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Examining voter turnout using multiscale geographically weighted regression: The case of Slovakia

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Abstract

Voter turnout is an essential aspect of elections and often reflects the attitude of a country's population towards democracy and politics. Therefore, examining the distribution of voter turnout and determining the factors that influence whether or not people will vote is crucial. This study aims to find significant factors that underlie the different levels of electoral participation across regions in Slovakia during the 2020 parliamentary elections. In this interpretation, special attention is paid to the ability of the main theories of voter turnout to explain the behaviour of Slovak voters. The primary analytical tool is multiscale geographically weighted regression, which represents an advanced local regression modelling variant. The results indicate that the multiscale geographically weighted regression is superior to the global ordinary least square model in virtually all aspects. Voter turnout is generally higher in economically and socially prosperous localities and regions, which is in line with the societal modernisation theory. Additionally, factors connected to mobilisation theory and the concept of 'left behind places' also proved to be valuable. However, in other cases, such as with the share of retirees and potential habitual voting, the outcomes were not overly convincing, and further research is required.

Keywords: voter turnout, parliamentary elections, theories of voter turnout, multiscale geographically weighted regression, left behind places, Slovakia

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1. Introduction

"Vote!" is heard from candidates on all sides of the political spectrum before elections. Turnout, or the different levels of mobilisation of voters from different regions and social groups, can significantly influence the outcome of an election. Despite the importance of elections and repeated mobilisation of voters, voter turnout has shown a downward trend since the 1980s, observed both globally and in most regions of the world (Franklin, 2004; Solijonov, 2016). The decline in post-socialist countries of Central and Eastern Europe has been faster than in established European democracies (Solijonov, 2016). Low turnout rates are considered a "serious democratic problem" by both politicians and political scientists (Lijphart, 1997, 1). Thus, the factors influencing turnout became the focus of several analyses in political science, sociology, and geography (Reif & Schmitt, 1980; Pacek et al., 2009; Schulz-Herzenberg, 2019).

Research into elections and their turnout began more seriously in the 1940s at Columbia University in New York. Through a series of public opinion surveys, Paul Lazarsfeld and his colleagues investigated how voters' attitudes toward voting are shaped in the months leading up to an election and examined how this process is influenced by existing attitudes, expectations, personal contacts, or affiliation with various social groups and

organisations (Blais, 2000). They pointed to the crucial role of categories such as education, socioeconomic status, or age in expanding the opportunities that individual voters can gain by participating in elections. Therefore, this sociological approach to participation is called the resource model (Brady et al., 1995; Schulz-Herzenberg, 2019).

The second traditional school of voting behaviour originated in the 1950s at the University of Michigan. It published its first conclusions in the classic monograph *The American Voter* (Campbell et al., 1960). The approach of this school is more social-psychological. While it does not dismiss the influence of the social categories with which the Columbia School works, it argues that they stand only at the beginning of the chain of causes and have only an indirect influence on the psychological processes that result in the decision to vote or not to vote (Brady et al., 1995). The Psychological Engagement Model of the Michigan School emphasises the influence of political interests, involvement, and party identification on participation but does not explain in principle why some people vote, and others do not (Blais, 2000; Schulz-Herzenberg, 2019).

A third group of approaches highlights the role of mobilising agents such as interest groups, churches, political parties, and other social networks. According to these approaches, the decision

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to participate in elections is influenced by the people and groups we encounter daily (Franklin, 2004). Mobilisation campaigns by political parties and candidates can be counted among these approaches. Geographers studying the uneven impact of political campaigns in this context write about the campaign effect (see Johnston, 1987; Pattie et al., 2019). The media is an important and frequently studied mobilising agent (Norris, 2000).

The fourth group of approaches is based on rational choice theory and emphasises the utility of voting for voters. If the costs, in the form of the time it takes to obtain information about candidates or the actual participation in voting, are higher than the expected gains, such as the likelihood of influencing the outcome of the election, the voter will stay home (Blais, 2000; Franklin, 2004; Schulz-Herzenberg, 2019). However, the notion that the level of turnout can be explained by a model based on individuals' rational decision-making is challenged by the paradox of voting formulated by the American economist Anthony Downs in the 1950s. According to him, the costs of voting, even if low, almost always outweigh the expected benefits because the probability that a voter's vote will make a decisive contribution to the election of the chosen party or candidate is negligible (Fieldhouse, 2019, 319).

The above approaches have been research-tested in many countries, and there is more interest in the issue of participation in some countries than in others. According to Plešivčák et al. (2016), there has been no long-term and systematic geographical research on voter turnout in Slovakia. Most authors address the issue only as a part of an overall analysis of elections in Slovakia (e.g. Kostecký, 2001; Madleňák, 2012; Kostecký & Krivý, 2015; Rybář et al., 2017). A few works focused on Slovak elections have paid more detailed attention to geography of turnout (Mikuš & Gurňák, 2014; Kevický, 2020a, 2020b; Kevický & Daněk, 2020). These papers have used correlation analysis or ordinary least square (OLS) to explain the factors influencing voter turnout. No work has attempted to explain the distribution of voter turnout in Slovakia using more advanced methods, such as geographically weighted regression (GWR) or multiscale geographically weighted regression (MGWR), which directly work with an aspect of geographical proximity.

This study aims to find significant factors influencing different electoral participation levels in Slovakia regions. In doing so, it will ask what factors influence voter turnout. Do these factors have the same impact throughout Slovakia, or is there spatial heterogeneity? Does the same factor cause an increase in turnout in one place and a decrease in turnout in another? In the search for answers to these questions, special attention will be paid to the ability of the main theories of voter turnout to explain the behaviour of Slovak voters. The primary analytical tool is the MGWR which represents an advanced local variant of regression modelling (Fotheringham et al., 2017). MGWR is not only able to identify potential spatial variation of analysed relationships, but also to manifest how different processes operate at various spatial scales (i.e. local, regional, and global) by estimating unique spatial bandwidths for each covariate (Cupido et al., 2021; Suchánek & Hasman, 2022). The geographic unit of analysis is municipalities, and we only pay attention to the 2020 parliamentary elections.

The following section presents the theories by which regional differences in voter turnout are most often explained and our hypotheses. The third section presents the evolution of turnout in parliamentary elections in Slovakia. That is followed by an introduction of the data and methods used in this paper and then the results of the analyses, while the last two sections discuss and summarise the paper's results.

2. Theories of voter turnout

Theories explaining voter turnout could be classified into two main streams according to the data type. On the one hand, there are theories using individual data. These theories focus

on the voting behaviour of individuals. They aim to find out how likely a particular voter is to participate in a given election and what influenced him or her in his or her decision. The most well-known theories in this category include the rational choice theory (see Downs, 1957) or the theory of valence politics (see Clarke et al., 2009). On the other hand, there are theories using aggregate data. These theories focus on analysing turnout at the level of a region and determining how and why it differs from other regions. Given the study's objective, these theories will be presented in more detail.

