A R T Y K U Ł Y

Studia Regionalne i Lokalne
Nr 1(83)/2021
ISSN 1509-4995; E-ISSN 2719-8049
doi: 10.7366/1509499518301

Paweł Kliber
Poznań University of Economics, al. Niepodległości 10, 61-875 Poznań, Poland;
email: p.kliber@ue.poznan.pl, ORCID 0000-0001-7796-6418

The Diversity of Okun's Coefficient in the Regions of Poland

Abstract: In the paper, we calculate Okun's coefficients in the regions of Poland. We compare the coefficients estimated for each region separately with the calculations obtained from seemingly unrelated regression (SUR) models. The results reveal that the latter method gives better estimates, because shocks in output are highly correlated across regions. Then, we consider the question concerning the existence of macroeconomic "clubs" among Polish regions. Two such clubs are found: the northwest of Poland and the eastern border region. Finally, some conclusions concerning economic policy preventing unemployment are drawn.

Keywords: Okun's law, unemployment, macroeconomic policy, regional growth

Regionalne zróżnicowanie współczynników Okuna w Polsce

Streszczenie: W artykule wyznaczono współczynniki Okuna dla województw Polski. Porównano współczynniki otrzymane na podstawie oszacowań przeprowadzanych osobno dla każdego województwa z wynikami uzyskanymi z zastosowaniem modelu pozornie niezwiązanych regresji (*seemingly unrelated regression*, SUR). Wyniki pokazują, że druga metoda daje lepsze oszacowania, ponieważ zjawiska szoku w produkcji są silnie skorelowane między regionami. Następnie rozważamy kwestię istnienia makroekonomicznych „klubów" wśród województw Polski. Otrzymane wyniki wskazują na istnienie dwóch takich klubów obejmujących: północno-zachodnią część Polski oraz wschodnie województwa Polski. Ostatecznie przedstawiamy wnioski dotyczące polityki gospodarczej przeciwdziałania bezrobociu.

Słowa kluczowe: prawo Okuna, bezrobocie, polityka makroekonomiczna, wzrost regionalny

1. Introduction

Unemployment is one of the most serious economic problems in Poland. High unemployment appeared in Poland in 1990, after the transformation from the centrally planned economy, as an unavoidable cost of the transformation. In the planned economy, before 1990, firms were hugely overstaffed and reductions in workforce were necessary to make production economically efficient. The rise of unemployment was partially due to the conversion of hidden unemployment (unnecessary workers) into evident unemployment. However, since that time the unemployment has not declined significantly. On the contrary, it reached its peak at the beginning of the 21st century. In some parts of Poland unemployment is an endemic problem. In some families, there has emerged a third generation of the unemployed. Unemployment remains the biggest social cost of the transformation from planned to market economy.

What should be given special attention is the fact that the unemployment in Poland is highly regionalised. There are some regions where the unemployment rate is usually low, while in other regions unemployment remains extremely high. The differences in the unemployment rate across the regions can be as high as 12 percentage points.[1] To develop and implement an appropriate policy that aims at reducing unemployment, the authorities should account for the differences across regions.

One of the most established relationships in the economy is Okun's law. It was known for long by economists that the unemployment rate is typically higher in the periods of slowdowns, while in the time of boom unemployment declines. This relationship was statistically documented and formalised for the first time by Okun (1962). In his seminal paper, Okun stated two relationships that he had found in the data concerning the U.S. economy. The first one, known as the difference form, was the connection between changes in the unemployment rate and the growth of real output. According to his results, the growth rate in the economy should equal at least 4% to prevent the rise of unemployment. Every percentage point of the deviation from this level increases the rate of unemployment by 0.3 percentage points. The second relationship relates the unemployment rate to the gap between potential and actual output. This version is known as the gap form of Okun's law. According to this version, a high rate of unemployment is usually connected with idle resources. The problem with assessing this statement is that potential output is not a directly observable macroeconomic statistic and has to be estimated with some statistical methods. This makes the measuring of Okun's coefficients an "estimation on estimates", which makes the results dubious.

Since the seminal paper of Okun, the existence and stability of the relationship between output and unemployment has been investigated in many studies. The main bulk of the literature studied Okun's law on the national level, and there is significantly less research investigating this issue on the regional level. Freeman (2000) estimated Okun's coefficients for six regions of the U.S. based on the data for the period of 1958–1998. He found some differences among the regions. Adanu (2005) calculated Okun's coefficients for the regions of Canada. He found that the costs of unemployment, expressed as Okun's coefficients, are higher in bigger and more industrialised provinces.

