Analysis of spatial dependencies and spatial effects in the relationship between economic growth and unemployment in Europe

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Abstract

The study presents an analysis of the relationship between unemployment and economic growth in European countries. The significant influence of the labour market situation on the economic condition of states is well-known. The analysis in this research was conducted using data from 43 selected European countries from 2006 to 2019. To evaluate the relationship between economic growth and the unemployment rate, enriched with spatial dependencies, spatial models for pooled time series and cross-sectional data (TSCS) were estimated. The neighbourhood was quantified using three types of connection matrices: (1) based on the common border criterion, (2) based on the maximum distance criterion, and (3) based on the similarity in economic situations. Matrices (1) and (2) relate to the geographical neighbourhood, while matrix (3) defines the economic neighbourhood based on the values of the consumption expenditures per capita. The choice of these types of matrices was associated with the migration process (geographical neighbourhood) and the imitation effect of labour market strategies (economic neighbourhood) mentioned above. Based on the estimation and verification results of the Spatial Durbin Models (SDM), the spatial spillover effects were evaluated. Cumulative spatial effects allowed us to determine countries with the greatest influence on others and countries that are following the leading ones.

Keywords: economic growth, economic neighbourhood, Spatial Durbin Model, short-term spatial effects, unemployment

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Introduction

Unemployment and insufficient economic growth are among the most important economic problems for every country nowadays. Policymakers and society concurrently monitor both processes as the primary indicators of economic development. Increasing the number of unemployed people concerns both developing and developed economies. However, unemployment in developing countries is primarily the result of capital inadequacy. In turn, technological progress is the reason for the decrease in the number of employed people in developed states (Soylu, Ö.B. *et al.* 2018). Another difference between unemployment in developed and developing countries is that the former experience extended periods of rapid economic growth. In contrast, the poorer ones either have never experienced significant growth or have had periods of economic growth and decline that occurred alternately (Madito, O. and Khumalo, J. 2014).

In theoretical and empirical macroeconomic research, the linkage between economic growth and the unemployment rate is widely studied. This relationship is one of the most important in economics. It is widely accepted that a higher growth rate of the Gross

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Domestic Product (GDP) of an economy causes a decrease in the unemployment rate. The negative short-run dependence between these processes was named Okun's law, which was formulated by Arthur Melvin Okun (Okun, A.M. 1962). Consequently, Okun pointed out that labour market modifications are the results of changes in economic development. The dependent variable in the most common direct regression of Okun's law is the difference between the actual unemployment rate (marked u_{it}) and the natural unemployment rate (or the equilibrium rate of unemployment – marked as u_{it}*). This process is dependent on the difference between actual (y_{it}) and potential or equilibrium output (y_{it}*). The regression parameter between these two processes is marked as β. Index i refers to the region (or another territorial unit), while index t indicates time. Moreover, β is an Okun's coefficient (ultimately with a negative sign). This method of considering Okun's relationship is called the Trial Gaps. Previous studies show that Okun's law is stable in many countries (Ball, L. *et al.* 2017). Instability in the relationship between states is visible in terms of the economic slowdown, resulting, i.e. from the financial crisis (Cazes, S. *et al.* 2011).

Apart from the Trial Gaps method, there are two alternative methods to estimate Okun's coefficient: (i) the First Differences method, and (ii) the Fitted Trend and Elasticity method (Barreto, H. and Howland, F. 1993). In the First Differences method, the form of the model is similar to that in the Trial Gaps method. However, the natural unemployment rate and potential output are replaced by the time lags of the actual unemployment rate (u_{it-1}) and actual output (y_{it-1}), respectively. As a result, the first differences of the unemployment rate and Gross Domestic Product are the dependent and independent variables, respectively. In turn, in the Fitted Trend and Elasticity method, the relationship between the natural logarithms of the unemployment rate (dependent variable) and GDP (independent variable) is considered. Moreover, the model is complemented by the deterministic time trend.

Based on the shown relationship, it is possible to answer what level of GDP should be expected under the economic conditions during the sample period if a certain level of unemployment is given. However, the reversed dependence has to be considered (Barreto, H. and Howland, F. 1993). The inverse relationship in the literature is also called Okun's law. The second approach is closer to economic growth theory, where the labour force is one of the factors that influence the production level. In this research, the economic growth changes as a result of changes in unemployment are speculated.

