal differences compared to the rural area.

In summer (Fig. 8b) the nocturnal $\Delta T_{s(LCZ\text{-}r)}$ values of Sz and NS fluctuate over a substantially smaller range compared to the daytime ranges, but nevertheless they follow similar patterns. In BS none of the zones are

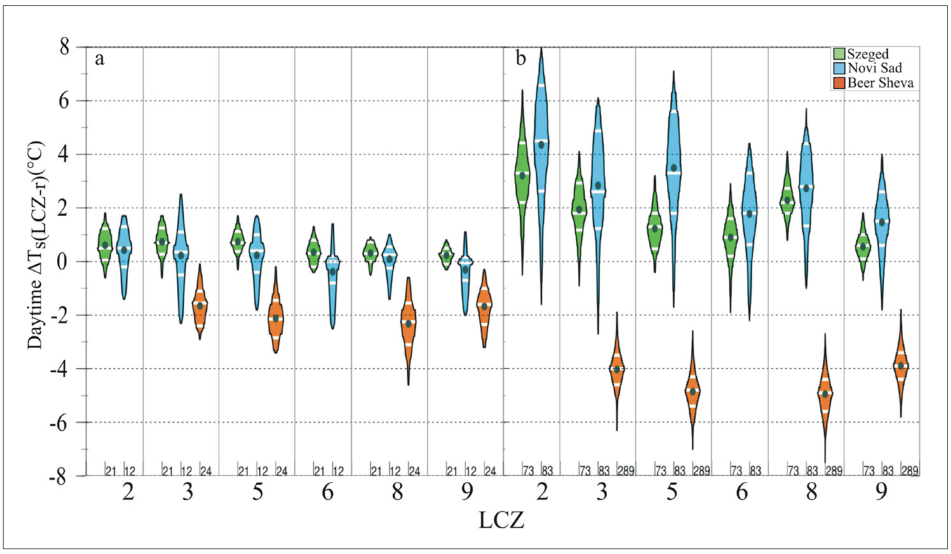


Fig. 7: Intra- (Cfa) and inter-climatic (Cfa vs. BWh) comparison of daytime mean LCZ-rural surface temperature differences ($\Delta T_{s(LCZ\text{-}r)}$) for (a) winter and (b) summer (Szeged, Novi Sad, Beer Sheva, clear days, 01.06.2014–31.05.2018). Note: small numbers at the bottom of diagram = the total numbers of selected satellite images by season in the studied cities. Source: authors' elaboration

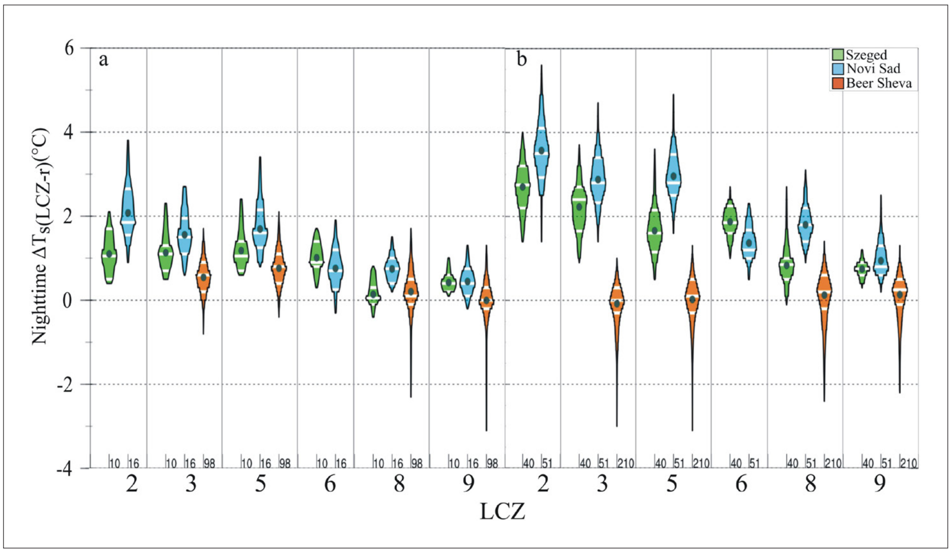


Fig. 8: Intra- (Cfa) and inter-climatic (Cfa vs. BWh) comparison of nocturnal mean LCZ-rural surface temperature differences ($\Delta T_{s(LCZ\text{-}r)}$) for (a) winter and (b) summer (Szeged, Novi Sad, Beer Sheva, clear days, 01.06.2014–31.05.2018). Note: small numbers at the bottom of diagram = the total numbers of selected satellite images by season in the studied cities. Source: authors' elaboration

considerably warmer than the rural surroundings, but some negative outliers can be found in each LCZ. In some extreme cases, T_s differences of around 3 °C occur (in LCZs 3 and 5). The relatively high presence of the negative outliers shows that the rural area around BS is rather warmer compared to the LCZs at night as well (although it is clearly less warm than during the daytime).

5. Conclusions

In this study, the surface thermal features of three urban areas were compared, taking into account their specific climatic regions. Szeged and Novi Sad are located in a temperate climate, in Central Europe, whereas Beer Sheva is situated in the semi-arid climatic region of Israel. We used the clear-sky surface temperature data product of the MODIS sensor between the summer of 2014 and spring 2018. To carry out comprehensive work, we performed LCZ mapping of the cities using the generally accepted WUDAPT methodology, and we delineated the urban and rural MODIS tiles according to different conditions in relation to the LCZ coverage. LCZ maps are able to illustrate the structure of the city that determines the thermal regimes. The seasonal urban-rural T_s differences were analysed and the results show that diurnal T_s differences are strongly affected by climatic conditions. Different urban effects were detected in the inter-climate comparison – the typical SUHI effect was recognised in Sz throughout the year in daytime, while the urban area showed a moderating/cooling effect in BS compared to the hot and semi-arid environment of the city. As it can be expected, the most intense SUHI effect was observed in the central and industrial parts of the cities in a temperate climate in summer. Regional plans should focus on limiting the built-up area density or providing more open, green spaces in the problematic areas.

Additionally, differences were also seen in the intra-climate comparison of Sz and NS. The largest difference between the thermal features of the two cities with similar climatic conditions was detected in spring in daytime. According to the 4-year diurnal time series of the T_s differences, in spring and in autumn the rural area of NS warm up more intensively than the urban area, while in Szeged the SUHI effect was detected in accordance with the other seasons. Since the two cities are located in the same climate zone of the Köppen-Geiger system, the difference can be related to the vegetation coverage. The patterns of NDVI values show more abundant vegetation in the rural area of Sz than around NS in spring, therefore the phenomenon of the cooling island of NS could be the result of a quick warm up of the rural areas covered with thin vegetation.

Increasing the ratio of urban vegetation would be beneficial in both climatic regions, as (i) it helps to mitigate the urban-induced warming in a temperate climate, whereas (ii) vegetation improves the well-being of the habitants of cities surrounded by desert, so extending their vegetation cover is recommended. The results of this present study should be taken into account in developing environmental planning and mitigation strategies in urban areas in order to support sustainable local conditions.