Societal modernisation theory assumes that a democratic form of government is a characteristic feature of modern society and that participation in elections is a necessary precondition for democracy. The degree of modernisation of a society can be measured quantitatively by a set of socioeconomic indicators. The higher the degree of modernisation, the higher the demands are made on the active participation of citizens in decision-making processes (Norris, 2002). Therefore, authors such as Norris (2002) and Birch (2003) conclude that the more advanced the modernisation of a society is, the higher participation in elections can be expected. Indicators traditionally used to measure the degree of modernisation are, for example, the urbanisation rate, the index of economic or human development, or the share of people working in the primary sector.

The theory of disenchanted voting explains voter turnout using socioeconomic indicators similar to societal modernisation theory but interprets their impact differently. The reason for the creation of this theory was the apparent inadequacy of societal modernisation theory for explaining the development and regional differences in voter turnout in post-socialist states. According to Kostadinova (2003) and Páček et al. (2009), the fact that a state has gone through a period of socialism reduces turnout while specifically conditioning the effect of socioeconomic characteristics. Nový (2013) notes that the specifics of socialist development caused economic and political problems after the fall of socialism. Therefore, although the indicators of social and economic development at the aggregate level grew, the quality of life of some citizens declined. In response, they decided to resign from participation in the democratic process. By this reasoning, the disenchanted voter theory seeks to explain why, in parallel with economic and social development, voter turnout declined in post-socialist states, while societal modernisation theory predicted that it would increase.

The socioeconomic status theory draws directly from the classical Columbia School of voting behaviour. It includes several approaches that explain voter turnout using individual citizens' economic and social characteristics. The most commonly used indicators are education, income, type of employment, unemployment, gender, or age of the person. The aim is to determine what socioeconomic characteristics of individuals influence their decision to go to votes. According to this theory, individuals with higher socioeconomic status are more likely to participate in elections because they have more resources (money, skills, or information) that reduce the cost of voting and allow them to gain more significant gains from the voting results (Wolfinger & Rosenstone, 1980). A criticism of the socioeconomic status theory is that socioeconomic characteristics do not tell us much about the motivation to vote and are often only indicators of other factors influencing voting behaviour.

Mobilisation theory assumes that the decision to vote or not to vote is not only based on citizens' values and attitudes but also strongly influenced by their surroundings. The theory assumes that voters are politically mobilised. Rosenstone and Hansen (2009) refer to political mobilisation as the process by which candidates, political parties, activists, and non-political organisations, such as churches, trade unions or special interest

groups, persuade citizens to vote. They distinguish between two types of mobilisations, namely, direct, and indirect. Rosenstone and Hansen (2009) consider direct mobilisation cases in which a political party or candidates approach a potential voter. Methods of such mobilisation include pre-election rallies, media campaigns, and contacting voters by telephone, mail or electronically. In the case of indirect mobilisation, a person is influenced by people in their neighbourhood. They may be mobilised by their friends, work colleagues, neighbours, and religious community members. The ethnic homogeneity of the community may also play a significant role. Linek (2015) also documented examples showing that the probability that a citizen will participate is significantly increased if an immediate family member has participated in an election. In addition, Knack (1992) notes that in certain areas, there is strong social control and pressure on residents to participate in elections due to the structure and stability of the settlement. Failure to participate can lead to the social exclusion of the resident from the community. The phenomenon of social control is particularly typical for small rural communities (Kostecký & Krivý, 2015).

The theory of habitual voting assumes that a voter who has participated in past elections is more likely to participate in future elections. Although the first ideas about voter turnout as a habit appeared in the work of Michigan School authors, the issue began to receive more attention after the publication of the study by Green and Shachar (2000). The theory posits that voting in elections contains an element of habit. Over time, a citizen develops a habit of being or not being part of the electoral process. The longer they participate or do not participate in voting, the more the habit is reinforced. Therefore, an important explanatory variable for turnout is participation in previous elections. According to Denny and Doyle (2009), citizens participate in elections regardless of whether they have a positive view of voting or think voting is the right thing to do. All that matters is that voters have built the habit of participating in elections in their minds. Within the post-socialist states, this can be seen in the high voter turnout of the older population, which built up the habit of going to vote during the socialist period when it was compulsory and retains this habit even today (Linek, 2013). Kostecký and Krivý (2015) note that higher voter turnout in parliamentary elections in small municipalities may be due to higher turnout in municipal elections. Thus, citizens develop a habit of participating in any election. The weakness of this theory is that it fails to explain why first-time voters participate in elections since they have not formed the habit of going to vote.

Moreover, many of these theories can also be connected to the geography of discontent and to 'left behind places' – concepts of timely relevance in social, political, and geographical research (Rodríguez-Pose, 2018; Pike et al., 2023). In simple terms, places that are objectively or subjectively associated with being left behind (supposedly by corrupt elites, metropolitan economic powerhouses, etc.) are often connected to feelings of discontent, neglect, and political disengagement (Pike et al., 2023). These perceived experiences, along with various feelings of political resentment, may result in voters turning away from voting in certain areas (Bucci, 2017), or possibly inclining to vote for radical populist parties (Rodríguez-Pose, 2018). However, who votes (or does not vote) is not the same everywhere, and such 'pools of nonvoters', potentially available to populism, are not evenly spread across space (Agnew & Shin, 2017).

Finally, to discuss the explanatory power of the above theories of voter turnout in the conditions of Slovak society, three hypotheses were formulated, which, considered together, will allow the testing of the explanatory power of these theories and, at the same time, identify the main factors underlying geographical differences in voter turnout. It is clear from the discussion that these theories do not represent mutually exclusive sets of propositions but overlap in parts and, in some cases, rely on the same or similar indicators

while interpreting their meaning differently. Therefore, the validity of each theory cannot be confirmed or refuted; we can only assess their relative contribution to explaining the relationship between the level of electoral participation and the social, economic, cultural, and other characteristics of the municipalities of Slovakia, which we express using empirical indicators. The hypotheses were formulated in such a way as to allow the best possible assessment of the theories' explanatory power and, at the same time to allow them to be tested using empirical indicators at the municipality level. The hypotheses are labelled H1 to H3.

H1: Voter turnout is higher in municipalities with a higher share of the population with a university education, a lower share of people working in the primary sector and a low unemployed population.

If this hypothesis proves valid, the societal modernisation and socioeconomic status theories would be relevant for explaining geographic differences in turnout. The theory of disenchanting voting would be more appropriate for negative results for this hypothesis, as it predicts the opposite results to the previous two theories. The variables chosen to test the hypothesis are related to the degree of modernisation of society, which all three of the above theories work with. In doing so, the relationship between the theories is not ambivalent, and the validity of one does not preclude the validity of the other.