In general, Okun's law has been formulated for closed economies and refers to regional analyses. Nevertheless, nowadays, when we are dealing with the free movement of the labour force and capital, the law mentioned above can also be used in analyses across countries. As concluded by Palombi, S. *et al.* (2015) "(…) the reliability of Okun's coefficients is not only of paramount importance for macroeconomic policy, but also for the regional distribution of unemployment rates in an open spatial system". Hence, we are able to recognize that the set of territorial units which are open economies creates an open spatial system. In this case, the spatial dependencies between countries in the study of the relationship between unemployment rates and economic growth are also significant. Formánek, T. and Hušek, R. (2016) pointed out that the spatial connections shown during the analysis of the link between labour market conditions and economic growth can also be interpreted as the influence of real, practically unobservable, and difficult-to-quantify spatial effects. Among these effects, they mention cross-border work commuting preferences, accounting for administrative employment barriers between countries, language differences, and aerial distances vs. topology. The importance of including the spatial connections in the analysis of the topic mentioned above across countries can be explained with the *push-pull* concept of territorial mobility as well (Lee, E.S. 1966). Based on this idea, every coun-

try has characteristics that are conducive to taking up employment (for example, higher earnings, higher levels of work culture) as well as determinants that are unfavourable. Hence, labour force migration causes modifications in the national labour market, and at the same time, in the labour market abroad, as well as in the output of other states. Moreover, when the labour force of a country increases (for example, in times of positive economic changes), there can be a problem with providing jobs for all, and as a result, people decide to look for jobs abroad (Maza, A. 2022). Based on all these determinants, the spatial aspect in the analysis of the relationship between unemployment and economic growth is desirable. This paper provides information about the spatial spillovers determined across countries, which constitutes the novelty and research gap.

In this study, the relationship between the unemployment rate and economic growth in 43 selected European economies between 2006 and 2019 is considered. The aim of the research is to designate the consequences for countries' economic growth caused by the modifications in the labour market through changes in the unemployment rate, determining spatial spillover effects. Cumulative spatial effects allowed us to identify countries with the greatest influence on others and countries that are following the leading ones. This analysis allows us to formulate some recommendations for governments in order to use the cooperation between neighbouring countries to improve their own labour market conditions and, as a result, the economic development. Almost all studies analysing economic growth and unemployment in Europe deal with the European Union members only. In this research, it was important to include countries located in Eastern Europe (considered relatively less developed than the EU members) as well. This allows for a wider analysis of the subject of Okun's relationship in Europe. In turn, the period from 2006 to 2019 is the longest available period with complete data for the chosen countries.

In the formation of the crucial economic indicators, such as economic growth and unemployment, long-term tendencies containing the crisis periods are important. In the chosen period, the financial crisis from 2008 and economic slowdown from 2012 are included. Given that countries, especially neighbouring ones, cooperate nowadays, the spatial, and spatio-temporal dependencies in the presented investigation are included. This allows for evaluating the impact of specific changes in a given region on the economic situation in others. Therefore, the spatio-temporal Durbin Model is estimated, based on which the spatial spillovers are determined. The hypotheses of this study are as follows: (1) changes in the labour market in given country have a significant impact on the output of the other, (2) changes in the labour market conditions in more developed countries have a stronger influence on the economic growth in others than in poorer ones, (3) the economic similarity of territorial units is more important than their geographical proximity in the formation of the relationship between economic growth and unemployment.

Review of the scientific literature

In the literature, the relationship between the unemployment rate and economic growth is widely speculated. Almost all researchers consider this dependence based on Okun's law. In previous studies, it is tough to find analyses using Okun's law in the Fitted Trend and Elasticity approach.

The first type of study conducted on the relationship between these processes contains analyses for a single country based on time series. Valadkhani, A. and Smyth, R. (2015) considered this relationship for the US in the period of 1948–2015 using quarterly data. They estimated models for the Trial Gaps method of Okun's law, determining potential output and the natural rate using the Hodrick-Prescott filter (Hodrick, R.J. and Prescott, E.C. 1997). Binet, M.E. and

Facchini, F. (2013) speculated models in the Trial Gap version for French regions in the years 1990–2008. They concluded about regional heterogeneity based on Okun's coefficient estimation. In turn, Li, C.S. and Liu, Z.J. (2012) used a Vector Error Correction Model (VECM) and Granger causality test to investigate the long-term and short-term dependencies between unemployment and economic growth in China from 1978 to 2010, among others. The Granger causality approach is a very popular tool in the analyses concerning these processes. For example, Louail, B. and Riache, S. (2019) used this method to speculate about unemployment and economic growth in Saudi Arabia in the period 1991–2017. In turn, Alhdiy, F.M. with co-authors pointed out that changes in unemployment caused changes in the GDP per capita for Egypt in the years 2006–2013 (quarterly data used) (Alhdiy, F.M. *et al.* 2015). Besides, Sadiku, M. with co-authors, studied causality using the Granger approach between these processes in North Macedonia (Sadiku, M. *et al.* 2015). The case of the verification of Okun's law for Nigeria, South Africa, and the USA was of interest to Onakoya, A.B. and Seyingbo, A.V. (2020). Based on the First Difference approach, they concluded that for Nigeria, the law formulated by Arthur Okun is not applicable. Moreover, this major macroeconomic relationship was verified for developing countries like Jordan (Al-Habees, M.A. and Rumman, M.A. 2012), Albania (Nikolli, E. 2014), and South Africa (Madito, O. and Khumalo, J. 2014; Makaringe, S.C. and Khobai, H. 2018).