The regional Okun's coefficients for Spain were estimated by Villaverde and Maza (2009). The article also offers some advice with respect to economic policy. The authors suggest liberalising the labour market and promoting human capital.

Okun's coefficients for the regions of Greece were estimated by Apergis and Rezitis (2003) and by Christopaulos (2004). The former authors found a structural

[1] In 2013 the unemployment rate in the region with the lowest level of this indicator (Wielkopolskie) was 9.6%, while in the region with the highest level (Warmińsko-Mazurskie) the unemployment rate was 21.7%.

break in Okun's relationship after 1981. Villaverde and Maza (2009) found that Okun's coefficients are usually higher in the regions with a higher growth of productivity.

Revoredo-Giha et al. (2012) used panel methods to estimate Okun's coefficients for the regions of Scotland. They found that Okun's law seemed to be valid for most regions. Their results also reveal higher values of Okun's coefficients in urban areas than in rural ones.

As for Poland, there is only a small number of studies estimating Okun's coefficients on the national or regional level. Hutengs and Stadtmann (2014) calculated Okun's coefficients for Poland and for other Central European countries on the national level and for five different age groups. They found that in younger age cohorts Okun's coefficients were higher, and so younger people are more prone to economic shocks. Majchrowska et al. (2013) prepared a detailed and comprehensive study of unemployment in Polish *powiaty* (counties, a unit below the NUTS-3 category). The authors estimated Okun's coefficients augmenting the usual equation for some additional exploratory variables to control the cultural and historical diversity of the regions. Okun's coefficients were calculated for regions at the NUTS-2 level using panel methods for data concerning regions at a lower level. Okun's law turns out to be statistically significant only in seven regions out of 16. The values of Okun's coefficients in these regions were high and ranged from 1.4 to 3.2. However, unlike in the standard approach to estimating Okun's coefficients, the authors used data on industrial production instead of GDP. Gajderowicz et al. (2014) used regional data to calculate Okun's coefficient for the whole Polish economy with a panel model. The authors also estimated regional Okun's coefficients with two forms of Okun's law, using regression for each region separately. Dykas et. al. (2013) performed a dynamic analysis of unemployment in the Polish regions, using a theoretical model similar to the difference version of Okun's model.

In the article, we try to estimate Okun's coefficients for the Polish regions on the NUTS-2 level. The methodology used by Majchrowska et al. (2013) has two drawbacks. Firstly, it is based on the data for counties, and these administrative units are too small to create their own job market. In some cases the diameter of a county is less than 10 kilometres and it is common (especially in bigger towns and areas around them) for the population of some counties to work in another region. The second problem with those estimations is the usage of data on industrial production instead of GDP. This affects the results, especially when one compares the coefficients in industrialised regions with the ones in rural regions. The article has two main goals. The first one is to obtain more accurate estimates of Okun's coefficients for the regions of Poland by accounting for common shocks in neighbouring regions. The second one is to identify groups of neighbouring regions that reacts similarly to shocks in the economy.

The article is organised as follows. After this introduction we present the data, the problems that arose during the estimation, and our methodology. Section 3 presents the main empirical findings, and the fourth section summarises the main results.

2. Data and methodology

Following the reform in 1998, the administrative division of Poland consists of three levels. Going from the lowest to the highest level, Poland consists of 2479 municipalities (*gminy*), 380 counties (*powiaty*) and 16 voivodships (*województwa*). In the Nomenclature of Territorial Units for Statistics (NUTS) voivodships have a NUTS-2 category. Counties (below NUTS-3 level and formerly classified as NUTS-4) and municipalities are categorised as LAU (Local Administrative Units), with counties being referred to as LAU-1.

The main problem with estimating Okun's coefficient for the Polish region is the lack of long time series. The voivodships in their present form were created in 1998. The data concerning GDP in the regions are available only on a yearly basis. The quarterly (and even monthly) observations of unemployment rates in the regions are available, but in order to calculate Okun's coefficients one should also have quarterly data on GDP, which are not available for the regions. There exist methods that allow to break down yearly observations of GDP into quarterly data with the use of space-state models (see Lütkepohl [2006], p. 617), but the