H2: Voter turnout is higher in municipalities with smaller populations, with a share of the population belonging to the Roman Catholic Church and a higher share of the population of Slovak nationality.

The hypothesis aims to test whether there is a more indirect mobilisation effect in Slovakia, conditioned by a higher representation of members of a religious community, national homogeneity, or social control in municipalities with a small number of inhabitants.

H3: Voter turnout is higher in municipalities with a higher proportion of residents of post-working age.

This hypothesis tests the habitual voting theory, assuming that older people have developed the habit of voting from the socialist period and thus participate in elections regularly, regardless of other factors. However, age structure is also related to other factors, such as economic development, urbanisation rate or migration balance. When interpreting the relationship between turnout and age, these factors' influence must also be considered.

3. Electoral turnout in Slovakia

Ten parliamentary elections have been held in Slovakia since 1989. The highest turnout was achieved in the very first democratic elections after the fall of the communist regime, held in 1990 (see Fig. 1). The turnout in these elections was above 95%, and no district had a turnout below 90%. In the next elections in 1992, turnout dropped by ten percentage points and continued to fall, except for the 1998 elections, which were specific to Slovakia (Krivý, 1999), until it reached an all-time low (54.7%) in the 2006 elections. In some districts, not even half of the eligible voters participated in these elections. In 2010, 2012 and 2016 elections, voter turnout stabilised below 60%. Almost two-thirds of all eligible voters took part in the 2022 elections.

The level of inter-regional disparities followed the opposite trend compared to the evolution of voter turnout. Figure 1 shows the evolution of the coefficient of variation, which reflects the overall level of differences between districts (it was calculated for a set of 79 districts of Slovakia, formed in 1996). The evolution of regional variability can be interpreted as a gradual widening of regional differences in voter turnout, from the lowest level in 1990 to the highest level in 2020. This trend was significantly interrupted in 1998 when the anti-Mečiar coalition succeeded in mobilising voters even in districts with lower turnout.

The increase in regional variability is confirmed by the evolution of differences in regions shown in Figure 2. Except for the 1998 elections, there is a clear trend of gradual differentiation, i.e. a moving away of most regions from the Slovak average. On the one hand, there is the group of Bratislava, Žilina and Trenčín regions with above average and relatively increasing participation. On the other hand, there is the group of Nitra, Banská Bystrica and Prešov regions with below average and relatively decreasing participation. The biggest 'outsider', i.e. the region furthest from all the others in terms of turnout, is the Košice region, with an extremely low turnout. While the difference between the Bratislava and Košice regions was zero in 1998, by 2010, it had risen to 15 percentage points; in 2016, it was as high as 23 percentage points. On the contrary, the Trnava region has long been the most typical within Slovakia, with a value remarkably close to the national average. The most notable change has been

in the Bratislava region, which had the lowest voter turnout in the 1990s but substantially increased after 2000 and had the highest turnout in the 2010, 2016 and 2020 elections.

4. Data and methodology

Voter turnout in the 2020 parliamentary elections was analysed. The territorial units used for the analysis were municipalities. In addition, Bratislava and Košice were divided into urban districts to increase the weight of population-sized districts in the analysis. The military district of Valaškovce was omitted from the analyses because no one has a permanent residence in its territory. Thus, we worked with a total of 2,926 administrative units which represents the finest administrative available level for which the selected independent variables are available.

4.1 Data

Data on voter turnout at the municipality level were obtained from the Statistical Office of the Slovak Republic (2023b). The independent variables were then chosen to relate to those aspects of the social structure and location of municipalities with which the theories mentioned above of turnout work. Two methods were used to avoid the multicollinearity of the independent variables. First, variables with high pairwise correlations with any of the other independent variables were excluded by correlation analysis. Subsequently, the multicollinearity test verified that none of the independent variables had a tolerance value less than 0.5 or a variance inflation factor (VIF) value greater than 2.

A total of seven independent variables were selected (Tab. 1). The share of the unemployed population (Unemployment), share of people working in the primary sector (Agricultural workers) and the share of the population with a university education (Tertiary Education) were selected to test the validity of the socioeconomic status theory, societal modernisation theory and theory of disenfranchised voting. To test the predictive power of the mobilisation theory, the variables of the religious and national status of the population were included, namely the share of the population belonging to the Roman Catholic Church (Catholics) and the share of the population of Slovak nationality (Slovaks). Also, logarithmically transformed municipality population sizes (Municipality size) were chosen as an indicator of the mobilisation theory. The proportion of residents of post-working age (Retirees) was chosen as an indicator relevant to the verification of the habitual voting theory. The data source on the social structure was the 2021 Population and Housing Census (Statistical Office of the Slovak Republic, 2023a). All variables entering the final models were standardised.

4.2 Methods

To examine associations between selected variables and voter turnout, we first calibrated an ordinary least square (OLS) regression model. In simple terms, OLS regression analysis represents a 'traditional' linear model which finds the best fit between analysed covariates via the minimised sum of squared prediction errors. This method proves to be very helpful not only

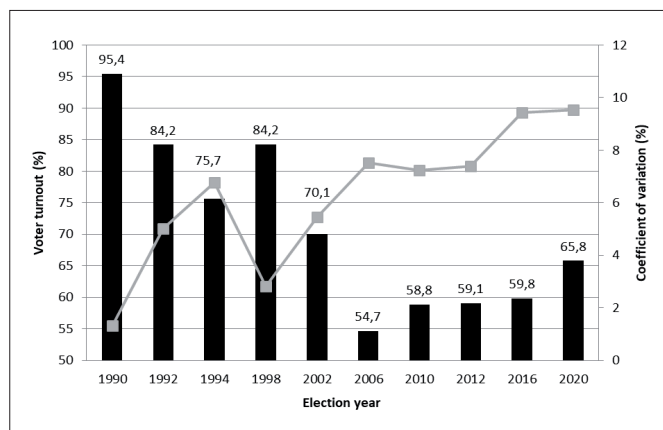


Fig. 1: Development of voter turnout in parliamentary elections in Slovakia (columns, left axis) and the coefficient of variation of voter turnout in districts (curve, right axis)
Sources: authors' elaboration according to the Statistical Office of the Slovak Republic (2023b)

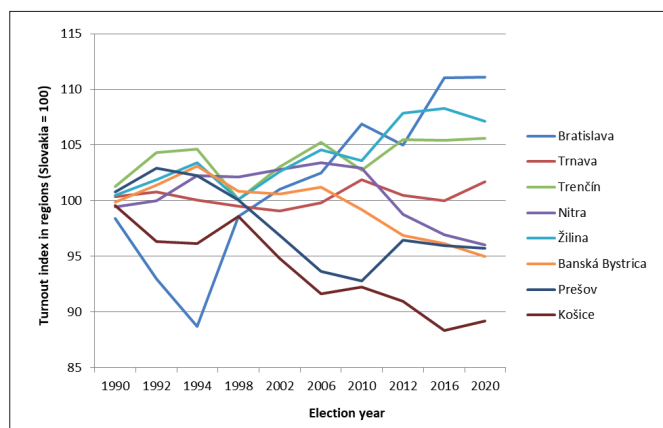


Fig. 2: Turnout index in regions in relation to the national average
Sources: authors' elaboration according to the Statistical Office of the Slovak Republic (2023b)