In order to fully describe the relationship of T_s and vegetation, further research is required with more detailed remote sensing datasets. Namely, beside the temporal variation of the vegetation cover, soil moisture also plays a principle role in the thermal environment (e.g. Seneviratne et al., 2006). Future research should focus on this variable. A better understanding of the spatial distributions of thermal properties and recognising the potentially problematic areas, will clearly contribute to more climate-sensitive urban planning for decision makers.

Acknowledgements

The MODIS data products were retrieved from the online Data Pool, courtesy of the NASA Land Processes Distributed Active Archive Center (LP DAAC), USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota, https://lpdaac.usgs.gov/data_access/data_pool. Landsat data were retrieved from www.earthexplorer.usgs.com. This research has been partly supported by the National Research, Development and Innovation Office, Hungary (NKFI K-120346, K-120605, and K-129162), and the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project No. 176020).

References:

BARTESHAGI KOC, C., OSMOND, P., PETERS, A., IRGER, M. (2018): Understanding land surface temperature differences of Local Climate Zones based on airborne remote sensing data. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 11: 2724–2730.

BECHTEL, B., ALEXANDER, P. J., BÖHNER, J., CHING, J., CONRAD, O., FEDDEMA, F., MILLS, G., SEE, L., STEWART, I. (2015): Mapping Local Climate Zones for a worldwide database of the form and function of cities. ISPRS International Journal of Geo-Information, 4: 199–219.

BECHTEL, B., DANEKE, C. (2012): Classification of Local Climate Zones based on Multiple Earth observation data. IEEE Journal Selected Topics in Applied Earth Observation and Remote Sensing, 99: 1–5.

BECHTEL, B., ALEXANDER, P., BECK, C., BÖHNER, J., BROUSSE, O., CHING, J., DEMUZERE, M., FONTE, C., GÁL, T., HIDALGO, J., HOFFMANN, P., MIDDEL, A., MILLS, G., REN, C., SEE, L., SISMANIDIS, P., VERDONCK, M. L., XU, G., XU, Y. (2019): Generating WUDAPT Level 0 data – Current status of production and evaluation. Urban Climate, 27: 24–45.

BECK, H. E., ZIMMERMANN, N. E., MCVICAR, T. R., VERGOPOLAN, N., BERG, A., WOOD E. F. (2018): Present and future Köppen-Geiger climate classification maps at 1-km resolution. Scientific Data, 5: 180–214.

CAI, M., REN, C., XU, Y., LAU, K. K-L., WANG, R. (2018): Investigating the relationship between local climate zone and land surface temperature using an improved WUDAPT methodology – A case study of Yangtze River Delta, China. Urban Climate, 24: 485–502.

CLINTON, N., GONG, P. (2013): MODIS detected surface urban heat islands and sinks: global locations and controls. Remote Sensing of Environment, 134: 294–304.

ESTY, W. W., BANFIELD, J. (2003): The Box-Percentile Plot. Journal of Statistical Software, 8(17): 1–14.

FU, P., WENG, Q. (2018): Variability in annual temperature cycle in the urban areas of the United States as revealed by MODIS imagery. ISPRS Journal of Photogrammetry and Remote Sensing, 146: 65–73.

GELETIČ, J., LEHNERT, M. (2016): A GIS-based delineation of local climate zones: The case of medium-sized Central European cities. Moravian Geographical Reports, 24(3): 2–12.

GELETIČ, J., LEHNERT, M., DOBROVOLNÝ, P. (2016): Land surface temperature differences within Local Climate Zones, based on two Central European cities. Remote Sensing, 8: 788.

GELETIČ, J., LEHNERT, M., SAVIĆ, S., MILOŠEVIĆ, D. (2019): Inter-/intra-zonal seasonal variability of the surface urban heat island based on local climate zones in three central European cities. Building and Environment, 156: 21–32.

GÉMES, O., TOBAK, Z., VAN LEEUWEN, B. (2016): Satellite based analysis of surface urban heat island intensity. Journal of Environmental Geography, 9: 23–30.

GEORGESCU, M., MOUSTAOUI, J. M., MAHALOV, J., DUDHIA, J. (2011): An alternative explanation of the semiarid urban area "oasis effect", Journal of Geophysical Research: Atmospheres, 116 (D24).

HARRIS, I., JONES, P. D., OSBORN, T. J., LISTER, D. H. (2014): Updated high-resolution grids of monthly climatic observations – the CRU TS3.10 Dataset. International Journal of Climatology, 34: 623–642.

HIDALGO, J., DUMAS, G., MASSON, V., PETIT, G., BECHTEL, B., BOCHER, E., FOLEY, M., SCHOETTER, R., MILLS, G. (2019): Comparison between local climate zones maps derived from administrative datasets and satellite observations. Urban Climate, 27: 64–89.

IMHOFF, M. L., ZHANG, P., WOLFE, R. E., BOUNOUA, L. (2010): Remote sensing of the urban heat island effect across biomes in the continental USA. Remote Sensing of Environment, 114: 504–513.

KOTHARKAR, R., BAGADE, A. (2018): Evaluating urban heat island in the critical local climate zones of an Indian city. Landscape and Urban Planning, 169: 92–104.

LECONTE, F., BOUYER, J., CLAVERIE, R., PÉTRISSANS, M. (2015): Using Local Climate Zone scheme for UHI assessment: Evaluation of the method using mobile measurements. Building and Environment, 83: 39–49.

LECONTE, F., BOUYER, J., CLAVERIE, R., PÉTRISSANS, M. (2017): Analysis of nocturnal air temperature in districts using mobile measurements and a cooling indicator. Theoretical and Applied Climatology, 130: 365–376.

LELOVICS, E., UNGER, J., GÁL, T., GÁL, C. V. (2014): Design of an urban monitoring network based on Local Climate Zone mapping and temperature pattern modelling. Climate Research, 60: 51–62.

MATHEW, A., KHANDELWAL, S., KAUL, N. (2018): Analysis of diurnal surface temperature variations for the assessment of surface urban heat island effect over Indian cities. Energy and Buildings, 159: 271–295.

MUSHORE, T. D., DUBE, T., MANJOWE, M., GUMINDOGA, W., CHEMURA, A., ROUSTA, I., ODINDI, J., MUTANGA, O. (2018): Remotely sensed retrieval of Local Climate Zones and their linkages to land surface temperature in Harare metropolitan city, Zimbabwe. Urban Climate. 27: 259–271.

NASSAR, A. K., BLACKBURN, G. A., WHYATT, J. D (2016): Dynamics and controls of urban heat sink and island phenomena in a desert city: Development of a local climate zone scheme using remotely-sensed inputs. International Journal of Applied Earth Observation and Geoinformation, 51: 76–90.

ODINDI, J., BANGAMWABO, V., MUTANGA, O. (2015): Assessing the value of urban green spaces in mitigating multi-seasonal urban heat using MODIS Land Surface Temperature (LST) and Landsat 8 data. International Journal of Environmental Research, 9: 9 – 18.

OKE, T. R. (1987): Boundary Layer Climates, 2nd edition. London, Routledge.

OKE, T. R., MILLS, G., CHRISTEN, A., VOOGT, J. A. (2017): Urban Climates. Cambridge, Cambridge University Press.