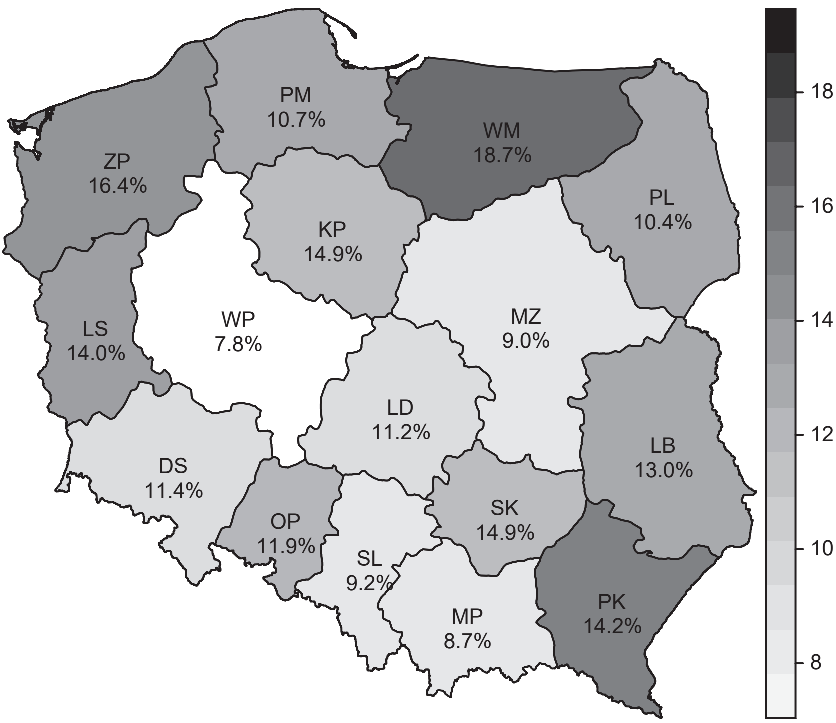

Fig. 1. Unemployment rates in Polish regions in 2007

Regions: WP –Wielkopolskie, KP Kujawsko-Pomorskie, MP – Małopolskie, LD – Łódzkie, DS – Dolnośląskie, LB – Lubelskie, LS – Lubuskie, MZ – Mazowieckie, OP – Opolskie, PL – Podlaskie , PM – Pomorskie, SL – Śląskie, PK – Podkarpackie, SK – Świętokrzyskie, WM – Warmińsko-Mazurskie, ZP – Zachodniopomorskie.

Source: own study.

time series of yearly GDP observations in the regions are too short to allow for such operations.

In the following estimations, we used yearly data concerning the GDP and unemployment rate in the regions of Poland. The data was taken from the Local Data Bank (*Bank Danych Lokalnych*) of the Polish Statistical Office and it covers the period from 1998 to 2017. Figure 1 presents the spatial pattern of the unemployment rate in Poland in 2004, i.e. in the middle of the considered period. Although there were some changes during the period of the analysis, the overall picture remains stable: the unemployment rates were the lowest in the regions of Mazowieckie (with Warsaw as the capital), Wielkopolskie, Małopolskie and Śląskie (the most urbanised and industrialised region of Poland). The exceptionally high unemployment rates were found in the northern regions of Warmińsko-Mazurskie as well as in Zachodniopomorskie. High unemployment in these two regions is connected with the liquidation of big, state-owned agricultural farms in 1991. In many areas in these regions, state-owned farms were the main employer, and after their liquidation the unemployment became endemic.

One can estimate Okun's coefficient separately for each region using short time series of data concerning GDP and unemployment rates. In the *gap form*, one has to estimate the following regressions

$$\tilde{u}_t^i = \alpha_i + \beta_i \tilde{y}_t^i + \varepsilon_t^i, \tag{1}$$

where $\tilde{y}_t^i$ is the gap between the logarithms of potential and actual output in the region at the moment t (i.e. $\tilde{y}_t^i = y_t^i - y_t^{P,i}$, where y_t^i is the logarithm of GDP and $u_t^{P,i}$ is the logarithm of potential GDP), $\tilde{u}_t^i$ is the gap between actual unemployment rate and natural unemployment rate ($u_t^{P,i}$), and ε_t^i is random error term. The potential outputs $u_t^{P,i}$ and the natural unemployment rates $u_t^{P,i}$ can be calculated, for example, with the use of the Hodrik-Prescott filter. Alternatively, one can use the *difference form* and estimate the following set of regressions (one for each region):

$$\Delta u_t^i = \alpha_i + \beta_i \Delta y_t^i + \varepsilon_t^i, \tag{2}$$

where $\Delta u_t^i = u_t^i - u_{t-1}^i$ and $\Delta y_t^i = y_t^i - y_{t-1}^i$.