Name of variable	Description	Data source
Municipality size	Logarithmically transformed municipality population size	2021 Population and Housing Census
Retirees	The proportion of residents of post-working age	2021 Population and Housing Census
Slovaks	The share of the population of the Slovak nationality	2021 Population and Housing Census
Tertiary education	The share of the population with a university education	2021 Population and Housing Census
Catholics	The share of the population belonging to the Roman Catholic Church	2021 Population and Housing Census
Unemployment	The share of the unemployed population	2021 Population and Housing Census
Agricultural workers	The share of people working in the primary sector	2021 Population and Housing Census

Tab. 1: Variables used to explain voter turnout
Sources: authors' calculations

due to its versatility and capability to make predictions, but also by providing crucial insights into relations between variables. Exploring mutual relationships of attributes in aggregate units by utilising the OLS analysis proved to be vital in a large number of studies analysing voter turnout (e.g. Kostadinova, 2003; Kerwin Kofi & Stephens Jr., 2013; Kevický & Daněk, 2020). However, the OLS analysis, like other global regression models, can provide only for results that represent average coefficient values for the whole unit of analysis. Assuming that each identified relationship is constant across the country is very limiting as the strength, scale, and even direction of covariates determining voter behaviour might substantially vary across spaces and places (Fotheringham et al., 2021). As such, conventional regressions (e.g. OLS or spatial error) can suitably act as a baseline for the local model results, but most attention should be placed on calibrating MGWR models, which superseded global and standard GWR models alike (Fotheringham, 2023).

The deficiency of OLS models can commonly be manifested through significant spatial clustering of its residuals estimated by spatial autocorrelation methods. The overall degree of clustering is dependent on the weighting matrix¹ and can be quantified by the global Moran's I coefficient. Moran's I takes on values from -1 to 1 which indicate whether positive or negative type of global clustering takes place (Cliff & Ord, 1981). Moreover, the local indicator of spatial association (LISA, see Anselin, 1995) analysis is used to verify the potential existence of spatial non-stationarity, as in such cases the usage of global models is generally inadequate (Suchánek & Hasman, 2022). Consequently, the LISA analysis can precisely detect various cases of spatial variation, i.e. clusters (hot and cold spots) and outliers, which then can be visualised for easy-to-understand mapping outcomes (see also Suchánek & Hasman, 2023).

Finally, we employ the multiscale geographically weighted regression (MGWR) analysis to fittingly compensate for the common shortcomings of traditional global regression models. MGWR represents a cutting-edge spatial regression technique which utilises geographical proximity to explore spatially varying relationships between variables (Zhou, 2022). Like conventional

geographically weighted regression methods, MGWR models utilise geographical weighting to generate location-specific regression coefficients. The resulting coefficients are based on proximity between centroids of each unit where the mutual influence of each unit gradually decays with distance (Fotheringham et al., 2017). The coefficients which surpass the adjusted t-value threshold (95%) can also be mapped for a visual overview of MGWR outcomes. But most importantly, MGWR also considers the possibility that the studied relationships may vary at different spatial scales, i.e. local, regional, and global. This is possible due to MGWR allowing bandwidths to be optimised to individual covariates entering the model (for more details, see Fotheringham et al., 2017; Li & Fotheringham, 2020; Fotheringham & Sachdeva, 2022). Therefore, the added value of MGWR models in our research is twofold. First, MGWR indicates the potential existence of spatial variance of variables' effect on electoral behaviour. Secondly, by relaxing the assumption that all processes operate at the same scale, we can further investigate various spatial mechanisms that ultimately affect these differences (see also Cupido et al., 2021).

5. Results

Before we move onto the description of regression results, we first run the LISA analysis to develop a comprehensive overview of spatial variation of voter turnout across the country. This helps the reader to understand which regions or specific locations vote the most or least before subsequent analyses that aim to understand what attributes and processes contribute to these spatial differences. Afterwards, we inspect the OLS model analysis results which we then compare with the MGWR model. This allows us to demonstrate clear improvements and benefits of the latter.

As shown in Figure 3, there is a strong spatial variation in voter turnout across Slovakia, with significant clustering occurring in many parts of the country. The considerable level of systematic spatial clustering is also indicated by a very high Moran's I value (0.409). Clusters of high voter turnout stretch from the capital Bratislava northeastwards to the Tatra Mountains. In contrast, clusters of low turnout are situated mainly in the southern and eastern parts of Slovakia.

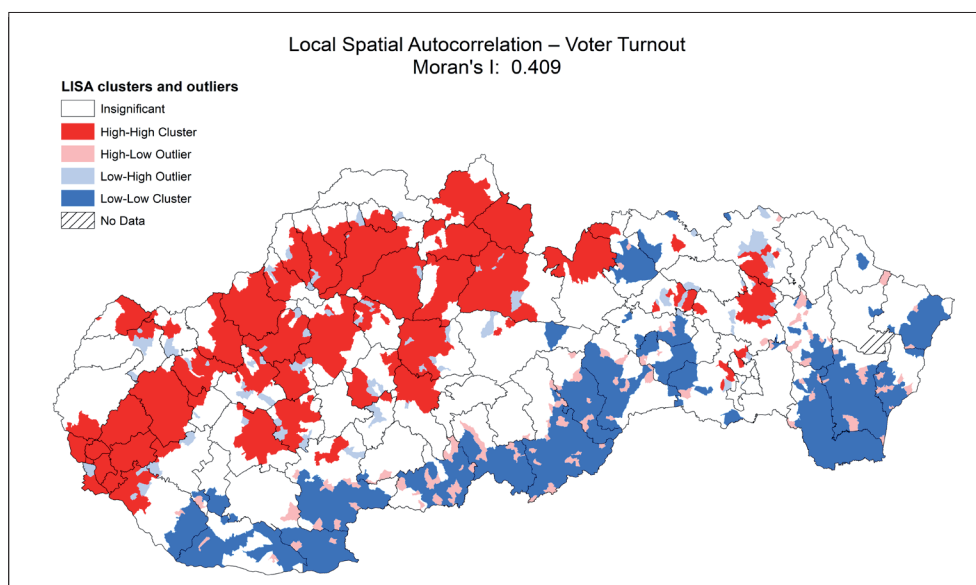


Fig. 3: Local Spatial Autocorrelation of Voter Turnout in Slovak Municipalities in 2020. Sources: authors' elaboration

¹ In our study, the weighting matrix of 8751.2911 metres for spatial autocorrelation methods was calculated using the Euclidean distance method in ArcMap 10.7. This value represents the minimum distance for each unit to have at least one neighbour. Other several weighting matrices were also tested (the 10 km distance or the queen-based contiguity weight matrix) which ultimately led to very similar results. For the MGWR model, we utilised a conventional Gaussian model and the adaptive bi-square kernel type weighting, which is the default setup in the MGWR 2.2 software.