PENG, S., PIAO, S., CIAIS, P., FRIEDLINGSTEIN, P., OTTLE, C., BRÉON, F-M., NAN, H., ZHOU, L., MYNENI B. R. (2012): Surface urban heat island across 419 Global Big Cities. Environmental Science & Technology, 46(2): 696 – 703.

PONGRÁCZ, R., BARTHOLY, J., DEZSŐ, Z. (2010): Application of remotely sensed thermal information to urban climatology of Central European cities. Physics and Chemistry of the Earth, 35: 95–99.

QUAN, S. J., DUTT, F., WOODWORTH, E., YAMAGATA, Y., YANG, P. P-J. (2017): Local Climate Zone mapping for energy resilience: A fine-grained and 3D approach. Energy Procedia, 105: 3777–3783.

RASUL, A., BALTZER, H., SMITH, C., REMEDIOS, J., ADAMU, B., SOBRINO, J. A., SRIVANIT, M., WENG, Q. (2017): A review on remote sensing of urban heat and cool islands. Land, 6(2): 38.

SAVIĆ, S., GELETIČ, J., MILOŠEVIĆ, D., LEHNERT, M. (2018): Analysis of land surface temperatures in the 'local climate zones' of Novi Sad (Serbia). Proceedings of the Cities and Climate Change Conference, Potsdam 2017. Springer.

SENEVIRATNE, S. I., LÜTHI, D., LITSCHI, M., SCHAER, C. (2006): Land-atmosphere coupling and climate change in Europe. Nature, 443: 205–209.

SHI, Y., LAU, K. K-L., REN, C., NG, E. (2018): Evaluating the local climate zone classification in high-density heterogeneous urban environment using mobile measurement. Urban Climate, 25: 167–186.

SKARBIT, N., GÁL, T., UNGER, J. (2015): Airborne surface temperature differences of the different Local Climate Zones in the urban area of a medium sized city. Joint Urban Remote Sensing Event (JURSE), Lausanne, Switzerland, PID3445901.

SKARBIT, N., STEWART, I. D., UNGER, J., GÁL, T. (2017): Employing an urban meteorological network to monitor air temperature conditions in the 'local climate zones' of Szeged, Hungary. International Journal of Climatology, 37/S1: 582–596.

STABLER, L. B., MARTIN, C. A., BRAZEL, A. J. (2005): Microclimates in a desert city were related to land use and vegetation index. Urban Forestry Urban Greening, 3(3 – 4): 137 – 147.

STEWART, I. D. (2007): Landscape presentation and the urban-rural dichotomy in empirical urban heat island literature, 1950–2006. Acta Climatologica et Chorologica, 40–41: 111–121.

STEWART, I. D. (2009): Classifying urban climate field sites by "Local Climate Zones". Urban Climate News, 34: 8–11.

STEWART, I. D., OKE, T. R. (2012): Local Climate Zones for urban temperature studies. Bulletin of American Meteorological Society, 93: 1879–1900.

STEWART, I. D., OKE, T. R., KRAYENHOFF, E. S. (2014): Evaluation of the 'local climate zone' scheme using temperature observations and model simulations. International Journal of Climatology, 34: 1062–1080.

THOMAS, G., SHERIN, A., ANSAR, S., ZACHARIAH, E. (2014): Analysis of urban heat island in Kochi, India, using a modified local climate zone classification. Procedia Environmental Sciences, 21: 3–13.

TRAN, H., UCHIHAMA, D., OCHI, S., YASUOKA, Y. (2006): Assessment with satellite data of the urban heat island effects in Asian mega cities. International Journal of Applied Earth Observation and Geoinformation, 8: 34–48.

UNGER, J., SAVIĆ, S., GÁL, T. (2011): Modelling of the annual mean urban heat island pattern for planning of representative urban climate station network. Advances in Meteorology, 2011: ID 398613.

UNGER, J., SAVIĆ, S., GÁL, T., MILOŠEVIĆ, D. (2014): Urban climate and monitoring network system in Central European cities. Novi Sad – Szeged, University of Novi Sad/University of Szeged.

UNGER, J., GÁL, T., CSÉPE, Z., LELOVICS, E., GULYÁS, Á. (2015): Development, data processing and preliminary results of an urban human comfort monitoring and information system. Időjárás, 119: 337–354.

UNITED NATIONS (2019): United Nations Demographic Yearbook 2017: Sixty-Eighth Issue, UN, New York.

WAN, Z. (2008): New refinements and validation of the MODIS land-surface temperature/emissivity products. Remote Sensing of Environment, 112: 59–74.

WAN, Z., DOZIER, J. (1996): A generalized split-window algorithm for retrieving land-surface temperature from space. IEEE Transactions on Geoscience and Remote Sensing, 34: 892–905.

WAN, Z., LI, Z. L. (2008): Radiance-based validation of the V5 MODIS land-surface temperature product. International Journal of Remote Sensing, 29: 5373–5395.

WAN, Z., SNYDER, W. (1999): MODIS land-surface temperature algorithm theoretical basis document. Institute for Computational Earth Systems Science, University of California, Santa Barbara.

WAN, Z., ZHANG, Y. L., ZHANG, Q. C., LI, Z. L. (2004): Quality assessment and validation of MODIS global land surface temperature. International Journal of Remote Sensing, 25: 261–274.

WANG, C., MIDDEL, A., MYINT, S. W., KAPLAN, S., BRAZEL, A. J., LUKASCZYK, J. (2018a): Assessing local climate zones in arid cities: The case of Phoenix, Arizona and Las Vegas, Nevada. ISPRS Journal of Photogrammetry and Remote Sensing, 141: 59–71.

WANG, R., REN, C., XU, Y., LAU, K. K-L., SHI, Y. (2018b): Mapping the local climate zones of urban areas by GIS-based and WUDAPT methods: A case study of Hong Kong. Urban Climate, 24: 567–575.

WUDAPT (World Urban Database and Access Portal Tools) [online]. [cit. 12.11.2019]. Available at: http://www.wudapt.org

YANG, X., YAO, L., JIN, T., PENG, L. L. H., JIANG, Z., HU, Z., YE, Y. (2018): Assessing the thermal behavior of different local climate zones in the Nanjing metropolis, China. Building and Environment, 137: 171–184.

ZHAN, W., CHEN, Y., VOOGT, J., ZHOU, J., WANG, J., LIU, W., MA, W. (2012): Interpolating diurnal surface temperatures of an urban facet using sporadic thermal observations. Building and Environment, 57: 239–252.

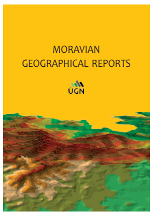
ZHOU, J., CHEN, Y. C., ZHANG, X., ZHAN, W. (2013). Modelling the diurnal variations of urban heat islands with multi-source satellite data. International Journal of Remote Sensing, 34(21): 7568–7588.

ZHOU, B., RYBSKI, D., KROPP, J. P. (2013): On the statistics of urban heat island intensity. Geophysical Research Letters, 40: 5486–5491.

ZHOU, B., LAUWAET, D., HOOYBERGHS, H., DE RIDDER, K., KROPP, J., RYBSKI, D. (2016): Assessing seasonality in the surface urban heat island of London. Journal of Applied Meteorology and Climatology, 55: 493–505.

