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The Synchronization of Regional Business Cycles with Nationwide Cycles

A b s t r a c t. This paper attempts to assess the level of synchronization between the business cycles of Poland's regions and those of the country as a whole. The measure of economic activity was an index of total industrial output sold, recorded monthly from January 1999 to December 2008, adjusted for seasonal and random fluctuations. The analysis of dominant business cycles was performed using spectral analysis. To assess the synchronization of cycles, characteristics of cospectral analysis were used: coefficient of coherence, amplitude intensification and phase difference. In the conclusion, an attempt is made to construct a synthetic indicator as a means of ranking the regions by degree of business cycle synchronization.

K e y w o r d s: spectral analysis, cospectral analysis, business cycle, synthetic indicator.

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1. Introduction

Comparison of the level of economic activity in Poland's regions (also called *provinces* or *voivodeships*) with that of the nation as a whole provides a source of information for both the regional authorities and central government. From a macroeconomic point of view, the observation of changes in a region may be an important factor for evaluating the effectiveness of anti-cyclic policy and monitoring the channels by which fluctuations spread.

The concept of synchronization of fluctuations is understood to relate to analysis of particular components of the business cycle in terms of similarity of shape, amplitude of fluctuations and relative time lags. To perform such an analysis, a measure of economic activity must be adopted. In the empirical investigation, the measure used was the monthly recorded indices of total sold industrial output from January 1999 to December 2008 (PR_IR_t = $=100 \cdot PR\_IR_t / PR\_IR_{t-12}$), adjusted to eliminate seasonal and random fluctuations (*Statistica 8* program, *Census 2* method). Hence the concept of economic activity is associated with changes resulting from the joint effect of growth factors and business cycle fluctuations. Frequency domain analysis was carried out, including both spectral and cospectral analysis.

Spectral analysis, in relation to the Polish economy, has been primarily used in macroeconomic research[1], because its use depends on a sufficient length of time series[2]. The fact that the present regional division of Poland has only been in existence since 1999 was a significant barrier in applying the spectral analysis.

2. Tools of Spectral and Cospectral Analysis

Spectral and cospectral analysis refer to stationary stochastic processes and to the frequency domain. Transition from the time domain to the frequency domain is accomplished by means of Fourier transformation. In the study, the stationarity assumption of the stochastic process was verified using the Dickey–Fuller (ADF) test.

Spectral analysis leads to the determination of a *power spectrum*, namely a spectrum of the considered time series:

$$f(\omega)=\frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty}K(\tau)\cos\omega\tau=\frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty}e^{-i\omega\tau}K(\tau) \quad \text{for} \quad \omega\in[-\pi,\pi], \tag{1}$$

where $K(\tau)$ is the autocovariance function, $\tau = t\text{–}s$ is the distance between the two analysed points in time, and $\omega = 2\pi/N$ is the frequency of harmonic components.

The power spectrum constitutes a distribution of variance of the analysed time series and makes it possible to identify the harmonic structure of the series and determine the contribution of individual components of the series to the variance of the process.

Joint spectral analysis enables testing the relations between particular frequencies of two time series. The basic magnitude in this case is the *cross-spectrum*, which is a distribution of the joint covariance of the two processes $K_{yx}(\tau)$:

$$f_{yx}(\omega)=\frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty}K_{yx}(\tau)\cos\omega\tau=\frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty}e^{-i\omega\tau}K_{yx}(\tau) \quad \text{for} \quad \omega\in[-\pi,\pi]. \tag{2}$$

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[1] Cf. for example P. Skrzypczyński (2006, 2008), S. Dudek, D. Pachucki, K. Walczyk (2008); include review of research with regard to synchronization of fluctuations, L. Talaga, Z. Zieliński (1986).

[2] In the literature it is stated that the minimum length of a time series should be such as to include approximately 100 observations.