5.1 Global regression model results

To further investigate what lies behind these previously identified distinctions of voter turnout, we first evaluate results stemming from the OLS model (Tab. 2). First and foremost, it is important to note that in this case, it is not necessary to rely on statistical significance as we are assessing a dataset that represents the whole population. Thus, we are not essentially drawing inferences, but rather exploring actual and verifiable differences. This is, however, not the case for the MGWR analysis, where an inferential modelling approach remains relevant due to the use of spatial weighting and individual assessments of each unit where their uneven absolute size is considered (see Jones et al., 2015). Regardless, the only variable in the model that did not yield statistical significance is the one pertaining to the share of agricultural workers.

In the global model, the share of the tertiary-educated individuals exerts by far the strongest positive effect (0.523) on voter turnout. This implies that higher levels of tertiary education in municipalities are associated with higher electoral turnout on average. Additionally, several other variables also exhibit relatively strong levels of influence on voting. The share

of Catholics reports a positive regression coefficient value (0.211) as well, while the municipality sizes (− 0.278) and the level of unemployment (− 0.224) have negative effects on voter turnout. This suggests that, generally, larger municipalities (in terms of population) and higher unemployment rates are related to lower voter participation. Another noteworthy relationship in

Voter turnout	Std. Coefficient	Std. Error	p-value
Intercept	0.000	0.012	1.000
Municipality size	− 0.278	0.015	< 0.001
Retirees	0.069	0.014	< 0.001
Slovaks	0.130	0.013	< 0.001
Tertiary education	0.523	0.015	< 0.001
Catholics	0.211	0.014	< 0.001
Unemployment	− 0.224	0.017	< 0.001
Agricultural workers	0.019	0.014	0.174
N	2,926		
AICc	5,879.7		
Adj. R ²	0.565		

Tab. 2: Global regression model (OLS)
Sources: authors' calculations

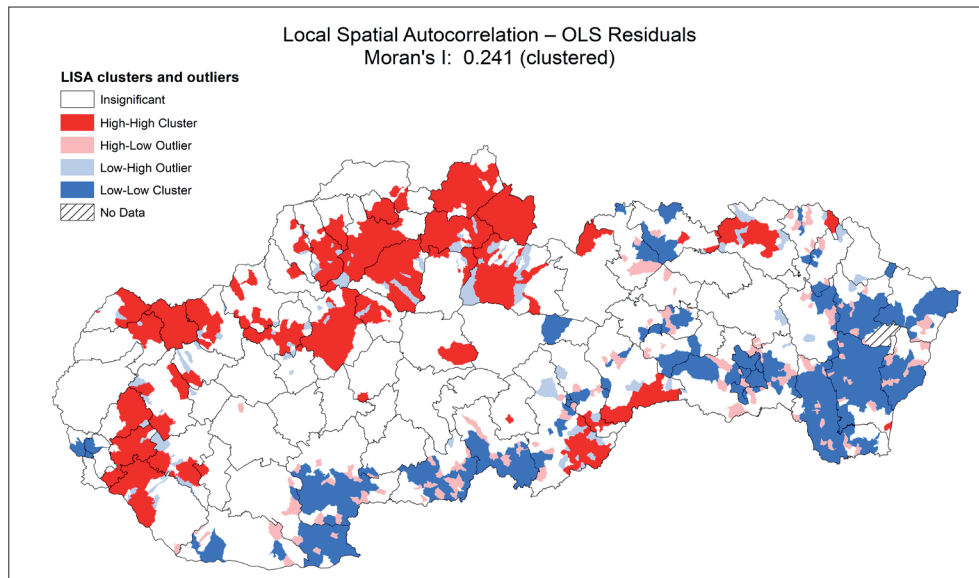


Fig. 4: Local Spatial Autocorrelation of OLS residuals (municipality-level)
Sources: authors' elaboration

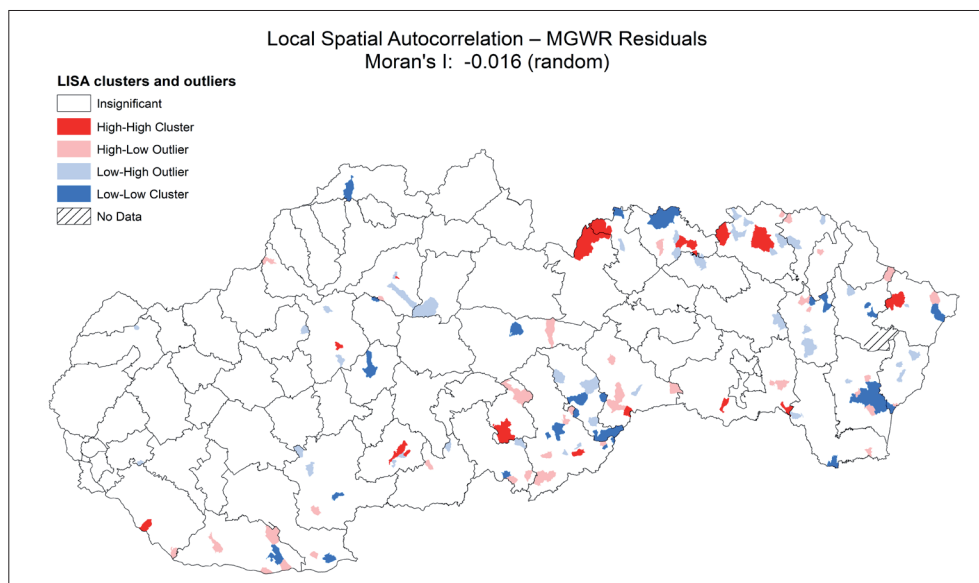


Fig. 5: Local Spatial Autocorrelation of MGWR residuals (municipality-level)
Sources: authors' elaboration

the model is between the voter turnout and the share of native population (Slovaks) with a coefficient of 0.130. Surprisingly, the effect of the share of retirees is rather weak (0.069), while the influence of agricultural workers is virtually negligible (0.019). Furthermore, considering the vast number of units (2,926) included in the regression, the adjusted R-squared (R^2) value of 0.565 is relatively high.