Equations (1) and (2) are estimated for each region separately, and this approach does not account for random shocks common to the whole country or parts of the country or some sectors of economy which are crucial in several regions. It is assumed that error terms ε_t^i are independent, i.e. ε_t^i, and ε_t^j are uncorrelated for $i \neq j$. This assumption is dubious as the error terms usually contain shocks common to the whole national economy. The estimators from the separate sets of equations (1) or (2) are thus unbiased, but not the most effective ones. One can obtain more effective estimators, taking account of the correlations between error terms in the regions, i.e. using the SUR (*Seemingly Unrelated Regressions*) model.

The SUR model consists of regression equations

$$z_t^i = \delta^i X_t^i + \varepsilon_t^i, \tag{3}$$

where $z^i = (z_1^i, ..., z_T^i)$ are dependent variables and X^i are vectors of independent variables. In our context, the z_t^i is $\tilde{u}_t^i$ or Δu_t^i and X_t^i consists of constant 1 and a variable describing growth: $\tilde{y}_t^i$ or Δy_t^i – depending on whether we chose model (1) or (2) – and the vector of parameters δ^i is $\delta^i = (\alpha_i, \beta_i)^T$. The error terms for different equations are assumed to be correlated and their covariance matrix does not change with time:

$$E\left[\varepsilon_t \varepsilon_t^T\right] = \Sigma, \text{ where } \varepsilon_t = \left(\varepsilon_t^1, ..., \varepsilon_t^m\right)^T. \tag{4}$$

In other words:

$$\operatorname{cov}\left(\varepsilon_t^i, \varepsilon_t^j\right) = \sigma_{ij}, \; i, j = 1, ..., m. \tag{5}$$

The estimator of $\delta = (\delta^1, ..., \delta^m)$ is given by[2]

$$\hat{\delta} = \left(X^T(\Sigma^{-1} \otimes I_m)X\right)^{-1} X^T\left(\Sigma^{-1} \otimes I_m\right)z, \tag{6}$$

where $X = \operatorname{diag}(X^1, ..., X^m)$ and $z = \left(z_1^1, z_2^1, ..., z_T^1, z_1^2, ..., z_T^2, ..., z_T^m\right)^T$ (assuming that there are T observations for each region). The model is estimated using the feasible generalised least squares (FGLS) method, which is a two-stage procedure. First, the correlation matrix $\sum$ is estimated based on the residuals from ordinary least squares (OLS) method for each equation (3) separately. Then, equation (6) is used. The estimators obtained in this way are more efficient than the estimators for each region separately. The greater the correlation of error terms in different regions, the greater is the gain in the efficiency compared to the ordinary least square method.

There are several methods to check if there are correlations in error terms for different regions, and if one has to use the SUR model instead of ordinary least squares in order to obtain efficient estimators. In the following considerations, we use two types of specification tests: the likelihood ratio test and the Lagrange multiplier test developed by Breusch and Pagan (1980). The likelihood ratio test uses the test statistic

$$\lambda = T \cdot \left(\ln |S_0| - \ln |S_1|\right), \tag{7}$$

where S_1 is the residual covariance matrix from the SUR model (estimated with the maximum likelihood method), whereas S_0 is the diagonal covariance matrix for residuals estimated from independent OLS models. The first determinant in (7) can be computed using the formula

$$\ln |S_0| = \frac{1}{T} \sum_{i=1}^{m} \ln e_i^T e_i, \tag{8}$$

[2] See for example Greene (2008, Chapter 10.2) or Maddala (2001, Chapter 15.5).

where e_i is the vector of residuals obtained from the OLS estimation for region *i*. The test statistic is asymptotically chi-square distributed with $m(m-1)/2$ degrees of freedom. In the Lagrange multiplier test, the statistic is

$$\lambda_{PB} = T \cdot \sum_{i=2}^{m} \sum_{j=1}^{i-1} r_{ij}^2, \tag{9}$$

where r_{ij} is the correlation coefficient between the OLS residuals for the region *i* and the region *j*.

The SUR model cannot be used for all the regions of Poland. There are 16 regions and we have only 20 observations (or 19 observations if we use the difference form). For the group of all regions, the covariance matrix $\sum$ estimated in the first stage is singular and one cannot use (6). The two-stage estimation of the SUR model is possible only if the number of observations is greater than the number of covariance coefficients between all pairs of regions.[3] Thus, we have to search for some territorial units greater than a single region and smaller than the whole country, in which the random shocks are similar. We followed the following procedure: for each region, we created a group containing this particular region and all of its closest neighbours. By the "closest neighbours", we understand all the regions which have a common border with the region under consideration. Then we performed a two-stage estimation of the SUR model for each group.