Using De Moivre's lemma, the cross-spectrum can be written in complex form:

$$f_{yx}(\omega) = \frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty} K_{yx}(\tau)\cos\omega\tau - i\frac{1}{2\pi}\sum_{\tau=-\infty}^{\infty} K_{yx}(\tau)\sin\omega\tau = \\ = c_{yx}(\omega) - iq_{yx}(\omega), \quad (3)$$

where $c_{yx}(\omega)$ is the *co-spectrum* (the real part of the cross-spectrum);

$q_{yx}(\omega)$ is the *quadrature spectrum* (the negative imaginary part of the cross-spectrum).

In cospectral analysis three characteristics are introduced which form a basis for comparison of the course of two processes. In the study, the variable *X* was associated with a series of nationwide output indexes, while the variable *Y* was associated with the corresponding series for a region.

a) Gain of the variable *X* with respect to *Y* is interpreted as the modulus of the coefficient β in the regression of variable *Y* with respect to *X* for a given frequency ω ($G_{yx}(\omega) > 1$ means that the amplitude of process y_t for frequency ω is associated with a lower amplitude of process x_t):

$$G_{yx}(\omega) = \frac{[c_{yx}(\omega)^2 + q_{yx}(\omega)^2]^{0,5}}{f_x(\omega)} \quad , \quad G_{yx}(\omega) \geq 0 \quad for\ \omega \in [-\pi;\pi]. \quad (4)$$

b) The phase difference identifies leads or lags of variable *X* with respect to *Y* (a positive value represents a lag, a negative value represents a lead) for frequency ω:

$$\phi_{yx}(\omega) = arctg\left(\frac{-q_{yx}(\omega)}{c_{yx}(\omega)}\right) \quad for\ \omega \in [-\pi;\pi]. \quad (5)$$

c) Coherence is a measure of the fit (R^2) in the regression of *Y* with respect to *X* for frequency ω:

$$K_{yx}^2 = \frac{c_{yx}(\omega)^2 + q_{yx}(\omega)^2}{f_x(\omega)\cdot f_y(\omega)} \quad , \quad 0 \leq K_{yx}^2(\omega) \leq 1\ for\ \omega \in [-\pi;\pi]. \quad (6)$$

In the empirical analyses we consider only such leads or lags at a given frequency which is associated with a high value of the coefficient of coherence (for strongly correlated frequency components).

3. Study Results in Frequency Domain

Theoretically, when adjusted for seasonal and random fluctuations, the annual indices of industrial output represent changes resulting not only from the business cycle, but also the underlying trend. The ADF test applied to the

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annual indices of output adjusted for seasonal and random fluctuations, in the case of the series for each of the analysed regions, indicated a significant negativity of the parameter δ in the model (7):

$$\Delta PR\_IR_t = \delta PR\_IR_{t-1} + \sum_{k=1}^{k} \delta_i \Delta PR\_IR_{t-i} + \varepsilon_t . \tag{7}$$

The ADF test statistics rejects the null hypothesis of unit root at the α = 0.001 significance level assuming first order autoregression (k=1). The stationarity of the time series means that any stochastic trend occurring in the annual indices of output can be regarded as a realization of low-frequency fluctuations.

For example, figure 1 shows indices of total industrial output sold for Poland. Test for stationarity was carried out based on the model:

$$\Delta PR\_IR_t^{POL} = -0.032 PR\_IR_{t-1}^{POL} + 0.95 \Delta PR\_IR_{t-1}^{POL} .$$

For parameter δ = -0,032 the statistic ADF is equal to -6.128.