All authors cited so far have not considered the spatial dependence between territorial units, which is a crucial issue in terms of international cooperation. Villaverde, J. and Maza, A. (2016) used the spatial panel approach to examine Okun's law for Spanish regions from 2000 to 2014. They employed various types of connection matrices, primarily distance matrices, citing Tobler's First Law of Geography (Tobler, W.R. 1970). Based on the Spatial Durbin Model, Villaverde, J. and Maza, A. (2016) quantified the direct and indirect effects of output growth. Montero Kuscevic, C.M. (2014) also quantified spatial spillovers in the relationship between output and unemployment rate at the metropolitan statistical area level (MSA) in the United States. Pereira, R.M. (2014) focused on the same statistical area to estimate regional spillovers, with a particular emphasis on the asymmetry in Okun's law. Additionally, Oberst, C. and Oelgemöller, J. (2013), as well as Salvati, L. (2015), highlighted the spatial dependencies and regional effects in the relationship between unemployment and output growth. The first study examined the mentioned dependence for German regions, while the second study used data from Italian provinces. Basistha, A. and Kuscevic, C.M.M. (2017), Palombi, S. *et al.* (2017), Elhorst, J.P. and Emili, S. (2022), and Jankiewicz, M. (2023) emphasized the important role of spatial connections in analyzing the relationship and also quantified spatial spillovers based on estimated models of Okun's relationship. Nevertheless, they determined only cumulative direct and indirect spatial effects additionally at the regional level. This analysis shows the strength of the spatial spillovers for individual territorial units at the country level. Detailing the spatial spillover effects and the transfer of the analysis to the macroeconomic scale are the novelties introduced in this study. Okoro-Ugochukwu, N.A. and Adenomon, M.O. (2021) conducted their research on the relationship between unemployment and economic growth in Nigerian regions, also utilizing a spatial approach. In turn, Xu, B. *et al.* (2021) introduced spatial dependence in the analysis of the relationship between entrepreneurship and regional economic growth across China provinces from 2010 to 2016. In their research, they used Mixed Geographically Weighted Panel Regression with Spatial Autoregression (MGWPR-SAR). In all cited works, the spatial dependence in the analysis of Okun's relationship turned out to be statistically significant. This study employs different types of spatial connection matrices, which can provide further insights

into the verification of Okun's law. Two matrices are based on geographical proximity: the first uses the common border criterion, while the second is built based on the maximum distance criterion (two countries are neighbours when the distance between them does not exceed 1000 kilometres). The geographical proximity is the most often considered in spatial analyses. This is related to the First Law of Geography formulated by Tobler, W.R. (1970). The third proximity matrix is based on economic similarity using the consumption expenditures per capita values. The premise for using this type of neighbourhood matrix is the significant role pointed out in the literature of consumption in the formation of economic growth and unemployment. Consumption is considered the main factor driving the economy. Moreover, the increase in consumption expenditures leads to a reduction in the unemployment rate. This is the very first time the proximity matrix based on the consumption expenditures level is employed in research based on Okun's law, which constitutes the next added value in the scientific literature.

Research methodology

The first part of the investigation deals with the analysis of a spatio-temporal structure of economic growth and unemployment to detect long-term tendencies in their formation. Initially, the spatio-temporal trend, which is responsible for the non-stationarity in the average, is analysed. The general form of the spatio-temporal trend model is characterized as follows:

$$Z(s_i, t) = \sum_{k=0}^{p} \sum_{m=0}^{p} \sum_{l=0}^{p} \theta_{kml} x_i^k y_i^m t^l + \varepsilon_{i,t}, \quad (1)$$

where Z denotes a considered process, $s_i = [x_i, y_i]$ is a vector of spatial units coordinates ($i = 1,2,\ldots, N$ denotes the number of territorial unity), $k + m + l \leq p$, and t indicates time.

Next, the spatial autocorrelation as the second component of the spatial structure, characterizing dependencies between neighbouring units, is tested. The Moran's I statistic verifying the presence of global spatial autocorrelation is described with the following formula (Moran, P.A.P. 1948; Schabenberger, O. and Gotway, C.A. 2005):

$$I = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \cdot \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\,[y_i - \bar{y}][y_j - \bar{y}]}{\frac{1}{n}\sum_{i=1}^{n}[y_i - \bar{y}]^2} = \frac{n}{S_0} \cdot \frac{z^T W z}{z^T z} \quad (2)$$

where y_i indicates the observation of the process in the i^{th} region, $\bar{y}$ denotes the average value of the process, and W is the spatial connections matrix between units. In this study, three types of spatial connections matrix are concerned. The first of them is the most used in spatial analyses a neighbourhood matrix based on the common border criterion (marked with $W1$). The other two matrices are created using the maximum distance criterion, one of which concerns a geographic distance (signed as $W2$), but the next is built based on the economic distance (named as $W3$). According to the $W2$ matrix, two regions are neighbours when the distance between them does not exceed 1000 kilometers. In turn, the economic distance in the $W3$ matrix is calculated using the level of consumption expenditures per capita. The $W3$ matrix is constructed using the algorithm presented in the article conducted by Jankiewicz, M. and Szulc, E. (2021). To determine the economic spatial weights matrix, the Euclidean distance between pairs of countries is calculated (in case of only one variable, this is the Manhattan distance). Then, the borderline value of the distance between countries is fixed, and the values exceeding the borderline are replaced with zeros. Subsequently, the non-zero elements are transformed by inversion. Finally, the elements of the proximity matrix are row standardized to one.

