The impact of public transport accessibility on the labour market in Poland – an econometric approach

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Introduction

Previous studies on transport exclusion in Poland have focused mainly on the local level, relying primarily on survey data and interviews conducted among residents. This approach has allowed for an in-depth understanding of the specific problems related to transport accessibility in particular municipalities or regions, but it has had limited scope and has not always allowed for the results to be generalised to the whole country. Nationwide studies that have been conducted so far have focused primarily on analysing transport accessibility and attempting to identify areas at risk of transport exclusion. Nevertheless, despite significant progress in identifying areas at risk of exclusion, there is a lack of comprehensive research analysing the impact of transport exclusion on key socio-economic indicators such as unemployment rates.

This study aims to fill this gap by examining how public transport accessibility affects the labour market in Poland. To this end, geographically weighted regression (GWR) will be used to examine the spatial variability of this relationship and to identify which areas of Poland could benefit most from increased accessibility. The aim of the study is to provide new, relevant insights that can contribute to a better understanding of the problem of transport exclusion and the development of more effective transport policy solutions.

First, a transport accessibility index will be developed for each municipality in Poland, which will serve as a basis for analysing the variation in transport accessibility at the local level. Then, based on this index and other variables, three geographically weighted regression (GWR) models will be constructed. On this basis, two GWR regression models will be constructed. The first will examine the relationship between local accessibility and unemployment in the municipality. The second will take into account the regional context, analysing the relationship between average accessibility in the poviat and unemployment in individual municipalities. This will make it possible to identify whether transport accessibility is important not only at the local level, but also in the context of the wider regional transport system.

Based on the objective of the study, the following research hypotheses were formulated, which refer to the expected results of the three designed regression models:

1. Local models using GWR better describe the examined relationship between transport accessibility and unemployment than local models based on the least squares method (OLS).
2. The relationship between the transport accessibility variable and the unemployment rate is significant and negative.

3. The relationship under study is highly geographically diverse, with transport accessibility being more important in certain areas.
4. The quality of the wider regional transport network is more significant than individual transport accessibility in a municipality.
5. Transport accessibility is more significant in rural areas, while in cities this relationship is weaker.

1. Literature review (skipped here)

2. Methodology and data

2.1. Data

The transport accessibility index was created for each municipality and city at the county level in Poland in order to assess the quality of local public transport. It is intended to be used to examine the relationship between transport accessibility and unemployment at the municipal level in Poland.

The indicator was developed on the basis of data for 2023, mainly from the Local Data Bank. The list of passenger transport operators compiled by the General Inspectorate of Road Traffic and data from the passenger exchange analysis carried out by the Railway Transport Office were also used. Data at the municipal, poviat and provincial levels were used to construct the indicator.

The indicator is composed of several variables (source – Local Data Bank, Polish Statistics):

- Number of bus stops in the municipality per square kilometre (PA)
- Municipal expenditure on transport per capita (WT)
- Number of carriers registered in the voivodeship per 100,000 inhabitants (PZ)
- Transport network density in the voivodeship (GS)
- Rail network density in the poviat (GK)

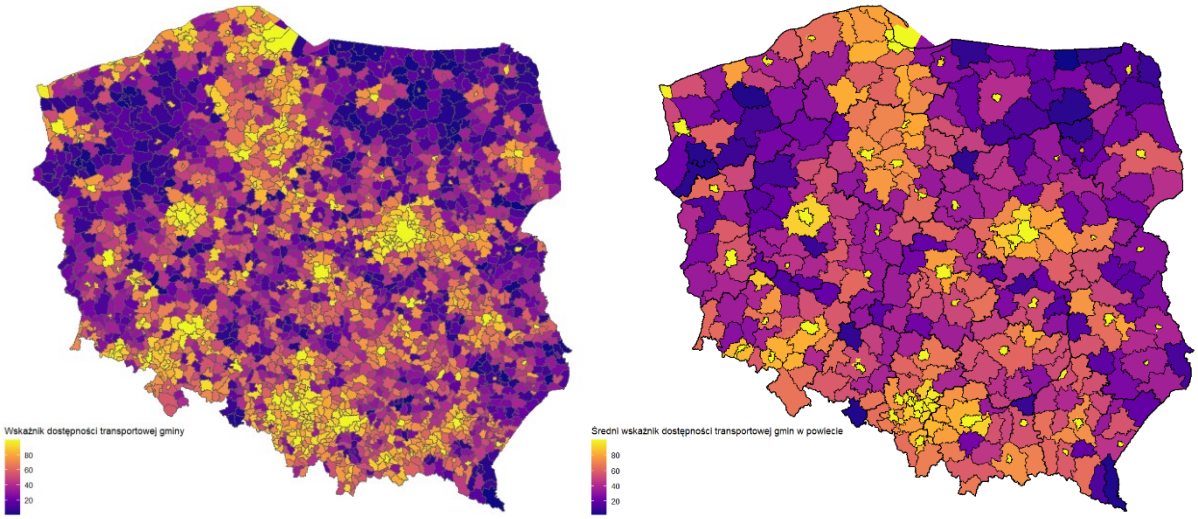
The transport accessibility index was constructed by aggregating the values of the above variables individually for each municipality in Poland. The process of constructing the index consisted of three stages: data collection and preparation, normalisation of variables, and aggregation of variables using appropriate weights. The methods used to develop the index and prepare the data are based on the OECD's recommendations for constructing composite indices (2008).