As mentioned in the previous section, a common limitation of OLS models lies in the significant residual clustering in space, as indicated by spatial autocorrelation methods. By employing the LISA analysis, we do indeed confirm a significant systematic clustering of residuals which signals the existence of spatial non-stationarity of studied relationships (Fig. 4). In other words, we identify many regions in Slovakia where neither high nor low voter turnout is satisfactorily explained by the global model, indicating that the utilisation of MGWR is desirable. Before we evaluate the MGWR results and mapping outcomes, we likewise conduct a LISA analysis on MGWR residuals to appropriately juxtapose the evident advancements of the MGWR model (Fig. 5). Moran's I values are also included in the figures.

5.2 MGWR model results

As demonstrated by the lack of MGWR residual clustering in the LISA analysis (Fig. 5), MGWR generates a more suitable model for both exploring and explaining electoral turnout in Slovak municipalities. These improvements are also reflected in the lower value of the corrected Akaike Information Criterion (AICc) and considerably higher adjusted R^2 value (Tab. 3). Moreover, the resulting coefficients are computed separately for each municipality, which allows us to develop custom maps with a uniform scale of regression strength and direction for more detailed evaluations (Fig. 6). All studied relationships also have their own assigned bandwidth (included in the mapping outcomes), which indicates the spatial scale upon which each process operates.

Starting with the municipality size variable (Fig. 6A), we recognise a uniform and relatively moderate negative effect on voter turnout across the entire country. This implies that smaller municipalities tend to have higher voter turnout regardless of their geographical location. This is consistent with the previous findings of the global OLS model. The bandwidth value is rather high, suggesting that this process potentially operates at a scale between regional and global. This is also reflected in the resulting map, as there are no statistically nonsignificant values in any municipalities, although the effect appears to be slightly weaker in the northwestern parts of Slovakia.

Similar to the global model, the relationship between the share of retirees (Fig. 6B) and voter turnout is quite surprising. Apart from one very small 'island' of significant negative coefficients, there are several regions which report a positive effect, primarily located in southern parts of the country with one region in the north. The bandwidth value indicates a somewhat local scale;

however, in most parts of the country, the outcomes are statistically insignificant. This overall finding is unexpected and deviates from what was initially anticipated.

The share of Slovaks (Fig. 6C) exhibits a low bandwidth value and produces intriguing outcomes. First, there is a clear spatial variability in the observed relationship, with a large portion of the northern and 'middle' areas of the country showing a strong positive effect. Additionally, there are other smaller territories across Slovakia reporting both positive and negative effects with varying coefficient strengths. This is both compelling and puzzling at the same time. Upon examining the spatial distribution of ethnic minorities (i.e. Hungarians, Roma) in Slovakia, we find that areas that display predominantly nonsignificant estimates generally have a higher share of minorities, and vice versa. Based on this, we incline to the interpretation that regions with a higher share of Slovaks tend to have higher voter turnout, despite some perplexing outcomes.

The share of tertiary education (Fig. 6D) also yields intriguing results. Given the lowest generated bandwidth among the covariates, MGWR allows us to map out numerous spatial 'nuances' across the country. While tertiary education had by far the strongest positive effect on voter turnout in the global model (mean and median MGWR coefficients were also the strongest), we can clearly demonstrate that this effect is not borne out on a national level. In other words, there are many regions where voter turnout did not significantly rely on tertiary education, alongside areas that were greatly affected by this pivotal attribute. Conversely, the share of Catholics (Fig. 6E) is easier to comprehend. As previously anticipated, the effect is fairly concise – with a consistent direction and strength, which is moderately positive, and almost nationalised. The bandwidth value then suggests a regional scale.

Along with the covariate of municipality sizes, the share of unemployment (Fig. 6F) was the only other variable which presumed a negative impact on voter turnout in the global model. In this case, the MGWR model does not add much value to the evaluation, as the effect remains virtually the same. The semi-global bandwidth does not leave much room for geographical variations, and the strength of the coefficients is effectively homogenous at the given scale.

Upon examining the regression coefficients obtained from the share of agricultural workers, we concluded that it is unnecessary to include the map in this paper. Both models suggest no noticeable effect of agricultural workers on electoral turnout. The minimum (0.007) and maximum (0.030) local estimates are essentially non-existent, and the vast majority of these coefficients resulted as nonsignificant, also rendering the bandwidth value practically global in scale (2,765).

Finally, due to each municipality having its own adjusted local R^2 value (Fig. 6G), it is evident that the explanation of variability through the selected independent variables is not spatially

Voter turnout	Mean	S.D.	Min.	Median	Max.
Intercept	- 0.148	0.200	- 0.620	- 0.121	0.214
Municipality size	- 0.283	0.055	- 0.353	- 0.295	- 0.177
Retirees	0.073	0.124	- 0.261	0.060	0.369
Slovaks	0.344	0.399	- 0.369	0.238	1.475
Tertiary education	0.492	0.247	- 0.382	0.468	1.291
Catholics	0.139	0.044	0.045	0.134	0.273
Unemployment	- 0.171	0.040	- 0.247	- 0.173	- 0.093
Agricultural workers	0.018	0.009	0.007	0.014	0.030
N	2,926				
AICc	4,695.5				
Adj. R^2	0.743				

Tab. 3: Multiscale geographically weighted regression model (MGWR)
Sources: authors' calculations