In the next step of the study, for processes filtered out from the long-term tendencies, the spatio-temporal model of dependence is estimated. The general form of the model is as follows:

$$Y_{i,t} = \alpha + \beta_1 X_{1i,t} + \beta_2 X_{2i,t} + \varepsilon_{i,t}, \quad (3)$$

where $Y_{i,t}$ denotes the GDP per capita, whereas $X_{1i,t}$ and $X_{2i,t}$ are the unemployment rate and inflation, respectively, in i^{th} country in time t. In turn, α, β_1 and β_2 are the structural parameters of the model, and $\varepsilon_{i,t}$ indicates the spatio-temporal random component.

To confirm the need to include the spatial dependencies in the model (3), the Lagrange Multiplier tests (LM) in two versions – basic and robust – are used (Anselin, L. *et al.* 2004). Consequently, the spatio-temporal Durbin model is considered in the following form (Elhorst, J.P. 2011):

$$Y_{i,t} = \rho \sum_{i \neq j} w_{ij,t} Y_{j,t} + \alpha + \beta_1 X_{1i,t} + \beta_2 X_{2i,t} + \theta \sum_{i \neq j} w_{ij,t} X_{1j,t} + \varepsilon_{i,t}, \quad (4)$$

where $w_{ij,t}$ are elements of the block matrix of spatio-temporal connections which is expressed as (Szulc, E. and Jankiewicz, M. 2018):

$$W^* = \left[w_{ij,t}\right]_{NT \times NT} = \begin{bmatrix} W_1 & 0 & \cdots & 0 \\ 0 & W_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & W_T \end{bmatrix}, \quad (5)$$

wherein W_1, W_2,…,W_T are standard spatial connectivity matrices, such as in (2). These matrices are the same for all years in the case of $W1$ and $W2$. In turn, the economic distance matrix ($W3$) changes over time.

Based on the model (4), the so-called direct and indirect spatial effects can be quantified. To obtain the mentioned effects, the general form of the non-dynamic model, i.e., the model (6):

$$Y_t = \rho W Y_t + \alpha \iota_N + X_t \beta + W X_t \theta + \varepsilon_t, \quad (6)$$

should be transformed to its reduced form (Vega, S.H. and Elhorst, J.P. 2013):

$$Y_t = (I - \rho W)^{-1} \alpha \iota_N + (I - \rho W)^{-1} (X_t \beta + W X_t \theta) + (I - \rho W)^{-1} \varepsilon_t, \quad (7)$$

Excluding from the matrix X_t the vector corresponding to the variable X_k, i.e., X_{kt} the following form is obtained:

$$Y_t = (I - \rho W)^{-1} \alpha \iota_N + (I - \rho W)^{-1} (\dot{X}_t \beta + W \dot{X}_t \theta) + (I - \rho W)^{-1} (\beta_k I_N + \theta_k W) X_{kt} + (I - \rho W)^{-1} \varepsilon_t, \quad (8)$$

where $\dot{X}_t$ indicates the matrix from which the X_{kt} has been removed.

The matrix of partial derivatives of Y concerning the k^{th} explanatory variable of X in region 1 up to region N at a particular point in time, given as (9), designates the short-term effects.

$$\left[\frac{\partial Y}{\partial x_{1k}} \ldots \frac{\partial Y}{\partial x_{Nk}}\right] = (I - \rho W)^{-1} (\beta_k I_N + \theta_k W), \quad (9)$$

The diagonal elements of matrix (9) represents direct effects. In turn, the non-diagonal elements correspond to spillover effects. Direct effects define impacts of change in observation x_k for i^{th} spatial unit (marked with x_{ik}) on the values of the depending variable in the same region (y_i). With non-diagonal elements of effects matrices, two types of impacts (spatial spillovers) can be identified (Lesage, J. and Pace, R.K. 2009):

(1) *Average Impact to an Observation* – the average impact on individual observation y_i resulting from changing k^{th} explanatory variable by an amount across all observations (the average of the sum across the i^{th} row),

(2) *Average Impact from an Observation* – the average impact over all y_i from changing the k^{th} explanatory variable by an amount in the j^{th} observation (the average of the sum down the j^{th} column).

Data and empirical results

This study examines the relationship between economic development and unemployment in general. Economic growth is measured by Gross Domestic Product (GDP) per capita (variable Y). Unemployment is quantified as the percentage of unemployed individuals within the total labour force (variable X_1).