Please cite this article as:

FRICKE, C., PONGRÁCZ, R., GÁL, T., SAVIĆ, S., UNGER, J. (2020): Using local climate zones to compare remotely sensed surface temperatures in temperate cities and hot desert cities. Moravian Geographical Reports, 28(1): 48–60. Doi: https://doi.org/10.2478/mgr-2020-0004



MORAVIAN GEOGRAPHICAL REPORTS

sciendo

The Czech Academy of Sciences, Institute of Geonics

journal homepage: http://www.geonika.cz/mgr.html

doi: https://doi.org/10.2478/mgr-2020-0005

SCIENTIFIC COMMUNICATION

Scientific citizens, smartphones and social media – reshaping the socio-spatial networks of participation: Insects, soil and food

Matt REED [a] *

Abstract

The conjunction of citizen science and social media through the mediation of the smartphone is investigated in this Scientific Communication, following on from the last issue of the Moravian Geographical Reports (2019, Vol. 27, No. 4). Through a reconsideration of three previously published articles, in part written by the author, this paper reflects on these topics with regard to farmer innovation, local food networks and citizen-informed ecology. Each of these papers has used Twitter to gather data about practices of innovation and observation that have revealed new insights about innovation networks amongst farmers, urban-rural connections and insect behaviours. The reflections reported here are embedded in a discussion of the rise of the term 'Citizen Science'. Recent experiences in areas as diverse as fisheries management and combating Ebola, have informed societal needs for greater engagement in finding inclusive, comprehensive solutions to urgent socio-ecological problems. This paper suggests a compositional approach to studies using citizen scientists and their data as a new avenue of practice and investigation.

Keywords: *citizen science; innovation practices; food networks; farmers; insect behaviours; Twitter*

Article history: *Received 4 April 2019, Accepted 2 February 2020, Published 31 March 2020*

1. Introduction

Many societies are facing a crisis of confidence in their institutions. Voting and consumption practices do not address this malaise, as technologies impact society in unanticipated ways. Simultaneously, there are a series of grand challenges such as the climate emergency, the diseases of affluence, the urban transition and the relative stagnation of many economies. All of these crises have elements that engage with science and technology, giving rise to the need to navigate the social change collectively, often called 'innovation' or 'disruption'. Greater engagement in science would seem to offer an essential adjunct to citizenship as part of the way out of this situation.

The loose use of the term 'citizen science' has conflated a discussion of the importance of participation, understanding science and access to the forums in which people can produce solutions. This paper focuses on three case studies from the United Kingdom that explore how a more nuanced understanding of the intersection of citizenship, technologies and social innovations, might inform a better understanding of science and citizenship. This communication follows from several questions raised in the last issue of the Moravian Geographical Reports (2019, Vol. 27, No. 4).

Social scientists have observed for more than two decades that the velocity of the development of the Internet, the technologies needed to access it, and the consequent societal changes are epochal in importance. In the smartphone, an array of technologies has come together, providing a mobile point of access to not only telephony but also to data networks. Portable and haptic smartphones have increased the scope of the devices, which now include built-in audio-visual capture, location tracking and sensors that allow for extensive data capture, as well as self-expression. Smartphones have penetrated many societies profoundly in less than two decades. Social media platforms, such as Facebook, Twitter and Instagram, allow people to create, share and discuss content within and between

[a] Countryside and Community Research Institute, University of Gloucestershire, UK (*corresponding author: M. Reed, e-mail: *mreed@glos.ac.uk*)

social networks. Financed by advertising and managed by algorithms, these platforms that are seemingly allowing open expression of ideas and experiences, have become part of the daily practices of billions of people. These social media are displacing, replacing, augmenting, and reconfiguring previous communication and cultural habits, such as letter writing, newspaper reading, radio listening, leaf-letting and TV viewing. The dynamic interaction between technological developments, software innovations, global distribution and social changes are intertwined in complex ways and at various levels, making policy interventions difficult.

Early discussions of the Internet and associated technologies were concerned with their unequal distribution of access, across gender, educational status, space and social status. As the technologies have developed, the infrastructure has spread and prices have fallen, so the discussion has deepened to focus on the data generated by users, the uses made of it, and the appropriate use of it. There has been a shift from questions of access to the technology to questions about the data that access generates. Scientists of many disciplines have found these new streams of data, often in unprecedented volumes, to be a valuable new field of enquiry. As a mass and collective phenomenon, the initial enquiries were quantitative in form. More recently, qualitative methods have become both applicable and available. Initially, it appeared that the smartphone was the choice of those with fewer financial means and technological tools – that these devices both enabled and constrained access to Information and Communications Technology (ICT). Similarly, the focus on these technologies was on the city, reflecting the dominant form of economic development but also the structures of the technology. Mobile telephone networks carrying data, satellite technologies and the spread of fibre cables mean that many rural areas have parity of connection with urban ones. This development validates Castells' observation that part of the innovation of the online is not to make space redundant but to cast it in different forms (Castells, 1996).

This paper focuses on three case studies (Hart et al., 2018; Reed and Keech, 2017; Mills, Reed, Skaalsveen and Ingram, 2019) to explore how social media is being used to reconfigure how people participate in society, illustrating varying degrees of reflexivity and deliberation across urban, rural and peri-urban spaces. These already-published case studies will be used to explore how citizen science might be understood more fully. The first study focuses on the role of users of social media as reporters of phenomena, which then can then be collected and analysed by researchers to gain more information about insect behaviours (Hart et al., 2018). This study focuses on the observational and collaborative role of citizens in the production of science. The second case considers an example of an affinity network around urban food, with a focus on how social media can be used to augment in-person networks of innovation. Through observational data, the study illustrates the social labour needed to foster social change and the emotional work around being critical (Reed and Keech, 2017). The third example is a case study focused on the activities of a network of farmers in sharing information and experimentation about farming practices aimed at securing the ecological health of the soil (Mills, Reed, Skaalsveen and Ingram, 2019). This trans-national network illustrates people developing, experimenting and sharing knowledge.

All of these examples intermesh complex networks of knowledge and social interaction. They raise important questions about how science can engage in promoting citizenship but also the need for greater sophistication in policy creation.

2. Theoretical departures

The public understanding of science, which shades into public engagement with science, has a long scholarly tradition that has significantly informed broader social theory, as well as being informed by it (Irwin, 2001). A brief consideration of this literature allows us to locate discussions of citizen science in a broader discussion, before coming to focus on some specific understandings of the term. Working from a broadly Foucauldian tradition, Rose identifies contemporary forms of science as they impact, particularly on the body, as creating a form of 'biocitizenship': "Strategies for making up biological citizens 'from above' tends to represent the science itself as unproblematic; they problematise how citizens misunderstand it. But these vectors 'from below' pluralise biological and biomedical truth, introduce doubt and controversy, and relocate science in the fields of experience, politics and capitalism" (Rose, 2007, p. 143).

This perspective places contemporary citizenship with a series of 'projects' in modernity, whereby various technologies shape, and are shaped, by people. For Rose, the emergence of genomic knowledge, a product of contemporary computational technologies, is paramount. Genomic information brings new responsibilities of taking on prudential actions, information seeking and new disciplines of the body. Significantly these are the grounds for hope: "Hope, here, is not mere wishing and anticipating - it postulates a certain achievable and desirable future, which requires action in the present for its realisation" (Rose, 2007, p. 148). The biocitizen is an active citizen, making use of the technologies and knowledges in this role to be agents in their world, working with others in the present to re-position science.