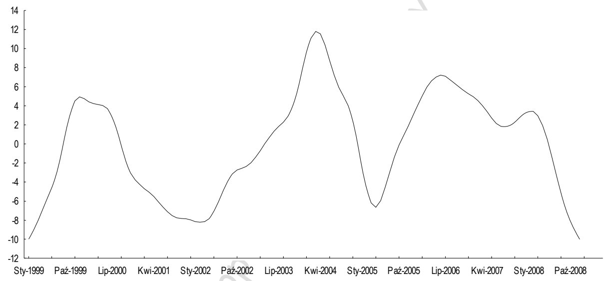

Figure 1. Indices of total industrial output sold for Poland from January 1999 to December 2008

Analysis of the dominant cycles was carried out based on the power spectrum. For a clear majority of regions it is possible to indicate one cycle which to a significant degree explains the fluctuations in the output indices (shown in bold type in Table 1).

The 40-month cycle turned out to be such a dominant cycle. In the case of the nationwide cycle it explains more than 52% of the variability of output indices**.** The effect of the remaining cycles is quite different. For the Wielkopolskie region we can notice an equivalent effect from three cycles (120, 60 and 40 months). Generally it is possible to identify groups of regions where economic activity is ruled by long cycles (120, 60 months), medium cycles (40, 30 months) and short cycles (24, 20 months). The regions with dominating long cycles are as follows: Lubuskie (59.8%), Wielkopolskie (59.05%) and Mazowieckie (58.27%). Medium cycles dominate in Podkarpackie (70.86%), Zachodniopomorskie (70.24%), Świętokrzyskie (63.41%) and Warmińsko-Mazurskie (62.97).

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Table 1. Dominant cycles: percentage of explained variability of the time series

Length of time Series	Regions	Frequency (duration in months)					
		0.008 (120)	0.017 (60)	0.025 (40)	0.033 (30)	0.042 (24)	0,050 (20)
120	POLAND	9.46	6.19	52.10	0.92	15.61	4.42
120	Dolnośląskie	3.46	8.94	42.43	6.97	5.17	4.51
120	Kujawsko-Pomorskie	3.99	13.75	40.01	4.70	16.71	8.90
120	Lubelskie	0.33	6.94	40.48	14.52	11.04	1.35
120	Lubuskie	15.33	44.46	6.73	16.65	0.44	0.20
120	Łódzkie	41.14	5.33	20.46	5.79	7.51	1.50
120	Małopolskie	6.96	3.14	33.43	13.37	3.19	2.82
118	Mazowieckie*	17.88	40.39	18.58	0.28	7.54	7.69
60	Opolskie***	xxx	29.66	xxx	37.53	xxx	2.26
120	Podkarpackie	6.21	9.77	59.26	11.61	3.53	5.87
120	Podlaskie	13.50	7.94	30.51	8.49	3.35	3.92
120	Pomorskie	7.11	12.90	10.20	20.38	14.58	25.72
114	Śląskie**	0.97	12.96	28.62	6.23	16.56	3.04
120	Świętokrzyskie	5.17	6.90	62.12	1.28	4.67	0.61
120	Warmińsko-Mazurskie	15.81	2.89	59.74	3.23	14.57	0.11
120	Wielkopolskie	28.03	31.01	30.41	0.21	3.19	6.73
120	Zachodniopomorskie	10.02	7.32	67.58	2.66	1.47	1.77

Note: With a number of observations less than 120, the length of the analysed cycles changes: * 118, 59, 39.3, 29.5, 23.6, 19.7; ** 114, 57, 38, 28.5, 22.8, 19; ***60, 30, 20 months.

Short cycles dominate mainly in Pomorskie (40.30%). In the mentioned above regions, the variability of the series of output indices is explained to a much higher degree than for Poland as a whole, where long cycles explain hardly 15.65%, medium cycles 53.02% and short cycles 20.02%. Taking dominant cycles as a criterion, the greatest similarity to nationwide activity was displayed by those regions where medium-length cycles dominate. Therefore the greatest synchronization is observed in the Warmińsko-Mazurskie and Świętokrzyskie regions.

Cospectral analysis was performed for all cycles lasting from 20 to 120 months[3]. The cospectral analysis characteristics are presented in Tables 2, 3 and 4.