The second stage of the procedure was to check if the parameters β (Okun's coefficients) have the same values for all the regions in the group of neighbours. We used the likelihood ratio test for nested models. In this way, we aimed to find the "clubs" of regions with a similar macroeconomic structure with respect to the reactions of their labour markets to changes in the growth of output. Having found such a "club", we augmented it as much as possible, adding the neighbouring regions, and again testing for the equality of Okun's coefficients.

To test the equality of Okun's coefficients for all regions in the club, we used standard methods for testing linear restrictions. For each club, we tested the hypothesis which can be formulated as follows:

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_m \tag{10}$$

The hypothesis was tested using the Wald statistic

$$\hat{F} = \frac{1}{m-1} R^T \hat{\delta} \left[R \operatorname{var}\left(\hat{\delta}\right) R^T \right]^{-1} R\hat{\delta}, \tag{11}$$

where R is the matrix defining the linear restrictions for the hypothesis (10), i.e. in our context

[3] If the number of observations is too small, one can perform the Bayesian estimation of the model. One can use the *a priori* information concerning the correlations between the shocks in regions. The estimation methods are described in Ando and Zellnery (2010a) and Ando and Zellnery (2010b). We made an attempt to estimate Okun's coefficient in this way, performing an MCMC (Markov Chain Monte Carlo) simulation to obtain the *a posteriori* distribution, using the neighbourhood of regions and estimations for the whole country as *a priori* information. However, this method failed because of indeterminacy. There can be at least two different sets of parameters that suit the data and the simulated chains of *a posteriori* parameters failed to converge.

$$R = \begin{bmatrix} 0 & -1 & 0 & 1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & -1 & 0 & 0 & 0 & 0 & \cdots & 0 & 1 \end{bmatrix}.$$

The asymptotic distribution of the test statistics is times chi-square with m degrees of freedom.

3. The results

To estimate Okun's coefficients for the Polish regions, we used the difference formulation of Okun's law (2). The reason for this is the difficulty in estimating the potential output (and the natural rate of unemployment) using filters. The time series are too short and, generally, in the period that we considered, the output in all the regions was growing.

Table 1 contains the estimated parameters for the difference version of Okun's law obtained with the use of two methods. The first one involves using ordinary least squares for each region separately – the parameters (with standard errors in parentheses) are given in the second and the third column of the table, and the fourth column contains R-squares of the regressions. Then, we estimated SUR models using the feasible generalised least squares (FGLS) method for each group of the neighbouring regions separately. We took each region and formed a group containing this particular region and all of its neighbours. There were 16 such groups, and every region belongs to of them (the number is given in the last column of the table). The computations were performed using the statistical software R.[4] The columns $\overline{\alpha}_i$ and $sd(\alpha_i)$ contain the means and standard deviations of the estimation of the α_i parameter in all N groups. The columns $\overline{\beta}_i$ and $sd(\beta_i)$ contain similar information about the estimators of β_i. For each group, we performed a likelihood ratio test (7) and a Lagrange multiplier test (9) to check if the matrix $\sum$ is non-diagonal and if the SUR model is valid. We do not present the results of these tests because in all cases the p-values were below 0.1%, which provides very strong evidence for the correlation of shock in different regions. (The table with p-values of the tests would contain only zeros.) This is the reason why we believe that estimates of Okun's coefficients from the SUR model are more precise. As one can see, estimated values in all cases are significantly lower (in the absolute value) than the estimates from OLS. Thus, not taking into account the heterogeneity of error shocks leads to false conclusions about the impact of growth on unemployment in regions.[5]

[4] See: R Core Team (2014).

[5] We also performed standard tests for the spatial correlation in residuals based on Moran's I (Moran 1950) and Geary's C statistic (Geary 1954). The results indicate that, although in some years the correlations cannot be found, there were years in which they were significant and strong. This suggests that the results taking into account the spatial neighbourhood of regions should be more robust.