If we take Rose's schema of citizenship from above and from below to consider a few examples of citizens' engagement with 'science', then the constellation of different definitions of citizen science becomes apparent. The EU's Common Fisheries Policy makes use of ecological models to manage not fish populations but fishing effort, through the allocation of quotas of fish to be caught. Failure to comply with such quotas can lead to fishers being heavily fined or even imprisoned. The conformity of aquatic realities to these models is contested (Symes and Phillipson, 2009). Many critics point to how the limitations of the scientific models when engaged in the reality of fishing technologies, the actions of markets for fish and the failure of nature to conform to the models, has seriously denuded the marine environment whilst damaging coastal communities. Stephenson and colleagues argue, from evidence across Europe, North America and Australia, that the engagement of fishers as citizens results in better science (Stephenson et al., 2016). In this example, science 'from above', creating a specific form of citizenship via science for fishers, has begun to accept the necessity of plurality and discussion.

The desperate situation analysed by Richards in his work on popular science during the west African Ebola outbreak 2013–2014, illustrates how citizen science 'from below' can negotiate joint epistemologies (Richards, 2016). Richards illustrates how citizens working with local medics and Medicines San Frontičres (MSF) had begun to contain the epidemic before the arrival of the US military's and the UK's NHS outreach operations. Richards argues that the treatment and containment of Ebola was not about the deficiency of medical facilities in the afflicted communities. High-tech, well-funded hospitals struggled with the disease, but success lay with knowing how to manage it in its social context. By using local knowledge of other diseases, such as cholera, and using protective gear fabricated from plastic bags and swimming goggles, combined with an acute sensitivity to the social context, an effective people's science was created. The innovations required were simultaneously medical and social scientific, with local people at the core of this process. In particular, the citizens were able to show medics how not caring for the bodies of the dead was as socially dangerous as it was medically risky. The dead could not be abandoned, and that medical framings of the disease would not be adopted until they attended to the socio-spiritual aspects, as well as the virological. The negotiation of this new science allowed people to work together with clinicians to defeat the outbreak. This vibrant example demonstrates the urgency but also the possibilities of science created from below.

Rose's binary allows us to develop an understanding of the tension between a popular, participatory science and one which is imposed on people. As an example, Silvertown, in a widely-cited paper, describes the benefits of the involvement of citizens, as providing a cheaper, volunteer workforce, which is seen positively by funding bodies, but he does not see their inclusion as changing the ontological grounding of science (Silvertown, 2009). This instrumental view of citizen participation continues to inform many environmental science approaches, as it does not challenge the power of scientists. Many proponents of citizen science are proposing a hybrid form which continues elements of the science from above, with the active participation of those below. Hinchcliffe and colleagues in their commentary on the 'fifth wave' of public health, note that publics are heterogeneous, hybrid and emergent (Hinchliffe et al., 2018). They argue that a 'compositional' approach needs to be taken, bringing the bio-medical sciences together with the humanities and social sciences to create new forms. Only by working together, sharing knowledge and experience, can complex problems such as anti-biotic resistance be countered. They identify "a process that is neither top down nor bottom up, but compositional, enabling the development of alliances where questions and approaches are co-created" (Hinchliffe et al., 2018, p. 8). They signal this transition by reversing 'public health' to 'healthy publics', suggesting an active, emergent and collective response rather than a singular solution. In this context Richards' 'popular science' is less from below than compositional, aligning western medics from MSF embedded in local communities with the people in those communities.

In less urgent contexts there are two intersecting spheres where active citizenship is coalescing with these mobile technologies, which bring accounts of social movement activity into contact with broader accounts of social change. Social movement scholars have noted for some time that social movements can produce new ways of knowing, creating new practices and technologies that are as diverse as petrol-powered cars, organic farming, recycling schemes and low carbon power generation. With the advent of pervasive ICT these technologies have become interwoven with these personalised practices to create what Bennett has described at Digital Network Activism (Bennett, 2012). Through these networks, protests are more easily coordinated, but also innovations such as changes in tactics can be quickly disseminated and the processes of learning are accelerated.

Such an ability of relatively small groups of people to create socially beneficial innovations has been noted and promoted by authors such as Geoff Mulgan, who terms this as 'social innovation': "Social innovation refers to innovative activities and services that are motivated by the goal of meeting a social need and that are predominantly diffused through organisations whose primary purposes are social" (Mulgan, Steinberg and Salem, 2005). Mulgan and collaborators draw attention to the processes of innovation that happen outside of business-orientated innovation or research and development, but rather point to the creativity of those working in the state, NGOs and coalitions of citizens. These accounts have tended to focus on the science of citizenship as applied in the field by those wanting to create pro-social change, which has clear correspondence with some of the goals of citizen science.

3. Methods and case studies

The social media platform that is the focus of these three papers and provides this text with a constant theme, is Twitter. This micro-blogging platform allows for short sections of text with attached images and videos to be posted online with networks of followers, and interaction through sharing (re-tweeting) or approval through a 'like'. To enable navigation through the vast flows of discussion, indexing terms (#hashtags) allow conversations to be interlinked. Weaving between these user-controlled and created elements are targetted advertisements and suggestions of possible connections generated by the Twitter algorithms. Significantly, for research purposes, it is possible to capture a small fraction of the streams of Twitter data, subject to limitations imposed by Twitter, either through bespoke programs or analytical packages such as Nvivo (Gonçalves, Perra and Vespignani, 2011). Most users understand that contributions to Twitter are published and can be subject to legal sanctions such as libel, as well as discussion and scrutiny. These features make Twitter an unusually public and readily available form of social media when compared to the more tightly-controlled platforms of Facebook or Instagram.

3.1 Intra-national networks: Observing insects

Recent concerns about the declining population of all insects, but pollinators in particular, has focused media attention on their situation. A range of studies and interventions have encouraged interested citizens to report sightings of various insects via specially created apps (applications), and even to kill and collect some insects to further the study of their population dynamics (Hart et al., 2018). In part, these studies build on more extensive surveys such as the U.K.'s Royal Society for the Protection of Birds (RSPB) annual 'Big Bird' survey, which encourages bird watchers to submit their observations to a national survey. Through the popular media, and targetted appeals to interested groups, many thousands of people have participated in such studies. Participants have been encouraged to record their observations using smartphone apps and even posting samples of dead insects to scientists. These studies have provided environmental scientists with data they would otherwise not have been able to access, as well as a public profile for the topic.

The critical literature of this approach within the ecological sciences notes the drawbacks to this form of research as results cannot be validated, it is less likely to address complexity, less consistent in form and tends towards densely populated areas. As it can generate large data sets, however, it is particularly suited to understanding species' populations and behaviours across space, and the seasons. The paper advanced from the hypothesis that Twitter users were moved to record the presence of insects for another reason. Flying ants were a likely candidate because of their propensity to swarm (Hart et al., 2018). This swarming happens only at particular times and in particular conditions, offering phenomena that might be recorded spontaneously. The team were able to provide earlier observations of flying insect data collected by citizen scientists deliberately, in a structured interaction with ecologists, which provided a way of validating the Twitter data.