Based on the literature review, the analysis also includes the inflation rate (variable X_2) as an additional factor influencing the economic situation of each country. In particular, the study investigates the spatial, and spatio-temporal relations between the analysed processes. All data are obtained from the World Bank database (https://data.worldbank.org/indicator) and directly used. The following indicators were used: GDP per capita (current USD) – variable X_1, unemployment (% of total labour force) – variable , and inflation measured by the consumer price index (the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals) – variable X_2. Data refer to the period of 2006–2019. All calculations and figures are performed using R software (version 4.1.1).

Table 1 presents the descriptive statistics of two crucial variables in this analysis – Gross Domestic Product (Y) and unemployment (X_1) over the period 2006–2019. It is worth noting that in the formation of both phenomena, the median value is lower than the mean value. In combination with the skewness coefficient values (1.3235 and 1.5696 for GDP and unemployment, respectively), we can note that the distributions of the considered variables are skewed right. This means that more than half of the observations have values lower than the mean. The volatility of the variables is similar and moderate. This is evidenced by the values of volatility index around 60 percent. Moreover, the kurtosis coefficient, with a value higher than two for both phenomena, indicates a too peaked distribution in comparison with the normal distribution. Additionally, in *Figure 1*, the scatterplot of the dependence between unemployment and economic growth for all countries in the whole research period (N = 602) is presented. The included regression line of negative slope allows us to pre-

Table 1. The descriptive statistics of variables used in the estimated models

Variable	Mean	Median	Minimum	Maximum
Y	34,263.0000	30,409.0000	7599.5000	114,890.0000
X_1	9.8093	7.6550	2.0100	36.0300
Variable	Standard deviation	Volatility index, %	Skewness	Kurtosis
Y	20,028.0000	58.46	1.3235	2.7865
X_1	6.2291	63.50	1.5696	2.2923

Source: Compiled by the author.

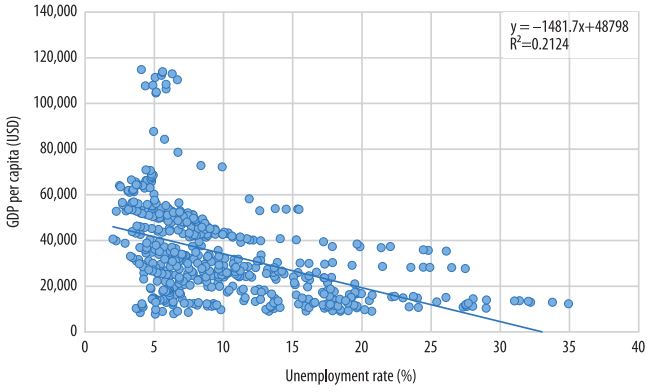

Fig. 1. The scatterplot of dependence between unemployment rate and economic growth in Europe in the period of 2006–2019 (N = 602). *Source:* Authors' own elaboration.

sume that in the considered area, higher values of unemployment are linked with lower economic growth.

In the first step of the research, the spatio-temporal trend models for GDP per capita and the unemployment rate were considered. The results of estimation and verification of the models mentioned above are presented in *Table 2*. The estimates of parameters θ_{100} and θ_{010} (negative and positive, respectively) show that in the examined period, the GDP per capita values have been increasing in the north-western direction. In turn, the average higher unemployment rate in the period was observed in South-eastern Europe. Moreover, the significant parameter θ_{001} for the GDP and also the p-values of the parameters θ_{001} and θ_{002} for the unemployment confirm the relevant changes of these processes over time.

For both models, residual spatial autocorrelation occurs in light of all defined spatial connection matrices. Nonetheless, the dependence between countries is stronger for the variable Y than X_1 for . Among the considered matrices, the highest value of Moran's I is obtained for geographical neighbours with a common border ($W1$), indicating the strongest reliance. But the strength of dependence between countries with similar values of consumption expenditures ($W3$) for GDP per capita does not differ significantly from that obtained for common border proximity. The geographical distance matrix shows the weakest connections between regions in terms of both GDP per capita and unemployment rate. On the other hand, the economic distance is not more significant for the unemployment rate than the physical distance.

Spatial dependence analysis began with the determination of its nature. For this purpose, a classical spatio-temporal model of the relationship between variables Y and X_1 was estimated and verified *(Table 3)*. Additionally, the influence of inflation is considered (variable X_2). Estimates of significant parameters β_1 and β_2 indicate that increased unemployment and inflation rates harm economic growth. The negative sign of Okun's parameter (β_1) confirms the truth of the major macroeconomic relationship in European countries. Moreover, the significant Moran's statistics indicate the presence of spatial autocorrelation in the model residuals.