Tab. 1. Estimated differential version of Okun's law

Region	α_i	β_i	R^2	$\overline{\alpha}_i$	$sd(\alpha_i)$	$\overline{\beta}_i$	$sd(\beta_i)$	N
WP	1.326	–0.442	0.332	0.415	0.018	–0.205	0.018	4
	(0.765)	(0.152)						
KP	1.912	–0.739	0.642	1.015	0.019	–0.427	0.019	6
	(0.494)	(0.134)						
MP	1.310	–0.510	0.673	0.725	0.028	–0.295	0.028	5
	(0.316)	(0.086)						
LD	1.843	–0.739	0.551	0.683	0.013	–0.349	0.013	4
	(0.651)	(0.162)						
DS	1.610	–0.538	0.379	0.514	0.040	–0.221	0.040	7
	(0.688)	(0.167)						
LB	1.771	–0.509	0.451	0.585	0.036	–0.190	0.036	4
	(0.629)	(0.136)						
LS	1.689	–0.414	0.284	0.609	0.026	–0.165	0.026	7
	(0.783)	(0.160)						
MZ	0.794	–0.396	0.568	0.338	0.025	–0.208	0.025	5
	(0.398)	(0.084)						
OP	1.510	–0.559	0.486	0.455	0.028	–0.202	0.028	4
	(0.514)	(0.139)						
PL	0.974	–0.370	0.266	0.247	0.018	–0.125	0.018	4
	(0.585)	(0.149)						
PM	1.195	–0.405	0.207	0.419	0.037	–0.194	0.037	5
	(0.873)	(0.192)						
SL	1.179	–0.441	0.245	0.255	0.035	–0.126	0.035	5
	(0.740)	(0.188)						
PK	0.666	–0.311	0.295	0.032	0.037	–0.076	0.037	7
	(0.495)	(0.116)						
SK	1.451	–0.626	0.347	0.608	0.119	–0.344	0.119	5
	(0.791)	(0.208)						
WM	2.111	–0.603	0.501	0.979	0.030	–0.311	0.030	8
	(0.662)	(0.146)						
ZP	1.796	–0.775	0.508	0.721	0.048	–0.374	0.048	4
	(0.680)	(0.185)						

Source: own study.

For each group of the neighbouring regions formed for the sake of estimating the SUR model, we performed the test for the equality of the coefficients, as stated in equation (10). The group of such regions can be interpreted as a "club" of regions in which the regional labour markets work similarly. In four cases the tests indicated the equality of the coefficients β_i. These were the neighbouring groups for the regions: LS (consisting of DS, LS, WP and ZP), PM (KP, PM, WM, WP and ZP), ZP (LS, PM, WP and ZP) and MP (MP, PK, SL and SK).

The first three groups intersect one another as they include the regions from the northern and western parts of Poland. The last group comprises the regions in the south of Poland. From this starting point, we tried to build groups of neighbouring regions with a common Okun's coefficient. The objective was to make each group as large as possible, with the restriction that the regions in the group should pass the test for the equality of coefficients β_i, stated in (10). Using this procedure, we obtained three clubs:

- western and northern regions: DS, LS, PM, WP and ZP,
- southern regions: MP, PK, SL and SK,
- eastern regions: LB, PL and WM.

Tab. 2. "Clubs" of regions with the same Okun's coefficient

	Region	α_i	β_i	R^2	$\overline{g}_y^i$
	DS	0.871	-0.324^{***}	0.309	2.69
		(0.541)	(0.051)		
	LS	0.608	-0.324^{***}	0.376	1.88
		(0.475)	(0.051)		
Club 1	PM	0.896	-0.324^{***}	0.199	2.77
		(0.555)	(0.051)		
	WP	1.027	-0.324^{***}	0.393	3.18
		(0.396)	(0.051)		
	ZP	0.584^{*}	-0.324^{***}	0.336	1.81
		(0.499)	(0.051)		
	MP	0.382	-0.135^{*}	0.208	2.82
		(0.445)	(0.064)		
	PK	0.257	-0.135^{*}	0.207	1.90
Club 2		(0.368)	(0.064)		
	SL	0.281	-0.135^{*}	0.127	2.08
		(0.529)	(0.064)		
	SK	0.192	-0.135^{*}	0.201	1.42
		(0.430)	(0.064)		
	LB	0.904^{**}	-0.361^{***}	0.616	2.50
		(0.293)	(0.074)		
Club 3	PL	0.947^{*}	-0.361^{***}	0.266	2.62
		(0.449)	(0.074)		
	WM	0.659	-0.361^{***}	0.285	1.82
		(0.541)	(0.074)		

Note: significance at * 10% level, ** 5% level, *** 1% level

Source: own study.

Table 2 contains the results of the FGLS estimation of the SUR models for these clubs. The results for the second club are dubious because R^2 values are at a very low level. However, the results for the two other clubs – the western and the eastern regions respectively – are valid. Tests (7) and (9) for the correlations of shocks (not presented here) in all cases gave the p-values below 1%. The last column in the table contains information about the estimated value of $\overline{g}_y^i$ – the rate of growth for GDP that guarantees a constant unemployment rate, which is sometimes called the natural rate of growth; it is based on (2): $\overline{g}_y^i = -\alpha_i / \beta_i$.