The results of the paper broadly demonstrated that Twitter data for complex ecological phenomena has limitations, some of which related to the indirect and retrospective method of collection. Via GPS (Global Positioning System) tagging it is possible for Tweets to be located, but often this option is turned off by users or, in a small minority of cases, set to be misleading (Hart et al., 2018). It does show that there is a potential to gather important data through the analysis of casual chat on Twitter, as people discuss events of passing interest to them. The paper found that it was possible to consider that accurate socio-spatial data could be collected, in this instance, the emergence of the flying ants, and this was useful at a national level. Testing specific hypotheses was not possible through data collected in this way (Hart et al., 2018). That Twitter might be a valuable tool for collecting phenological data, about the appearance of seasonal or cyclic events in readily identifiable species, may be of increasing salience as climate change begins to disrupt established patterns.

3.2 Urban to rural networks: A circle of friendship

There have been widespread discussions about the intersection of urban infrastructure with ICT capabilities and 'mobiquity', intending to create a 'smart city' (Kitchin, Lauriault and McArdle, 2015; Saunders and Baeck, 2015; Wiig, 2015). Many of these schemes are promissory, awaiting an anticipated but yet to be realised intermeshing of technologies, but nascent examples are apparent. Already many cities have been significantly altered by peer-to-peer marketing platforms such as Airbnb (accommodation), Trip Advisor (dining), Uber (transport) and Facebook (advertising) (Calafiore, Boella, Grassi and Shcifanella, 2018). As Castells argues, there is already considerable evidence of a bottom-up movement to make the city smart through the quotidian use of information sharing through social media (Castells, 2012).

Urban agriculture has become a prominent topic in part because it presents opportunities to connect to, and link, a range of social problems in a relatively non-contentious manner (Moragues-Faus and Morgan, 2015; Morgan and Sonnino, 2010). In this way, at times the discussion of urban agriculture is a proxy for debating the future of urban forms, food system resilience, the future of urban governance or the development of new communities of interest, and sometimes it is about urban agriculture. The city of Bristol has become a prominent node in the discussion of urban agriculture because of the vibrant networks of experimentation that are taking place in and around the city, as well as the self-publicity/reflection those networks generate (Carey, 2013; Halliday and Barling, 2018).

Twitter accounts were identified through semi-structured interviews with some of the participants in the networks (Reed and Keech, 2017). These become the entry points into mapping the social networks of these groups through social network analysis software, focused around a prominent vegetable box scheme operating in Bristol. This large-scale analysis identified 23 sub-networks or communities within the Twitter networks, revealing the network as a series of loosely connected groups rather than a tightly bound or coherent group. Through detailed consideration of these smaller networks, including textual analysis of the material being exchanged, it was apparent that social media plays a role in re-affirming social connections there are personal, friendly and positive in tone. This disposition creates on-line networks of social appreciation and a space that promotes the goals of the network into social media; in this way, interpersonal connections are congruent with those online. In part, this can be anticipated as those engaged in these networks are individuals who are trying to work collectively to reshape consumerism and use food as a tool for creating community. It is also apparent in these network diagrams that key activists play a role in both creating and sustaining these networks. Their social skills, energy and examples are essential as they act as movement entrepreneurs. The findings of this paper suggest that social media is not inherently anti-social (Reed and Keech, 2017). Instead, there are questions about its uses as a primary tool of social interaction or as an additional means. This example does confirm the importance of social media 'bubbles' which reinforce pre-existing norms and attitudes, albeit, in this case, they are pro-social.

3.3 Rural to rural networks: saving the soil

Historically, farmers and the rural communities in which they reside, have been relatively isolated with the advent of mass broadcast media connecting rural areas to urban ones in new ways. While in many rural areas, interconnectivity via broadband lags behind urban areas, mobile telephone networks have advanced more uniformly. As with many other small business operators, farmers have found smartphones to be useful (Roberts and Townsend, 2015; Salemink, Strijker and Bosworth, 2017). This technology has opened the opportunity for rural-to-rural networking, as people in rural areas can connect directly to their peers, overcoming some of the problems associated with innovation in rural areas.

Simultaneously, the EU has emphasised the importance of farmer-led innovation, in line with CAP initiatives, but also agri-tech innovations as an opportunity for the heavily mechanised UK industry to gain comparative advantage and potentially export markets (Faure, Desjeux, and Gasselin, 2012; Mills et al., 2013). Research findings have consistently pointed to the importance of peer-to-peer exchange as the preferred mechanism, which has informed policy (Dwyer et al., 2007; Gibbs, 2013). These initiatives to encourage farmers are in addition to spontaneous self-organisation by farmers, who are sharing their innovations on social media and networking via this medium. With the advent of cheap 'action' video cameras mounted on equipment, as well as video cameras in smartphones, they are sharing images of the equipment in action. Farmer-to-farmer learning networks are emerging based on experimentation and sharing experience.

In this paper (Mills, Reed, Skaalsveen and Ingram, 2019) a content analysis of a Twitter account of the EU research project 'SoilCare' was combined with in-depth qualitative interviews with five farmers using Twitter, and was used to explore the extent and type of peer-to-peer knowledge exchange about sustainable soil management practices. The research identified evidence of learning taking place through these exchanges. Twitter offers a medium which captures the immediacy of the field operations through visually impactful media, based in the field. The brief messages channelled through Twitter appeal to farmers, who feel themselves to be time-constrained. Hashtags, as indexing terms, have allowed networks of practice concerning sustainable soil management to coalesce and within these networks: 'farmer champions' are emerging who are respected by their peers. These champions have committed considerable effort to Twitter, for example posting over 100,000 tweets, but as they are attentive to, and responsive to farmers, they are important conduits of information. The interviewees view Twitter as working best for those actively seeking information, echoing the role of the bio-citizen as an active user, as well as creators of knowledge. This perspective suggests that optimally Twitter should be combined with forms of face-to-face interaction as part of a blended approach to learning. Additionally, Twitter offers a space for researchers and advisers to share insights and experience with farming to widen the informational base of the networks (Mills et al., 2019).

4. Discussion

This trio of papers begins to suggest some ways a more nuanced account of the interactions between social media usage, smartphones and citizenship could emerge (Hart et al., 2018; Reed and Keech, 2017; Mills, Reed, Skaalsveen and Ingram, 2019). Although each of the papers is different in focus, disciplinary field, and approach to the data, there are some intersections that suggest important commonalities:

i. collecting data;

ii. an understanding of who is active in these networks; and

iii. what it says about participation.

4.1 Collecting data

All of these data are in the public domain, available to be accessed, collected and analysed by any interested party. For those posting this material, on one level this is assumed. This activity is the deliberate creation of new and public knowledge in an open forum. Some of those taking up the building of alternative food networks in Bristol, for example, had only one audience in mind, those with whom they had interacted off-line. In these ways, social media as a public forum is a part in the flying ant study, those participating did so knowing that ecologists were looking for these data. The farmers looking to protect the soil used hashtags so that others could find their discussions. Those delivering crucial new knowledge and opportunities to learn were enabled.

There are two important caveats to this public domain of knowledge. The first is that the researchers are not able directly to return the knowledge to these networks. Lags in time caused by analysis and publishing, mean that there is little opportunity for direct, timely feedback. Second, the role of the platform remains opaque, in that data collection is limited and the part of advertising algorithms in these networks is unknown.