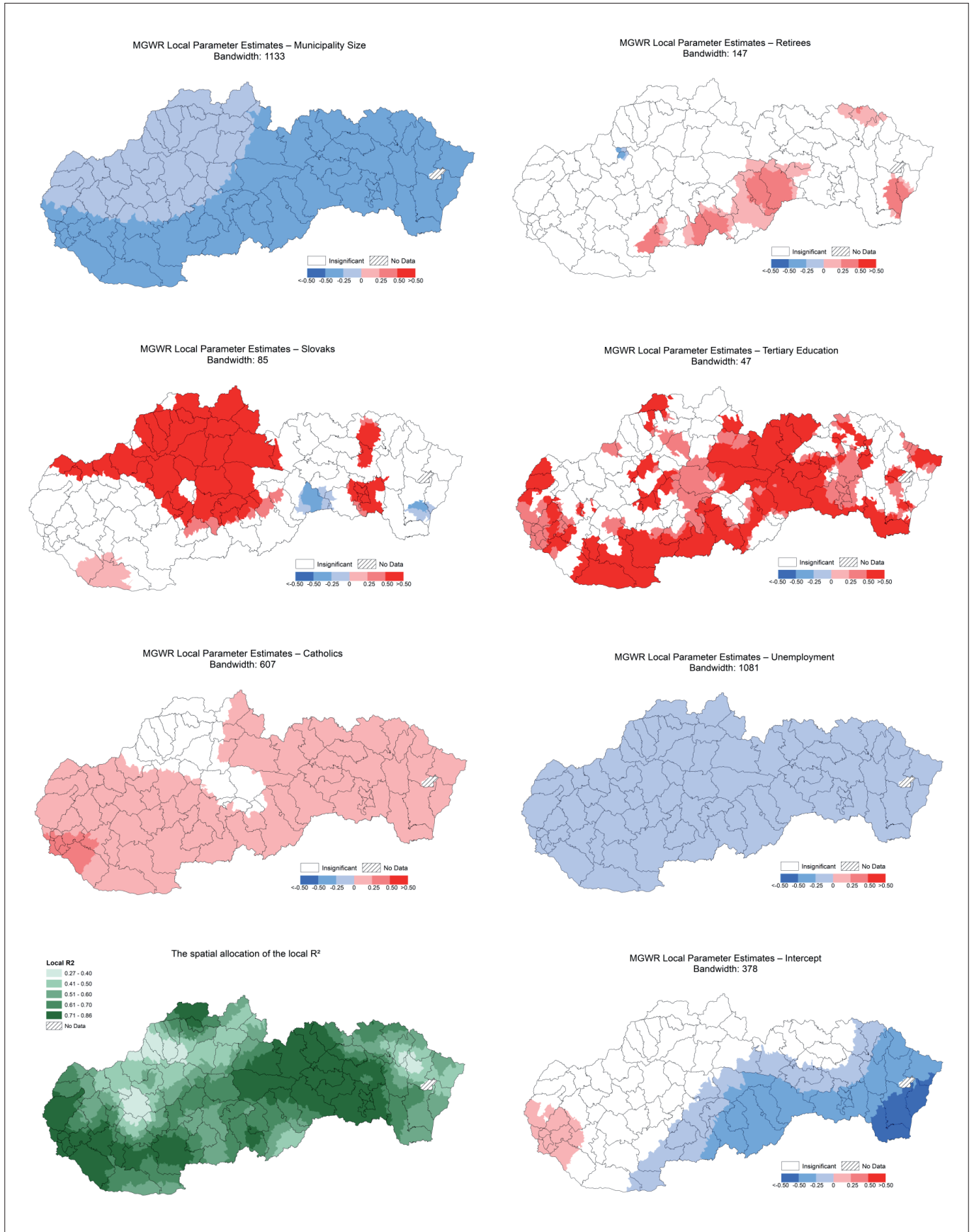


Fig. 6: MGWR Local Parameter Estimates
Sources: authors' elaboration

consistent. This is, however, to be expected in all local regression modelling to varying degrees (see Shi et al., 2021). Moreover, MGWR also estimates local intercept values which may be the most interesting MGWR output as they essentially measure the effect of the spatial context per se (Fotheringham et al., 2021). This is because the MGWR model provides local intercept values as if all analysed covariates were rendered constant. In our study, local intercept estimates reveal how voter turnout in each municipality would differ as a result of the ‘unmeasurable effects of place’ (Fotheringham et al., 2021). Specifically, the MGWR model assumes that substantial portions of eastern and southern parts of Slovakia have significantly lower voter turnout, while the very western part of Slovakia has a higher electoral turnout (Fig. 6H).

With this being said, logically there are a number of questions that arise: What variables were perhaps excluded from the analysis? In what ways are different regions specific? What subsequent analyses can be conducted to further investigate the identified spatial patterns?

6. Discussion

Before discussing our results below, is important to note that the main goal of most studies in quantitative geography is not to achieve flawless research (which is often impossible, especially when dealing with social science data), but rather to maximise knowledge on spatial processes while minimising errors (Fotheringham et al., 2000). Spatial regression modelling can provide both intriguing and ‘expected’ results along with somewhat confusing ones (Suchánek & Hasman, 2022). In addition, by evaluating outcomes stemming from extensive spatial analyses applied on aggregate data, the ecological fallacy must be considered (Spurná, 2008). In this study, however, the added value of the local model when compared to the global model is clearly demonstrated. MGWR proves to be a much better fit, is able to estimate regression coefficients locally, and points to spatial scales upon which different processes operate by utilising unique bandwidths for each covariate.

The first hypothesis (H1) tested the validity of societal modernisation theory, socioeconomic status theory, and theory of disenchanting voting. It relied on education, working in the primary sector and unemployment indicators. The analysis of empirical data showed that a higher proportion of the tertiary educated positively influenced voter turnout. It was also true in the elections studied that voter turnout was higher in municipalities with lower unemployment rates. In contrast, both models suggest no noticeable effect of agricultural workers on electoral turnout.

Consistent with societal modernisation theory, higher voter turnout is found in more economically developed regions, such as Bratislava and its surroundings (Fig. 6H). Comparing these findings with the results of Kostecký (2001), who examined voter turnout in the 1990s, we see a transformation of metropolitan regions from areas with high non-participation to areas with high participation. In the 1990s, when turnout was lower in regions with higher average wages, the theory of disenchanting voting could explain its regional variability. The transformation of the turnout map, together with the transformation of the factors that explain this map, thus convincingly supports the view of Nový (2013). He argues that there has been a change in the explanation of turnout contingency in post-socialist countries because in the 1990s the theory of disenchanting voting had more explanatory power, but that recent elections increasingly confirm the validity of societal modernisation theory.

A fact that limits the explanatory power of societal modernisation theory in interpreting the map of electoral participation in Slovakia is the low turnout in Slovakia's second-largest city, Košice. It is significantly lower than the theory suggests would correspond to

a centre of its size and importance. The delayed transition from the model of the theory of disenchanting voting to the societal modernisation theory model can partly explain the low turnout in Košice. However, a role may also be played by the capital city effect, which encourages an increase in participation in Bratislava more than corresponds to its educational and employed structure, as well as the effect of simple geographical distance, which may lead some voters in the east of Slovakia to believe that the parliament is too far away and the possibility of influencing its decisions too low to make it worthwhile to go to the elections.

The second hypothesis (H2) tested the validity of the mobilisation theory, precisely the question of whether belonging to a particular perceived community, formed based on religion, ethnic homogeneity, or locality, can mobilise for electoral participation. The results confirmed a higher voter turnout in generally smaller municipalities, consistent with citizens mobilising for social control within the municipality, as hypothesised by Knack (1992). The regression models also showed high turnout in municipalities with more people professing the Roman Catholic faith. Last but not least, turnout was shown to be high in municipalities with a higher proportion of Slovaks, which is entirely in line with mobilisation theory. However, it is questionable how much of an impact this has on low voter turnout in municipalities with a higher representation of the Hungarian and Roma minorities, as previous research has shown (Kevický, 2020b; Kevický & Daněk, 2020). Thus, the higher turnout in municipalities with a higher representation of Slovaks may reflect less interest in elections among national minorities.

The third hypothesis (H3) tested the validity of the theory of habitual voting. It hypothesised that retirees are accustomed to voting due to habitual voting from the socialist era (Linek, 2013). Regression models did not conclusively confirm the positive effect of the proportion of retirees in a municipality on voter turnout. However, the validity of the theory of habitual voting in Slovakia is supported by the increased voter turnout in the smallest municipalities. At the same time, however, it should be remembered that the age structure also reflects the influence of other factors, such as educational structure, geographical location or the size of the municipality, and the relationship between voter participation and age is therefore not independent of other conditioning factors. In this sense, the empirical verification of all the hypotheses mentioned above must be considered mediated and conditioned by factors other than those supporting the hypothesis.