The measure of correlation in particular fluctuation bands is the coefficient of coherence. The highest values of K^2 (which averages 0.933 across the regions) is observed for the dominant 40-month cycle and the long-term activity

[3] For three regions, some data could not be obtained. In those cases the cycles analysed are accordingly shorter. These regions are asterisked in the tables, and the duration of the components is given at the foot of the table. The shortest series, for the Opolskie region, allowed only 3 cycles to be analysed.

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represented by the 120-month cycle (average 0.830 across the regions). The most weakly correlated are the 30-month cycles (average K^2 across the regions: 0.451). The results obtained confirm certain intuitive suppositions that the differentiation in economic activity may refer to shorter cycles. In the long term a higher coherence can be expected between regional and nationwide economic activity. Analysing the various fluctuation bands, certain groups of regions can be identified where $K^2 \geq 0.95$ (shown in bold type in Table 2). For short, 24- and 20-month cycles there are far fewer such regions than for long cycles (120 and 60 months), which confirms the intuitive assumptions referred to above. Taking as a criterion the average value of K^2 for all frequencies, it is possible to identify the regions with high average coefficients of coherence (Mazowieckie and Wielkopolskie, with averages of 0.913 and 0.894 respectively) and with relatively low average coefficients of coherence (Lubuskie and Lubelskie, with averages of 0.448 and 0.491 respectively). The averages given are a measure of the mean correlation between the cycles distinguished for a given region and the nationwide cycles.

Table 2. Values of coefficient of coherence

Length of time Series	Regions	Frequency (duration in months)					
		0.008 (120)	0.017 (60)	0.025 (40)	0.033 (30)	0.042 (24)	0,050 (20)
120	Dolnośląskie	0.817	0.809	0.970	0.071	0.862	0.891
120	Kujawsko-Pomorskie	0.579	0.511	0.964	0.639	0.966	0.921
120	Lubelskie	0.219	0.691	0.948	0.038	0.822	0.227
120	Lubuskie	0.733	0.616	0.671	0.253	0.267	0.145
120	Łódzkie	0.982	0.361	0.940	0.461	0.938	0.667
120	Małopolskie	0.975	0.938	0.963	0.203	0.749	0.930
118	Mazowieckie*	0.960	0.737	0.897	0.972	0.977	0.934
60	Opolskie***	Xxx	0.967	Xxx	0.912	xxx	0.662
120	Podkarpackie	0.980	0.970	0.974	0.027	0.660	0.577
120	Podlaskie	0.955	0.856	0.984	0.553	0.827	0.692
120	Pomorskie	0.827	0.718	0.851	0.191	0.665	0.583
114	Śląskie**	0.644	0.870	0.964	0.360	0.917	0.887
120	Świętokrzyskie	0.923	0.909	0.993	0.526	0.912	0.100
120	Warmińsko-Mazurskie	0.964	0.060	0.975	0.746	0.967	0.437
120	Wielkopolskie	0.991	0.827	0.963	0.740	0.930	0.912
120	Zachodniopomorskie	0.993	0.986	0.995	0.531	0.707	0.573

Note: With a number of observations less than 120, the length of the analysed cycles changes: * 118, 59, 39.3, 29.5, 23.6, 19.7; ** 114, 57, 38, 28.5, 22.8, 19; ***60, 30, 20 months.

Gain coefficients make it possible to compare the amplitudes of cycles observed in a region with the amplitude of nationwide cycles within particular bands of fluctuations. Analysing the values given in Table 3, it is noticed that

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the average coefficients of intensification for 120- and 60-month cycles (1.141 and 1.296 respectively) indicate that on average, the amplitude of long-term fluctuations within regions is higher than the amplitude of nationwide fluctuations.