Importantly in two of these papers (Reed and Keech, 2017; Mills, Reed, Skaalsveen and Ingram, 2019, the authors combined qualitative analysis with that of an understanding of the Twitter networks, overcoming some of the problems of the large-scale quantitative analyses of Twitter. Understanding that social media is only part of a broader constellation of information and interactions is essential to contextualising it. Considering the sub-communities of networks within an affinity network in Bristol counters the idea of undifferentiated blocs or 'bubbles' of opinion. Thick and detailed descriptions of Twitter are essential in understanding how these platforms become woven into daily practices and ways of knowing.

4.2 Who is active in the process?

In each of these studies, a diverse range of people is present, although unified in sharing access to the platform. This access is vital in changing the demographics and dynamics of participation, with smartphones being the critical technology. Each of these papers is focused on a different field, but each is remote from deskbound computing. The soil saving farmers are Tweeting from and videoing farm machinery in their fields, the observations of flying ants are from people watching the swarming insects on a summer evening. Smartphones and their attendant data connections allow for the spontaneity that underpins these interactions.

Much of the literature about citizen science implies a binary division between those contributing the data – the citizens – and the experts, who can analyse the results. Much of the literature and some of the practice of citizen science appears to embed those assumptions. Yet in the detailed work in these papers, it is clear that there is a mixture of citizens, who might be farmers or food activists but also those who hold professional status and expertise. Rather than a binary of expert/non-expert, we are observing a mixing of expertise. Some of this expertise is in the pragmatics of no-till farming, others in the statistical analysis of Tweets. What is incomplete in these studies is the access of the 'citizens' to the agendas of knowledge in scholarly domains. Citizen science in this context reflects the power structures of peer-reviewed science in contrast to other forms of knowledge.

4.3 The nature of participation

As noted above, many of those active in these Twitter networks are self-consciously creating new forms of knowledge and social practice. Interwoven with the unwitting contributor are those attempting to develop new types of agricultural practice or new systems of food distribution. The contributors are expressing and sharing their expertise in a public forum to share and co-create new forms of knowledge, with the academic researchers contributing to this effort much later. This model is far from the binary of top down/bottom-up creation of knowledge inherent in some models of citizen science. Instead, we are closer to the 'compositional model' proposed by Hinchcliffe and colleagues (Hinchliffe et al., 2018, p. 8). In this model, people create alliances to co-create new knowledge together.

This effort is both self-conscious and voluntary, and although conducted in public, is done so through the medium of a corporately-owned social space – Facebook, Twitter, Whatsapp and the like. It raises important questions about how policy should respond to citizens taking up such initiatives. Would it be helpful for such data to be routinely available via a data commons rather than left on the servers of a corporate actor? Or should, over time, new spaces of civic debate be created to which policy actors are more integrated. While these debates are being held, alliances of citizens are forming new knowledge in the spaces afforded to them.

5. Conclusions

Currently, a backlash is developing against the advertisement-driven, corporate surveillance model of social media, and how it has been open, or even party to, forms of manipulation that are unethical and potentially illegal. This movement suggests that there could be advantages in academics forming a partnership with those who are seeking to wrest control of the Internet back to its users, preserving it from being solely a space of entertainment and associated marketing efforts. The case studies in this paper hint at a more purposeful and constructive use of social media, even when used in a recreational format as users provide data indirectly (Leadbetter, 2008). Some might argue for a market mechanism through which users get paid for the data they generate. A parallel route might be to allow scholars to access data preferentially, with a tighter on access and the management of that data after the Cambridge Analytica scandal (House of Commons, 2019).

It also suggests that the focus on big data and computational insights has overshadowed the study of the meso-level uses of social media. In comparison, text messages (SMS), 'WhatsApp' groups and micro-blogging are the non-dramatic but increasingly quotidian communication forms that are bringing groups together and can be inaccessible to researchers. A common feature of all the discussions of the citizen, be they top-down or bottom-up, is that these new forms of (bio)citizenship are suffused with hope. The studies in this paper offer a new form of observational data that suggests that more accurate data are possible through gathering social media postings, the 'chat' of online social life. The possibilities of deeper engagement, when people take up forms of (bio)citizenship suggest that this hope may not be misplaced. The grand challenges of the transition to greater sustainability are that environmental management, in various forms, will be met by new forms of association and collaboration, re-making places and re-locating, as people work together with their smartphones in their hands.

References:

BENNETT, W. L. (2012): The Personalisation of Politics: Political Identity, Social Media, and Changing Patterns of Participation. The Annals of the American Academy of Political and Social Science, 644: 20–39.

CALAFIORE, A., BOELLA, G., GRASSI, E., SHCIFANELLA, C. (2018): Turin's Foodscapes: Exploring Places of Food Consumption through the Prism of Social Practice Theory. In: Westerholt, R., Mocnik, F. B., Zipf, A. [eds.]: Proceedings of the 1st Workshop on Platial Analysis (PLATIAL'18) (pp. 37–43), Heidelberg, PLATIAL´X.

CAREY, J. (2013): Urban and Community Food Strategies. The Case of Bristol. International Planning Studies, 18(1): 111–128.

CASTELLS, M. (1996): The Rise of the Network Society (Vol. 1). London, Blackwells.

CASTELLS, M. (2012): Networks of Outrage and Hope: Social Movements in the Internet Age. London, Polity Press.

DWYER, J., MILLS, J., INGRAM, J., TAYLOR, J., BURTON, R., BLACKSTOCK, K. et al. (2007): Understanding and influencing positive behaviour change in farmers and land managers. Cheltenham, Gloucestershire, Countryside and Community Research Institute, University of Gloucestershire.

FAURE, G., DESJEUX, Y., GASSELIN, P. (2012): New Challenges in Agricultural Advisory Services from a Research Perspective: A Literature Review, Synthesis and Research Agenda. Journal of Agricultural Education and Extension, 18(5): 461–492.

GIBBS, C. (2013): The Value of Advice Report [online]. Vancouver, the Investment Funds Institute of Canada. Available at: https://www.ific.ca/wp-content/uploads/2013/02/IFIC-Value-of-Advice-Report-2012.pdf/1650/

GONÇALVES, B., PERRA, N., VESPIGNANI, A. (2011): Modelling Users' Activity on Twitter Networks: Validation of Dunbar's Number. PLoS ONE, 6(8): e22656.

HALLIDAY, J., BARLING, D. (2018): The Role and Engagement of Mayors in Local Food Policy Groups: Comparing the Cases of London and Bristol. Advances in Food Security and Sustainability, 3. London, Academic Press.

HART, A., CARPENTER, W., HLUSTIK-SMITH, E., REED, M., GOODENOUGH, A., ELLISON, A. (2018): Testing the potential of Twitter mining methods for data acquisition: Evaluating novel opportunities for ecological research in multiple taxa. Methods in Ecology and Evolution, 9: 2194–2205.

HINCHLIFFE, S., JACKSON, M. A., WYATT, K., BARLOW, A. E., BARRETTO, M., CLARE, L., et al. (2018): Healthy publics: Enabling cultures and environments for health. Palgrave communications, 4(1): 1–10.