Table 4 shows the results of the estimation and verification of Spatial Durbin Models for the considered relationship. The sign of the estimate of parameter β_1 did not change compared to the OLS model (β_1 for OLS model is equal to -0.3852). Nevertheless, the strength of the dependence is less (the greatest difference is observed using the $W1$ matrix). Based on the significance of parameter p, it can be concluded that there is a similarity in GDP per capita between neighbouring countries. The most similar regions are those that have a common border, while the least similar are states with a similar level of consumption expenditures per capita. On the other hand, the statistical significance of parameter θ_1 indicates that changes in the labour market in neighbouring countries

Table 2. The results of spatio-temporal trend models estimation and verification

Parameter	Y			X_1		
	Estimate (p-value)			Estimate (p-value)		
θ_{000}	9.2835 (0.0000)			3.3423 (0.0000)		
θ_{100}	-0.0250 (0.0000)			0.0037 (0.0086)		
θ_{010}	0.0269 (0.0000)			-0.0325 (0.0000)		
θ_{001}	0.0162 (0.0001)			0.1302 (0.0000)		
θ_{002}	–			-0.0094 (0.0000)		
Moran test	$W1$	$W2$	$W3$	$W1$	$W2$	$W3$
I	0.3200	0.1821	0.3195	0.2283	0.0801	0.1119
p-value	0.0000	0.0000	0.0000	0.0000	0.0007	0.0002

Source: Compiled by the author.

Table 3. The results of the OLS Okun's relationship model estimation and verification

Parameter	Estimate	t-statistics	p-value
α	0.0632	3.7480	0.0002
β_1	-0.3852	-13.0850	0.0000
β_2	-0.0185	-6.6830	0.0000
Diagnostics			
R_2	0.2484		
Moran test	*W*1	*W*2	*W*3
	0.1801 (0.0000)	0.0795 (0.0007)	0.0881 (0.0023)
LM_{err}	33.8150 (0.0000)	10.6239 (0.0011)	7.6657 (0.0056)
LM_{lag}	68.0270 (0.0000)	24.9503 (0.0000)	43.0832 (0.0000)
RLM_{err}	21.2290 (0.0000)	9.7046 (0.0018)	77.4523 (0.0000)
RLM_{lag}	55.4420 (0.0000)	24.0311 (0.0000)	112.8698 (0.0000)

Source: Compiled by the author.

Table 4. The results of estimation and verification of the non-dynamic Spatial Durbin models

Parameter	Model		
	SDM *W*1	SDM *W*2	SDM *W*3
α	0.0430 (0.0049)	0.0654 (0.0001)	0.0568 (0.0003)
β_1	-0.2800 (0.0000)	-0.3514 (0.0000)	-0.3112 (0.0000)
θ_1	-0.1724 (0.0010)	-0.1383 (0.0381)	-0.4835 (0.0000)
β_2	-0.0148 (0.0000)	-0.0162 (0.0000)	-0.0148 (0.0000)
ρ	0.3854 (0.0000)	0.2224 (0.0005)	0.0818 (0.0541)
Diagnostics			
Moran test	0.0045 (0.4231)	0.0004 (0.4655)	-0.0387 (0.1215)
Log-lik	-162.8580	-194.6190	-160.4491
AIC	337.7200	401.2400	332.9000

Source: Compiled by the author.

(regardless of the used spatial connections matrix) significantly influence the output in a certain state. The impact has the same nature as changes in the unemployment rate in a certain country. In case of geographical proximity (matrices *W*1 and *W*2), it is the impact of weaker strength. In contrast, in the economic neighbourhood (matrix *W*3), the influence of labour market changes in other countries is stronger than changes within the given country. The statistical significance of parameters p (a close significance for *W*3 matrix) and θ_1 allows for quantifying short-term indirect spatial effects caused by shocks in the labour market conditions in European countries.

The desirable property of all models is the absence of spatial autocorrelation in residuals. Based on the Akaike criterion (AIC) and the logarithm of likelihood (Log-lik) values, the Spatial Durbin Model with the neighbourhood quantified using the *W*3 matrix is the best.

Figure 2 presents the spatial distributions of spatial spillovers obtained when considering a common border neighbourhood. The top map in *Figure 2* shows the distribution of average inflows via the unemployment rate in individual countries on the output growth in a given country. We can see that most of the Western and Northern European regions (Finland, Ireland, Norway, Sweden, United Kingdom) were among those that received transmission impulses from other regions with the lowest strength. It should be noted that these are countries characterized by relatively high economic growth. The countries most affected by all other countries through the transmission of labour market conditions included the Czech Republic, Estonia, Denmark, Hungary, Lithuania, Moldova, and Switzerland.

Map b) of *Figure 2* contains the distribution of the average impacts of a given country's unemployment rate on the economic growth in all other economies. It is worth noting that most of the countries least influenced by others were those that strongly affected other countries. Thus, changes in the unemployment rate in France, Germany, Serbia, Turkey, and Russia most strongly affect the output in other countries. On the other hand, countries such as the Czech Republic, Denmark, Estonia, Italy, Moldova, Portugal, Spain and Sweden gave the weakest transmission impulse to other countries.