Table 3. Gain coefficients

Length of time Series	Regions	Frequency (duration in months)					
		0.008 (120)	0.017 (60)	0.025 (40)	0.033 (30)	0.042 (24)	0.050 (20)
120	Dolnośląskie	0.859	1.408	1.318	0.509	0.841	1.301
120	Kujawsko-Pomorskie	0.711	1.165	1.139	1.262	1.354	1.739
120	Lubelskie	0.180	1.029	1.126	0.432	1.026	0.387
120	Lubuskie	1.558	2.115	0.509	1.095	0.228	0.226
120	Łódzkie	1.822	0.519	0.555	0.687	0.619	0.463
120	Małopolskie	0.951	0.830	0.902	0.818	0.518	0.816
118	Mazowieckie*	1.273	1.646	0.602	0.565	0.674	1.070
60	Opolskie***	xxx	1.486	xxx	1.733	xxx	0.496
120	Podkarpackie	0.974	1.344	1.246	0.314	0.529	0.925
120	Podlaskie	0.792	0.639	0.524	0.672	0.322	0.524
120	Pomorskie	1.147	1.339	0.635	1.144	1.213	2.304
114	Śląskie**	0.473	1.609	1.312	1.073	1.701	1.282
120	Świętokrzyskie	1.163	1.600	1.737	1.184	0.836	0.240
120	Warmińsko-Mazurskie	1.457	0.256	1.234	1.215	1.106	0.399
120	Wielkopolskie	1.985	1.856	0.883	0.662	0.531	1.202
120	Zachodniopomorskie	1.773	1.888	1.959	1.426	0.489	0.771

Note: With a number of observations less than 120, the length of the analysed cycles changes: * 118, 59, 39.3, 29.5, 23.6, 19.7; ** 114, 57, 38, 28.5, 22.8, 19; 60, 30, 20 months.

In turn, the short cycles (24 and 20 months, with average values 0.799 and 0.884 respectively) are characterized by a higher amplitude of nationwide fluctuations. Closest to unity are the average gain coefficients for medium-term fluctuations (40 and 30 months, average values 1.045 and 0.924 respectively), which indicate the greatest degree of synchronization with nationwide fluctuations.

For each band of fluctuations it is also possible to indicate the region displaying the greatest synchronization with the nationwide cycle:

- Podkarpackie and Małopolskie for the 120-month cycle;
- Lubelskie for the 60-month cycle;
- Małopolskie for the 40-month cycle;
- Śląskie for the 30-month cycle;
- Lubelskie for the 24-month cycle;
- Mazowieckie for the 20-month cycle.

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Table 4. Phase difference in radians (in months)