Lastly, with regard to the geography of discontent and ‘left behind places’ concepts, we posit that regions with thriving socioeconomic and demographic attributes and places close to prosperous core areas are reporting higher electoral turnout that their peripheral counterparts. Therefore, our outcomes are generally in line with the anticipated theoretical expectations of ‘left behind places’ or the geography of discontent (e.g. Rodríguez-Pose, 2018; Dijkstra et al., 2020; Pike et al., 2023). But this might not always be very obvious. For example, the city of Košice, the second largest city in Slovakia, is reporting a lower electoral turnout than the local regression model would suggest (Fig. 6H). Once an important industrial city, Košice is now experiencing long-term economic stagnation along with some unfortunate ethnic “clashes” inside the city, and to an extent suffers from a geographical isolation from other cores as well (Kerekes, 2018). Arguably, despite Košice being relatively well-off in the region, many voters might feel some sort of discontent or political resentment and therefore be discouraged from participating in elections. However, the nature of our analysis cannot adequately either confirm or reject this hypothetical assumption.

Needless to say, many of the above theoretical concepts are mutually interconnected and relate to each other to varying degrees; therefore, some of the ‘left-behindedness’ was already anticipated through associated theoretical perspectives (i.e.

societal modernisation theory, socioeconomic status theory, and theory of disenfranchised voting). It should be noted, however, that the theories analysed are not all-encompassing. As mentioned in the second section, we did not work with theories based on individual data because of the data and method used. Hence, some outliers could be explained by these theories and the qualitative research methods. Nevertheless, to put it simply, that was not the purpose of this study as we utilise methods whose aim is also exploratory in terms of examining broader findings.

7. Conclusion

Our study offers several contributions to the nascent literature about the geographical aspects of voter turnout. First, we test the validity of several theories explaining the uneven distribution of voter turnout in the case of Slovak parliamentary elections. We confirm that using advanced spatial statistical methods brings about substantial enhancements to traditional regression modelling. However, we realise that MGWR, despite being superior to the global OLS model in virtually all aspects, is not all-explanatory. As such our model performed better at investigating and explaining turnout in some locations; in others, it performed worse (see also Shi et al., 2021). This could have been caused by various factors common to regression methods such as the MGWR (Suchánek & Hasman, 2022): perhaps some vital variables were omitted from the analysis, or some local mechanisms and processes simply cannot be measured using aggregate data at all. Consequently, these spatial inconsistencies in explaining voter turnout could be analysed in future research not only by employing additional quantitative (both extensive and intensive) analyses but also by utilising qualitative methods situated in specific locations. For instance, individual-level data could be employed to further explore characteristics of electoral behaviour that are elusive when using aggregate units of analysis (e.g. emotional factors). In-depth interviews with representatives in regions with low local R^2 values in our model can also be conducted to potentially provide new insights into the geographical distribution of voter turnout.

Despite these limitations, we were able to find satisfactory answers to all of our set hypotheses. Voter turnout proved to be overall higher in economically and socially prospering localities and regions, such as Bratislava and its neighbouring regions, where the education and economic status of voters is noticeably higher on average – this is in line with societal modernisation theory. Additionally, factors connected to the mobilisation theory also proved to be valuable, as both religious and ethnic identities of voters play a substantial role in electoral turnout. However, in other cases, such as with the share of retirees and potential habitual voting, the outcomes were not overly convincing, and further research is required.

Moreover, although we did not initially establish a separate hypothesis about 'left behind places' and the geography of discontent concepts (see Rodríguez-Pose, 2018; Dijkstra et al., 2020), we are inclined to an overall assumption that they are of vital importance and should be studied in future research. This is especially important as previous studies have predominantly focused on the relationship between 'left-behind places,' geography of discontent, and populist/protest/radical voting (recently, e.g. Suchánek & Hasman, 2023; Urso et al., 2023), but not specifically on abstaining from voting (for a rare exception see Bourdin & Tai, 2022). In our study, we have also identified that territories which can generally be characterised as socioeconomically disadvantaged, peripheral, and in overall decline, report even lower than expected voter turnout (see Fig. 6H). Therefore, the idea of abstaining from voting as a special form of protest vote in 'left-behind places' ought to be studied in more detail and across different contexts. In this regard, future research should also

employ individual-level data because people who abstain from voting may not necessarily be economically struggling themselves, but they may perceive that they live in relative deprivation due to the declining localities they inhabit. Consequently, they may experience a strong sense of discontent, unfairness, and/or resentment (Bourdin & Tai, 2022).

Accordingly, this study could also prove to be of interest to various policymakers. Identifying spatial patterns and investigating fundamental relationships behind voting should provide a solid foundation for those who wish to expand the pool of people participating in the democratic act of voting. Both supporters and opponents of the government and democratic institutions live in territories heavily influenced by decisions proposed and pushed through by said actors, therefore the spatial geographical dimension plays a key role in electoral behaviour (Bourdin & Torre, 2022). Besides, various inequalities between regions, places, and people are closely related to radical and protest voting (e.g. nativist and populist) (see Pike et al., 2023; Rodríguez-Pose et al., 2023). Well-designed policies aimed to reduce such inequalities might prove effective in curbing both. For instance, our research can help policymakers understand where it is important to educate about the importance of democratic elections and what criteria (e.g. level of education; unemployment) are essential for voter participation. It is important to note, however, that the implementation of narrow policy prescriptions based on conventional growth-oriented thinking, which typically favours competitive and dynamic places with high levels of innovation and productivity, needs to be challenged and new complex and alternative approaches that go beyond the limited scope of economic growth, such as addressing issues of belonging and attachment, should be considered (MacKinnon et al., 2022, 40–42).

Lastly, arguably in comparison to other threats liberal and pluralist democracies are facing, and with radical populism and nativism being on the rise, (e.g. Bergmann, 2020; van Leeuwen & Vega, 2021), abstaining from voting might seem rather harmless. Nevertheless, turning away from voting is just one possible outcome of some sort of discontent or political resentment of people living in increasingly polarised societies (Bucci, 2017). It is in our interest to study diverse phenomena related to people's dissatisfaction, whether it is economic, social, or political, regardless of the character of manifestation or perhaps the imagined degree of seriousness. Along with the election of Donald Trump and Brexit (Norris & Inglehart, 2019) in 2016, we have seen many other electoral 'earthquakes' in all parts of the world (e.g. Rybář et al., 2017; Voda & Havlík, 2021). Even if it is virtually impossible to consistently predict such political shocks, it is our task to at least try to understand them.

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