In turn, *Figure 3* shows the distributions of indirect effects evaluated based on the geographical distance dependence between countries. As with *Figure 2*, the top map

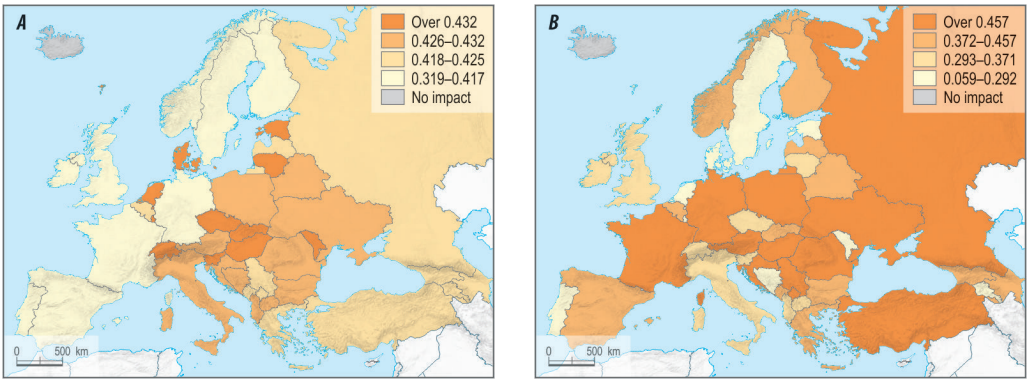

Fig. 2. The distribution of the average short-term impacts across Europe in the period of 2006–2019 of the spatially lagged unemployment rate on the output growth in individual economies *(A)*, and a change of the unemployment rate in a particular economy on the economic growth in all other economies *(B)*, based on the *W*1 matrix. *Source*: Authors' own elaboration.

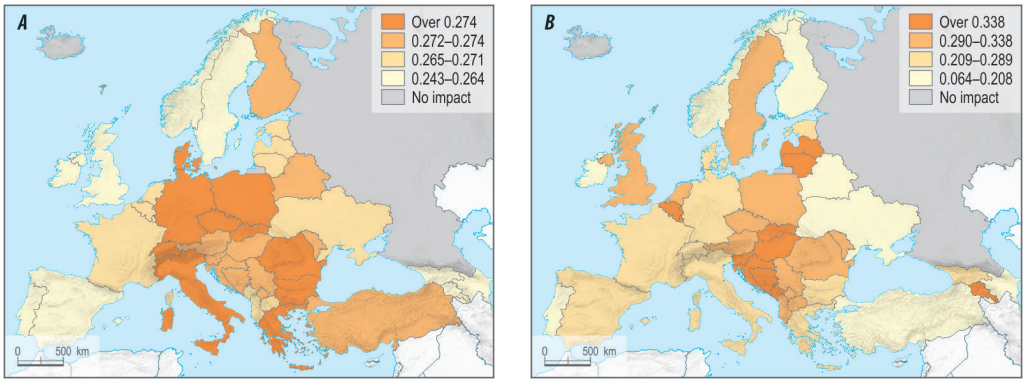

Fig. 3. For explanation see *Fig. 2*, but the values of *(A)* and *(B)* are based on the *W*2 matrix. *Source*: Authors' own elaboration.

contains average impacts to an observation, while the bottom map contains average impacts from an observation. Countries in Central Europe received the strongest transmission impulses from other countries. Moreover, Eastern and Northern European countries were highly sensitive to changes in the unemployment rate in other countries. Simultaneously, most of them had a poor effect on other economies. Among the selected countries, some showed weak strength in both spatial impacts, such as Ireland, Norway, and Spain. It is worth noting that most of the Central-Southern European countries (especially Western Balkans economies) were relatively most influenced by others. This group of regions also included Belgium, Latvia, and Lithuania.

Figure 4 presents the distributions of short-term indirect effects resulting from the economic distance between countries. We can see that, in general, countries in Eastern Europe received the highest strength transmission impulses from other countries, par-

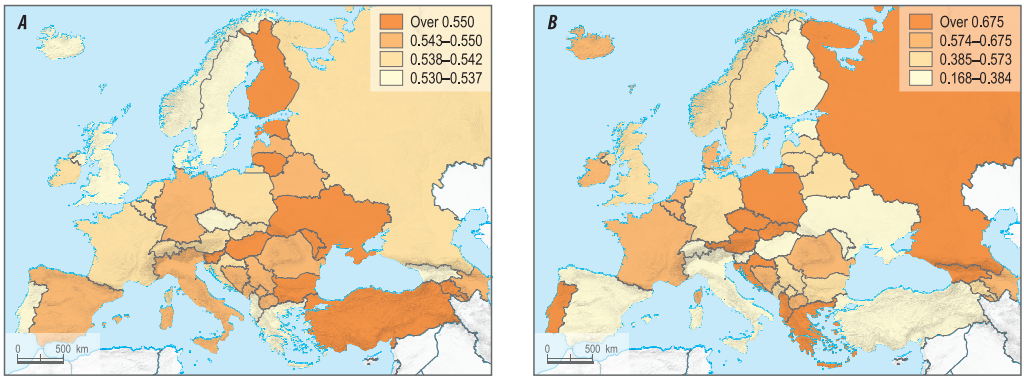

Fig. 4. For explanation see *Fig. 2*, but the values of *(A)* and *(B)* are based on the *W*3 matrix.
Source: Authors' own elaboration.

ticularly Belarus, Estonia, Latvia, Lithuania, Moldova and Ukraine. Changes in the unemployment rate in other economies had the most influence on output growth in several Southern European countries, including Croatia, Georgia Greece and Portugal. It is worth noting that the regions that were least influenced by others were the ones that most strongly affected other regions.