Length of time series	Regions	Frequency (duration in months)					
		0.008 (120)	0.017 (60)	0.025 (40)	0.033 (30)	0.042 (24)	0,050 (20)
120	Dolnośląskie	-0.563 (-10.8)	0.485 (4.6)	0.017 (0.1)	0.527 (2.5)	0.652 (2.5)	1.058 (3.4)
120	Kujawsko-Pomorskie	-1.490 (-28.5)	1.099 (10.5)	0.048 (0.3)	0.045 (0.2)	1.043 (4.0)	0.654 (2.1)
120	Lubelskie	-0.760 (-14.5)	1.099 (10.5)	0.421 (2.7)	-0.502 (-2.4)	0.123 (0.5)	2.339 (7.4)
120	Lubuskie	-1.215 (-23.2)	0.497 (4.7)	0.722 (4.6)	0.278 (1.3)	1.299 (5.0)	1.762 (5.6)
120	Łódzkie	-1.766 (-33.7)	-1.147 (-11.0)	0.556 (3.5)	1.194 (5.7)	1.428 (5.5)	0.323 (1.0)
120	Małopolskie	-0.212 (-4.0)	0.338 (3.2)	0.170 (1.1)	-0.706 (-3.4)	-0.132 (-0.5)	-0.026 (-0.1)
118	Mazowieckie*	-0.635 (-11.9)	-0.682 (-6.4)	-0.081 (-0.5)	-0.097 (-0.5)	-0.087 (-0.3)	-0.424 (-1.3)
60	Opolskie***	xxx	0.145 (1.4)	xxx	-0.420 (-2.0)	xxx	-0.221 (-0.7)
120	Podkarpackie	-0.444 (-8.5)	-0.087 (-0.8)	0.072 (0.5)	1.038 (5.0)	2.261 (8.6)	-0.972 (-3.1)
120	Podlaskie	-0.624 (-11.9)	0.419 (4.0)	0.743 (4.7)	0.677 (3.2)	1.563 (6.0)	2.140 (6.8)
120	Pomorskie	-0.615 (-11.7)	0.797 (7.6)	0.531 (3.4)	0.740 (3.5)	-1.431 (-5.5)	1.626 (5.2)
114	Śląskie**	-0.002 (-0.04)	0.449 (4.1)	0.018 (0.1)	0.881 (4.0)	-0.404 (-1.5)	0.143 (0.4)
120	Świętokrzyskie	-0.268 (-5.1)	0.520 (5.0)	0.280 (1.8)	0.526 (2.5)	0.693 (2.6)	-1.892 (-6.0)
120	Warmińsko-Mazurskie	-2.058 (-39.3)	-1.711 (-16.3)	-0.266 (-1.7)	-0.068 (-0.3)	1.070 (4.1)	1.186 (3.8)
120	Wielkopolskie	0.438 (8.4)	0.139 (1.3)	-0.163 (- 1.0)	-0.129 (- 0,6)	-0.676 (- 2.6)	-0.594 (- 1.9)
120	Zachodniopomorskie	0.302 (5.8)	-0.070 (-0.7)	-0.170 (-1.1)	-0.429 (-2.0)	0.379 (1.4)	-2.003 (-6.4)

Note: With a number of observations less than 120, the length of the analysed cycles changes: * 118, 59, 39.3, 29.5, 23.6, 19.7; ** 114, 57, 38, 28.5, 22.8, 19; 60, 30, 20 months.

The phase differences presented in Table 4 enable analysis of the leads and lags of nationwide components of the business cycle relative to the corresponding components for a region. It should be noted that for most regions (apart from Wielkopolskie and Zachodniopomorskie), the 120-month cycle, connected with long-term activity, displays a lag with respect to nationwide activity. The longest lags are found in this fluctuation band (more than three years for the Warmińsko-Mazurskie region). For each component of the cycle it is possible to indicate the regions where economic activity runs in parallel with nationwide activity (without leading or lagging). However these results are different from those obtained using amplitude of fluctuations as a criterion. The greatest

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number of regions, for which the phase difference in radians is smaller in absolute value than 0.1, can be indicated as having a dominant 40-month cycle. Such a phase difference is associated with lags (leads) in economic activity by up to one month. These are the regions Dolnośląskie, Kujawsko-Pomorskie, Mazowieckie, Podkarpackie and Śląskie.

4. Indicator of Synchronization of Fluctuations

To summarise the study, an attempt was made to build a synthetic indicator as a basis for assigning ranks to each region depending on the degree of synchronization of fluctuations. For this purpose three characterictics of cospectral analysis were used, together with a cycle pattern perfectly synchronized with the national cycle. Such a cycle would be a cycle observed in a region having $K^2 = 1$, $G(\omega) = 1$ and $\phi(\omega) = 0$ (maximum correlation, no intensification of fluctuations and no phase difference).