The final results are presented in Figure 2. The clubs that were found are marked out by different shades of grey. The numbers in each region are Okun's coefficients and the natural rate of growth (in brackets). For the club containing northern and western regions as well as for the club of eastern regions, Okun's coefficients were assumed to be constant – they were taken from Table 2. For all other regions, the coefficients were taken from the estimations of SUR models for the groups of neighbours.

4. Conclusions

In the paper, we estimated Okun's coefficients for the regions of Poland. Such a study is needed because, since the change of the economic regime in 1990, Poland has displayed a high and persistent dispersion in unemployment rates

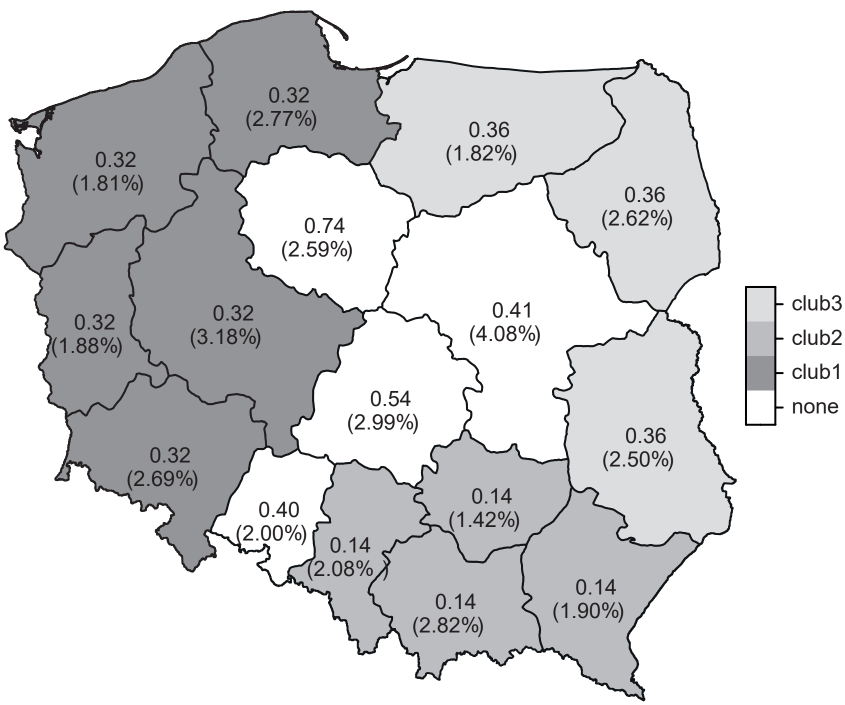

Figure 2. Estimated Okun's coefficients and natural rates of growth (in brackets)

Source: own study.

between the regions. The main problem with the estimation is the fact that the time series concerning unemployment and regional GDP are short in comparison to the number of regions, and the pattern of growth in Poland made it impossible to filter the growth into trends and cyclical effects. Thus, we cannot use the common "gap" specification and are forced to use the "difference" specification instead.

Several conclusions can be drawn from our analysis. First of all, Okun's law holds on the regional level in Poland. The rise of the growth rate in the region of one percentage point reduces the unemployment rate and the scale of this reduction is in the range from 0.05 to 0.46 percentage points. Note that these values are usually higher than the original estimations of Okun (1962) for the U.S. economy. This finding can be used in the forecasting of unemployment and in planning the economic policy. Secondly, the shocks (or error terms) in the estimated equations are highly correlated across regions. Taking this fact into account should give better estimations of Okun's coefficients. That is why we are prone to consider the results from SUR models as closer to the real values than the estimates obtained for each region separately. Thirdly, there is a significant diversity across regions concerning Okun's coefficients and natural rates of growth. The regional response of unemployment to output varies very much, and this can be connected with the structure of unemployment in different regions.

Especially the southern regions have very low values of this coefficient, which can be attributed to the agricultural character of their economies. Fourthly, we found some "clubs" of Polish regions with the same Okun's coefficients. This finding is interesting because Okun's coefficient incorporates several fundamental structural parameters describing microeconomic foundations (firms' demand for labour) and macroeconomic structure of the economy (production function, labour participation) – see Permana and Tavera (2005). The equality of these coefficients says something about the deep structural similarity of the regions. We found two main clubs: the club of western and northern regions and the club of eastern regions. This is consistent with the findings obtained in other ways by Majchrowska et al. (2013). For the club of southern regions, the results are ambiguous.