After aggregating the variables, the index was normalised using percentiles for easier interpretation of the results, in a manner analogous to that previously presented for individual variables. The transport accessibility index also has values from 0 to 100 based on percentiles, where 0 is the municipality with the worst transport links and 100 is the municipality with the best transport links. The corresponding values refer to the percentile in which the variable is

located, i.e. for example, a municipality with an index value of 60 is better connected than 60 percent of municipalities in Poland.

Fig. 1a presents map of transport accessibility index. The highest values of the indicator, marked in yellow, are concentrated around large cities, mainly provincial capitals, and urban agglomerations. Municipalities located slightly further away from the largest metropolises have average values, marked in orange and pink. The lowest values of the indicator, marked in purple, occur in peripheral areas distant from regional centres.

Figure 1. Transport accessibility index: a (left) – municipalities, b (right) – average accessibility in municipalities of a given poviat



Source: own elaboration

Fig. 1b shows a map of the average transport accessibility of municipalities in a given poviat. The analysis of this variable yielded similar conclusions to the analysis of individual municipality accessibility. As before, the voivodeships where the relationship between the accessibility index and the unemployment rate is least visible are Lubusz and Wielkopolska. When comparing the unemployment rate maps with the map of average county accessibility, the discrepancies in the Kujawsko-Pomorskie and Świętokrzyskie voivodeships seem to be slightly smaller than in the case of the previously studied voivodeships.

2.2. Methodology

Econometric methods were used to examine the impact of public transport availability on unemployment levels, using data from the Local Data Bank (Polish Statistics) for 2023 at the level of individual municipalities. The dependent variable in the study is the share of registered unemployed persons in the working-age population in the municipality. The main independent variable on which the analysis focuses is the previously constructed transport accessibility index. A key element of the analysis will be to examine the impact of this variable on the unemployment rate. A negative relationship between accessibility and the unemployment rate

is expected. In addition, control variables, both demographic and economic, as well as a division into types of municipalities (urban, urban-rural, rural) were included in the model in order to avoid the error of omitting important variables. However, these control variables will not be analysed in detail. The selection of these variables was based on the recommendations of the literature examining local unemployment variation in Poland (Ciżkowicz, Kowalczuk, & Rzońca, 2016; Ingham, Ingham, & Herbst, 2011).

Except from the initial model (OLS) this study utilises GWR model introduced by Brunsdon, Fotheringham & Charlton (1996):

$$y_i = \beta_{i0} + \sum_{k=1}^{m} \beta_{ik} x_{ik} + \epsilon_i,$$

Where y_i is the dependent variable in location i; x_{ik} is the k-th independent variable in location i; m is the number of independent variables; β_{i0} is the intercept in location i; β_{ik} is the local regression coefficient for the k-th independent variable in location i; and ϵ_i is the random error in location i.

Two GWR models will be analysed:

1. The first model uses an individual transport accessibility indicator for the municipality.
2. The second model uses a variable that determines the average transport accessibility of the poviat in which the municipality is located.

3. Results

The goodness-of-fit measures presented in Table 1 for both models indicate a significantly better fit of models using GWR regression to the data than global models.

Table 1. Comparison of the fit of local (GWR) and global (OLS) models

	GWR - municipality	OLS - municipality	GWR - poviat	OLS - poviat
R^2	0,7421	0,1703	0,7627	0,1724
R^2_{adj}	0,6347	0,1682	0,6662	0,1704
AIC	8516,107	10856,2	8291,492	10849,67