Table 5. Synthetic indicators and ranks for individual regions

Regions	Partial synthetic indicators						Final synthetic indicator	Ranks
	Frequency (duration in months)							
	0.008 (120)	0.017 (60)	0.025 (40)	0.033 (30)	0.042 (24)	0,050 (20)		
Dolnośląskie	0.179	0.239	0.094	0.519	0.181	0.265	0.175	2
Kujawsko-Pomorskie	0.431	0.367	0.055	0.197	0.251	0.309	0.191	4
Lubelskie	0.586	0.270	0.110	0.546	0.085	0.755	0.220	7
Lubuskie	0.407	0.487	0.341	0.320	0.633	0.742	0.429	15
Łódzkie	0.468	0.505	0.213	0.435	0.322	0.298	0.388	14
Małopolskie	0.051	0.113	0.062	0.420	0.228	0.075	0.148	1
Mazowieckie*	0.174	0.353	0.149	0.135	0.103	0.101	0.235	11
Opolskie***	xxx	0.156	xxx	0.277	Xxx	0.276	0.226	9
Podkarpackie	0.077	0.111	0.082	0.657	0.559	0.303	0.185	3
Podlaskie	0.158	0.201	0.233	0.334	0.455	0.532	0.255	12
Pomorskie	0.184	0.297	0.220	0.420	0.373	0.708	0.436	16
Śląskie**	0.257	0.264	0.095	0.364	0.265	0.131	0.196	6
Świętokrzyskie	0.106	0.259	0.231	0.284	0.171	0.772	0.227	10
Warmińsko-Mazurskie	0.422	0.756	0.106	0.152	0.191	0.515	0.192	5
Wielkopolskie	0.317	0.298	0.66	0.194	0.240	0.166	0.222	8
Zachodniopomorskie	0.243	0.242	0.271	0.331	0.285	0.490	0.272	13

Note: With a number of observations less than 120, the length of the analysed cycles changes: * 118, 59, 39.3, 29.5, 23.6, 19.7; ** 114, 57, 38, 28.5, 22.8, 19; 60, 30, 20 months.

For each region in each band of fluctuations, the modulus of the distance from the pattern was analysed. These distances were normalized according to the simple formula: modulus of observed distance divided by maximum distance. This approach meant that the range of variability could be normalized and the

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distances made independent of the units used. The partial synthetic indicator in a given band is the arithmetic mean of the normalized distances. The final synthetic indicator for a given region, encapsulating information from all bands, was based on a weighted average, where the weights reflected the degree of variability explained by each component of the cycle. The values of the synthetic indicators and the ranks assigned to each region are presented in Table 5. The smaller the value of the synthetic indicator, the smaller the distance from the model. Hence a rank of 1 denotes the highest degree of synchronization.

5. Summary

Summing up the results of the spectral and cospectral analysis, it is possible to identify one cycle which is dominant both for nationwide activity and for the majority of the regions. This is the 40-month cycle, which also displays the greatest synchronization when nationwide changes are compared with the changes observed in the regions. However, the classification of the regions varies depending on the criterion adopted for comparison.

The indicator constructed in subsection 4 can take values from 0 to 1. The final values of the indicator appearing in the table lie within the interval [0.148, 0.436]. The relative narrowness of this interval and the values of the synthetic indicator (< 0.5) indicate a high level of synchronization between the business cycles recorded in the regions and those of the country as a whole.

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Synchronizacja cykli koniunkturalnych województw z cyklami ogólnokrajowymi

Z a r y s t r e ś c i. W artykule podjęto próbę oceny stopnia synchronizacji cykli koniunkturalnych województw Polski z cyklami ogólnokrajowymi. Miernikiem aktywności gospodarczej były rejestrowane miesięcznie od stycznia 1999 do grudnia 2008 indeksy produkcji sprzedanej przemysłu ogółem oczyszczone z wahań sezonowych i przypadkowych. Analizę dominujących cykli koniunkturalnych przeprowadzono z wykorzystaniem analizy spektralnej. Do oceny synchronizacji cykli wykorzystano charakterystyki analizy kospektralnej: współczynnik koherencji, wzmoc-

nienie amplitudy oraz przesunięcie fazowe. W podsumowaniu artykułu podjęto próbę budowy miernika syntetycznego, który był podstawą przypisania rang poszczególnym województwom ze względu na stopień synchronizacji cyklu koniunkturalnego.

S ł o w a k l u c z o w e: analiza spektralna, analiza kospektralna, cykl koniunkturalny, miernik syntetyczny.

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