The results lead to some conclusions concerning economic policy. In order to fight unemployment, which is the one of the biggest economic problems in Poland, a more regionalised policy should be implemented. There are regions with very low Okun's coefficients (mainly agricultural ones), in which boosting the output alone does not lead to great successes in fighting unemployment. There are also regions with high values of this coefficient, in which the policy of stimulating production should be more effective. In the regions with lower Okun's coefficients, a successful anti-unemployment policy should be different. As the unemployment problems in these regions are connected with the transformation from agricultural economy to an industrial one, accompanied with the withdrawal of industry after the transformation, the optimal economic policy should involve such measures as promoting mobility, investments in human capital and developing more technologically advanced industries. In the long run, it would be optimal for all regions to promote acceleration of growth. However, in the short or even medium horizon, one has to account for the differences between the regions and diversification of their macroeconomic structure.

References

Adanu, K., 2005, "A cross-province comparison of Okun's coefficient for Canada", *Applied Economics*, 37, 561–570.

Ando, T., and Zellnery, A., 2010a, "Hierarchical Bayesian analysis of the seemingly unrelated regression and simultaneous equations models using a combination of direct Monte Carlo and importance sampling techniques", *Bayesian Analysis*, 5, 65–95.

Ando, T., and Zellnery, A., 2010b, "A direct Monte Carlo approach for Bayesian analysis of the seemingly unrelated regression model", *Journal of Econometrics*, 159, 33–45.

Apergis, N., and Rezitis, A., 2003, "An examination of Okun's law: Evidence from regional areas in Greece", *Applied Economics*, 35, 1147–1151.

Breusch, T., and Pagan, A., 1980, "A LM test for heteroscedasticity and random coefficient variation", *Review of Economic Studies*, 47, 239–254.

Christopaulos, D., 2004, "The relationship between output and unemployment: evidence from Greek regions", *Papers in Regional Science*, 83(3), 611–620.

Dykas, P., Misiak, T., and Tokarski, T., 2013, "Czynniki kształtujące regionalne zróżnicowanie stóp bezrobocia rejestrowanego w Polsce w latach 2002–2010", *Humanities and Social Sciences*, 20(1), 9–22.

Freeman, D.G., 2000, "Regional rests of Okun's law", *International Advances in Economic Research*, 5, 557–570.

Gajderowicz, T., Grotkowska, G., Wincenciak, L., and Wirtek, E., 2014, "Wrażliwość stóp bezrobocia względem wahań PKB w przekroju województw", *Ekonomia*, 39, 29–58.

Geary, R.C., 1954, "The contiguity ratio and statistical mapping", *The Incorporated Statistician*, 5(3), 115–145.

Greene, W.H., 2008, *Econometric Analysis*, Upper Saddle River, NJ: Prentice Hall.

Hutengs, O., and Stadtmann, G., 2014, "Don't trust anybody over 30: Youth unemployment and Okun's law in CEE countries", *Bank i Kredyt*, 45, 1–16.

Lütkepohl, H., 2006, *New Introduction to Multiple Time Series Analysis*, Berlin: Springer.

Maddala, G.S., 2001, *Introduction to Econometric*, New York: John Wiley & Sons.

Majchrowska, A., Mroczek, K., Tokarski, T., 2013, "Zróżnicowanie stóp bezrobocia rejestrowanego w układzie powiatowym w latach 2002–2011", *Gospodarka Narodowa*, 265, 69–90.

Moran, P.A.P., 1950, "Notes on Continuous Stochastic Phenomena", *Biometrika*, 37(1), 17–23.

Okun, A., 1962, "Potential GNP: its measurement and significance", *American Statistical Association, Proceedings of the Business and Economics Section*, 98– 103.

Permana, R., and Tavera, C., 2005, "A cross-country analysis of the Okun's law coefficient convergence in Europe", *Applied Economics*, 21, 2501–2513.

R Core Team, 2014, *R: A Language and Environment for Statistical Computing*, Vienna: R Foundation for Statistical Computing, Vienna, http://www.R-project.org.

Revoredo-Giha, C., Leat, P.M.K., and Renwick, A.W., 2012, "The relationship between output and unemployment in Scotland: A regional analysis", *Land Economy Working Paper Series*, 65.

Villaverde, J., and Maza, A., 2009. "The robustness of Okun's law in Spain, 1980–2004: Regional evidence, *Journal of Policy Modeling*, 31, 289–297.