Conclusions

The relationship between the unemployment rate and economic growth, as one of the major relationships in economics, is widely considered in many studies. Almost all confirm the nature of this relationship, formulated by Arthur Okun, which points out that an increase in the unemployment rate causes a decrease in output growth. It is no different in this research that examines the case of European economies. Almost all cited studies concluded that the relationship between the unemployment rate and economic growth is negative. Some of them underlined the differences in the operation of Okun's law between emerging and developed economies. This is the clue for improving this research in the future by dividing the set of countries into two separate groups.

The analysis of spatial dependencies allows us to conclude the need to include interactions between neighbouring countries in Okun's relationship models. The use of several spatial connection matrices shows that the geographical neighbourhood (defined by a common border or distance between countries) was stronger than the economic neighbourhood adopted in this research (defined as similarity in the level of consumption expenditures). This means that, the third hypothesis of the research has not been confirmed. Therefore, there is a need to look for another economic similarity that may be more relevant in the relationship between the unemployment rate and economic growth than geographical proximity. This research shows that the geographical location is very important in the case of formation the economic phenomena. Undoubtedly, the geographical proximity is the source of the imitation effect, where economies follow their neighbours, primarily in terms of consumption, but not only. Most of the migrant workforce chooses the nearest countries as the goal of their migration. Additionally, the geographical neighbourhood allows economies to cooperate and establish unions more easily, what leads to their faster development. Which is why the geographical neighbourhood can be the driver for most

of economic factors. Nevertheless, changes in economic growth and the unemployment rate in neighbouring regions significantly influence output growth in a certain country, regardless of the neighbourhood matrix adopted. This means that different factors are leading the labour force to take up jobs abroad. Some people prefer to be near their family home, while for others, higher earnings and much better working conditions drive migration much further. Undoubtedly, competition in the labour market and trust in the government of the host country are also factors that significantly influence the choice of workplace.

Quantified short-term spatial indirect effects show a difference in their distributions depending on the neighbourhood matrix used. Firstly, the knowledge spillover effect leads to a change in the country's labour market. Producers are able to rapidly transform their production systems by learning new technologies from manufacturers in other countries (particularly those similar in socio-economic conditions). As a result, economic growth accelerates, and short-term spatial effects become stronger. Moreover, the mobility of production factors strengthens the spatial spillovers in the short term as well, mainly labour force mobility. The worsening of the labour market in a given country often forces the population to migrate for work to other states. Comparing the spatial spillovers analysis with the studies conducted so far, this analysis confirms the significance of the spatial connections in the considered relationship, as concluded also by Palombi, S. *et al.* (2017), and Elhorst, J.P. and Emili, S. (2022). Based on the analysis presented in this paper, there is the opportunity to formulate some recommendations for policymakers. First of all, they should provide decent conditions of employment and reduce the negative modifications of the labour market conditions that have unfavourable consequences for output. So the *pull* factors have to be eliminated. Only then will the labour force not be transferred abroad. Moreover, policymakers should improve the effectiveness of economic policies and the overall condition of the economy, for example through the development of technologies and infrastructure in the labour market. All these decisions have relevant geographical consequences, particularly in the socio-economic dimension. The progressing modifications in the labour market and the economic structure can lead to changes in the age structure of the population and the structure of natural resource use. This study shows that the cooperation between the nearest economies significantly influences the economic situation. In the light of these results, policymakers should strive to the intensification of exchange of views and experiences with the governments of their neighbours. In order to slow down the outflow of human capital and, as a result, increase a potential of the national economy, policymakers should also support entities in case of the outplacement process.

Mostly in the short term, countries that received transmission impulses from other countries with the least (higher) strength were those more (less) affecting other countries. Moreover, the most highly developed countries in the short term were least sensitive to labour market shocks in the neighbouring states. Nevertheless, there is not an unambiguous division that points out that relatively highly developed countries have a greater influence on others than the poorer ones. Hence, the second hypothesis provided is not completely true.

In further research, it is worth conducting an analysis of the division into relatively poor and relatively rich economies. The division of countries considered in this study according to Human Development Index (HDI) level into developing and developed economies can provide significant conclusions about differences in the formation of economic growth resulting from changes in the labour market. Moreover, the research can be enriched with other types of spatial connection matrices. It is also interesting to compare the results obtained in this study with the analysis based on another method of estimation of Okun's relationship (Trial

Gap and First Differences methods). It is also worth studying the impact of the COVID-19 pandemic on Okun's relationship. There was a significant shock for the economies of the world, and relevant changes happened. For sure, in the studied relationship, structural change occurred. But the particular consequences of the COVID-19 pandemic can be an element of this study's improvement.

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