HOUSE OF COMMONS (2019): Disinformation and 'fake news': Final Report. Digital, Culture, Media and Sport Committee, London, HMSO.

IRWIN, A. (2001): Constructing the scientific citizen: science and democracy in the biosciences. Public Understanding of Science: 10: 1–18.

KITCHIN, R., LAURIAULT, T. P., MCARDLE, G. (2015): Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. Regional Studies, Regional Science, 2(1): 6–28.

LEADBETTER, C. (2008): We-think. Mass Innovation, not Mass Production. London, Profile Books.

MILLS, J., GASKELL, P., REED, M., SHORT, C., INGRAM, J., BOATMAN, N., et al. (2013): Farmer attitudes and evaluation of outcomes to on-farm environmental management. Report to Defra. Project Report. Gloucestershire, Countryside and Community Research Institute, University of Gloucestershire.

MILLS, J., REED, M., SKAALSVEEN, K., INGRAM, J. (2019): The use of Twitter for sustainable soil management knowledge exchange. Soil Use and Management, 35(1): 195–203.

MORAGUES-FAUS, A., MORGAN, K. (2015): Reframing the foodscape: the emergent world of urban food policy. Environment and Planning A, 47(7): 1558–1573.

MORGAN, K., SONNINO, R. (2010): The urban foodscape: world cities and the new food equation. Cambridge Journal of Regions, Economy and Society, 3(2): 209–224.

MULGAN, G., STEINBERG, T., SALEM, O. (2005): Wide Open. Open Source methods and their future potential. London, Demos.

REED, M., KEECH, D. (2017): The 'Hungry Gap': Twitter, local press reporting and urban agriculture activism. Renewable Agriculture and Food Systems. 33(6): 558–568.

RICHARDS, P. (2016). Ebola: How a People's Science Helped End an Epidemic. London, Zed Books.

ROBERTS, E., TOWNSEND, L. (2015): The Contribution of the Creative Economy to the Resilience of Rural Communities: Exploring Cultural and Digital Capital. Sociologia Ruralis, 56(2): 197–219.

ROSE, N. (2007): The Politics of Life Itself. Princeton, Princeton University Press.

SALEMINK , K., STRIJKER, D., BOSWORTH, G. (2017): Rural development in the digital age: A systematic literature review on unequal ICT availability, adoption, and use in rural areas. Journal of Rural Studies, 54: 360–371.

SAUNDERS, T., BAECK, P. (2015): Rethinking Smart Cities from the Ground Up. London, Nesta.

SILVERTOWN, J. (2009): A new dawn for citizen science. Trends in Ecology and Evolution 24(9): 467–470.

STEPHENSON, R. L., PAUL, S., PASTOORS, M. A., KRAAN, M., HOLM, P., WIBER, M., et al. (2016): Integrating fishers' knowledge research in science and management. ICES Journal of Marine Science, 73(6): 1459–1465.

SYMES, D., PHILLIPSON, J. (2009): Whatever became of social objectives in fisheries policy?. Fisheries Research, 95(1): 1–5.

WIIG, A. (2016): The empty rhetoric of the smart city: from digital inclusion to economic promotion in Philadelphia. Urban Geography, 37(4): 535–553.

Please cite this article as:

REED, M. (2020): Scientific citizens, smartphones and social media – reshaping the socio-spatial networks of participation: Insects, soil and food. Moravian Geographical Reports, 28(1): 61–67. Doi: https://doi.org/10.2478/mgr-2020-0005

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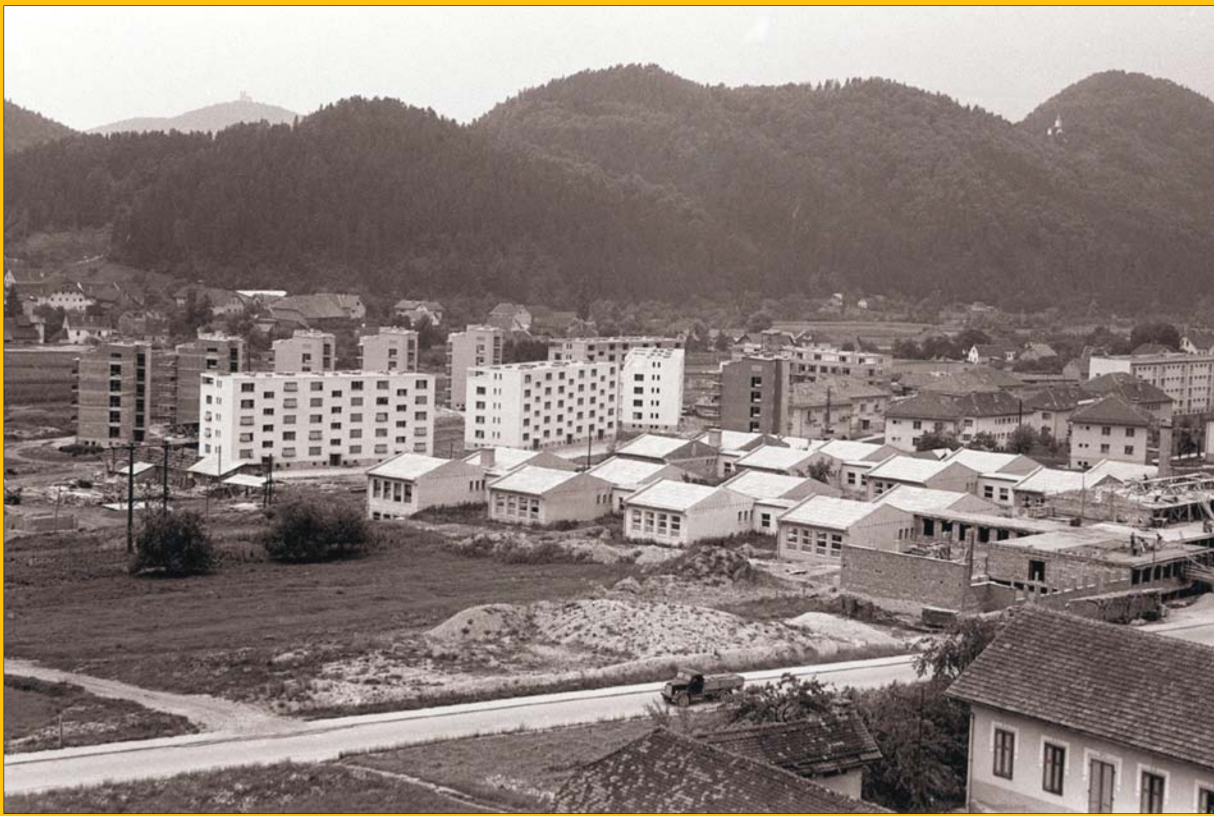

Fig. 2: The industrialisation of smaller towns and rural countryside in the socialist era is a trait of the Slovenian urban system; photo of Velenje in 1958, a "new" coalmining town often presented as the "socialist wonder". (Photo: J. Gal, Večer)

Fig. 3: Many successful Slovenian industrial towns specialised into niche manufacturing sectors, such as Idrija, which became a globally important supplier in the automotive industry. (Credit: J. Polajnar – Yerpo).

Illustrations related to the paper by D. Bole et al.