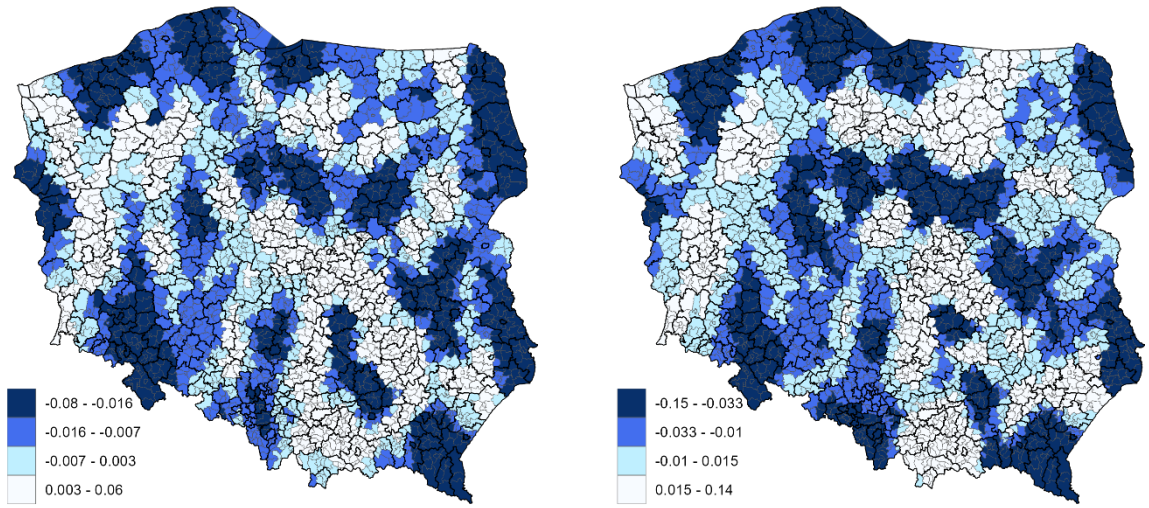
Source: own calculations

The tests proposed in Leung et al. (2000a) were performed on GWR models. The first two tests, F1 and F2, assess in different ways whether the GWR model describes the data better than the global model. In all tests performed, the null hypothesis that there are no significant differences in the fit of the GWR and OLS models to the data was rejected, which clearly indicates that for both models studied, local models describe the relationships between variables much better than their global counterparts.

Another test performed was the F3 test, also from Leung et al. (2000a), in which the null hypothesis means that the regression coefficients for the variables take identical values in all locations. For each variable, the null hypothesis was rejected, indicating spatial heterogeneity across spatial units.

The last test performed was a test for autocorrelation of local model residuals based on Moran's I statistic from Leung et al. (2000b). In this test, the null hypothesis is that there is no autocorrelation of the residuals was not rejected. This means that spatial approach in modelling unemployment performs better than a-spatial.

Figure 2. Local regression coefficient values for the transport accessibility variable for the model with municipality accessibility (left), for the model with average accessibility in the poviat (right)



Source: own calculations

Comparing models 1 and 2 (see Fig. 2), we can conclude that the spatial distribution of the regression coefficient values for the transport accessibility variable shows significant variation in both local models analysed – both for the model with accessibility in the municipality and the model with average accessibility in the poviat. In both models, the median coefficient is negative, which allows us to conclude that for most municipalities, improved transport accessibility is associated with a decrease in the unemployment rate. In the case of the GWR model based on transport accessibility in the municipality (left map), the coefficient values range from -0.08 to 0.06. The areas with the lowest coefficient values, marked in dark blue, are mainly concentrated in the border areas of the Lower Silesian, Silesian, Podkarpackie, Lubelskie, Podlaskie, Warmian-Masurian, Pomeranian and West Pomeranian voivodeships, as well as in the northern part of the Mazowieckie voivodeship and in the Kuyavian-Pomeranian voivodeship.

4. Conclusions

Transport accessibility proved to be a significant variable explaining the level of unemployment, although its impact was not uniform across the country. In most municipalities,

the regression coefficient for accessibility was negative, confirming the expected negative relationship between transport accessibility and unemployment levels. However, this variable was statistically significant only in selected regions, mainly on the peripheries of voivodeships, especially in border regions. This suggests that improving transport accessibility may be particularly effective in reducing unemployment in isolated areas most vulnerable to transport exclusion.

A comparative analysis of models with individual accessibility of the municipality and average accessibility in the poviat showed that regional transport accessibility has a stronger impact on the level of unemployment than local accessibility. The model using average accessibility in the poviat was better fitted to the data and had higher values of the coefficient of determination. These results suggest that not only local transport infrastructure but also the coherence of the transport system at the regional level is crucial for reducing unemployment. Residents often travel outside their municipality in search of work, which is why transport accessibility in a broader regional context plays an important role.

The research confirms that the availability of public transport is a significant factor influencing the level of unemployment in Poland, with this relationship showing considerable spatial variation. The results indicate the need to take into account the regional context of transport accessibility in anti-unemployment policies, especially in peripheral and less developed areas.