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# WAVELET ANALYSIS OF UNEMPLOYMENT RATE IN VISEGRAD COUNTRIES

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**Abstract.** Visegrad countries, Poland, Slovakia, Czech Republic and Hungary have common history and have faced the same challenges created by globalisation process for the last three decades. They have successfully transformed from central planned to market economies. They have implemented fundamental reforms of their whole institutional systems and finally joined the European Union in the year 2004. During this process the most significant changes, which were directly influenced by opening of these economies in the reality of globalisation, have been seen on the labour markets. From the policy point of view the labour markets are always considered as crucial for social and macroeconomic stability of economies. This forces the economists to constant empirical research in this field. In this context the aim of the article is to conduct comparative analysis of the unemployment phenomena in the four countries. For this purpose wavelet analysis was applied. In the research a discrete wavelet transformation was used, which has been recently effectively used for analysis of macroeconomic indicators. The empirical research was conducted for the years 1998-2016 and it was based on the Eurostat data. In the research the following hypothesis was verified: the phenomenon of unemployment in the case of Poland, Slovakia and Hungary is formed in a quite similar way, whereas in Czech Republic the situation on the labour markets is mainly determined by factors of different nature.

**Keywords:** unemployment, wavelet analysis, multiresolution analysis, Visegrad countries

**JEL Classification:** E2, E24, C45

## 1. Introduction

Visegrad countries are currently considered as an example of effective transformation from central planned to market economy. The countries are often pointed as benchmark cases of modernisation process, which have increased their competitiveness in globalised economy. This achievement was based on fundamental institutional reforms (Balcerzak, 2009; 2015; Balcerzak & Pietrzak, 2015a, 2016a), significant technological changes and adequate improvement of quality of human capital (Cieślak, 2014; Balcerzak, 2016a; 2016b; Balcerzak & Pietrzak, 2015b, 2016b, 2016, c, 2017), and finally relatively effective fiscal stabilisation policy (Balcerzak et al. 2016; Balcerzak & Rogalska, 2016). All these fundamental changes were affecting situation on labour markets in these countries (Müller-Frańczek, & Pietrzak 2011; Zieliński, 2015; Bieszk-Stolorz & Markowicz, 2015; Woźniak-Jęchorek, 2015; Pietrzak & Balcerzak, 2016a). On the other hand, the situation on the labour markets was significantly affecting the above mentioned factors. As a result, relatively effective labour

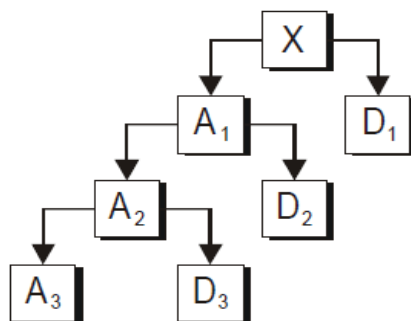
market policy was a key element supporting modernisation of these economies in the reality of globalisation. Thus, the labour markets of these economies can be the subject of interesting comparative research.

In this context, the aim of the article is the analysis of long term tendencies on the labour markets of Visegrad countries. Specifically the evaluation of fluctuations of unemployment rate for the pointed trends is conducted in the article. Large fluctuations of the unemployment rate indicate high vulnerability of labour markets to exogenous factors coming from global economy. Its low fluctuations indicate relatively high stability of the labour markets. In the research wavelet analysis was applied, which enabled to assess the tendencies and the scale of valuations of unemployment rate in the years 1998-2016. The research enables to conclude that the labour markets of the four Visegrad countries react differently to exogenous factors coming from the globalized economy.

## 2. Wavelet analysis

A multiresolution analysis can be considered as a tool for time series analysis that is relevant to wavelet analysis. This approach relies on a processing of time series at various levels of resolution as a result of their decomposition into two functions, which are known as approximation and detail. At each level the approximation from previous level is again decomposed into two parts: approximation and detail. The idea of multiresolution analysis is presented in Figure 1.

Figure 1: Multiresolution analysis



Source: own work.

In the multiresolution analysis a wavelet decomposition is applied, where discrete wavelet transformation can be used. The wavelet analysis is the development of the Fourier analysis, which allows a presentation of a given process only in a frequency domain. The pointed development consists of adding time domain, which means that the wavelet analysis allows to determine the moments, in which significant changes in the process occurred. More specific presentations of the multiresolution analysis and applications of wavelets are given by Mix & Olejniczak (2003), Dooms & Daubechies (2011) and Hadaś-Dyduch (2015a, 2016a, 2016b, 2016c, 2016d).

Wavelets we call function  $\Psi(x) \in L^2(\mathbb{R})$ , such that the system function (see: Mix, & Olejniczak, 2003):

$$B_{\Psi} = \left\{ 2^{\frac{j}{2}} \Psi(2^j x - k) \right\}; \quad j \in \mathbb{Z}, \quad k \in \mathbb{Z} \quad (1)$$

is an orthonormal basis in the space  $L^2(\mathbb{R})$ . Family  $B_\psi$  is called wavelet base.

The simplest wavelet is the Haar wavelet. The Haar wavelets we call a function on the real line  $\mathbb{R}$  defined by the formula (see: Dooms & Daubechies (2011); Hadaś-Dyduch, 2015b, 2015c; Mix & Olejniczak, 2003):

$$H(x) = \begin{cases} 1 & \text{for } x \in \left[0, \frac{1}{2}\right) \\ -1 & \text{for } \left[\frac{1}{2}, 1\right) \\ 0 & \text{for other } x \end{cases} \quad (2)$$

The Haar wavelet is considered as a special case of Daubechies wavelet (db1). The Daubechies wavelets are marked db1, db2, db3 respectively, where the number on the right of the symbol describes the level of regularity of the wavelet. The Daubechies wavelet is a wavelet  $\psi$ , which is given with the formula 3 (see: Dooms & Daubechies (2011)):

$$\psi(r) = -\frac{1+\sqrt{3}}{4}\varphi(2r-1) + \frac{3+\sqrt{3}}{4}\varphi(2r) - \frac{3-\sqrt{3}}{4}\varphi(2r+1) + \frac{1-\sqrt{3}}{4}\varphi(2r+2) \quad (3)$$

$$\psi(r) = 0 \text{ dla } r < -1 \text{ lub } r > 2.$$

It should be mentioned that the wavelets are defined as wavelet functions and scaling functions. The wavelet functions are commonly called the mother wavelets, and the scaling wavelet are called the father wavelet. As Addison (2002) stresses: “ (...) the wavelet function is in effect a band-pass filter and scaling it for each level halves its bandwidth. This creates the problem that in order to cover the entire spectrum, an infinite number of levels would be required. The scaling function filters the lowest level of the transform and ensures all the spectrum is covered (...). For a wavelet with compact support,  $\varphi$  can be considered finite in length and is equivalent to the scaling filter  $g$ ”.

For Daubechies wavelet  $\psi$  scaling function can be given with formula 4 (Dooms & Daubechies, 2011):

$$\varphi(r) = \frac{1+\sqrt{3}}{4}\varphi(2r) + \frac{3+\sqrt{3}}{4}\varphi(2r-1) + \frac{3-\sqrt{3}}{4}\varphi(2r-2) + \frac{1-\sqrt{3}}{4}\varphi(2r-3), \quad (4)$$

where:

$$\sum_{k \in \mathbb{Z}} \varphi(k) = 1, \quad \varphi(r) = 0 \text{ for } r \leq 0 \vee r \geq 3,$$

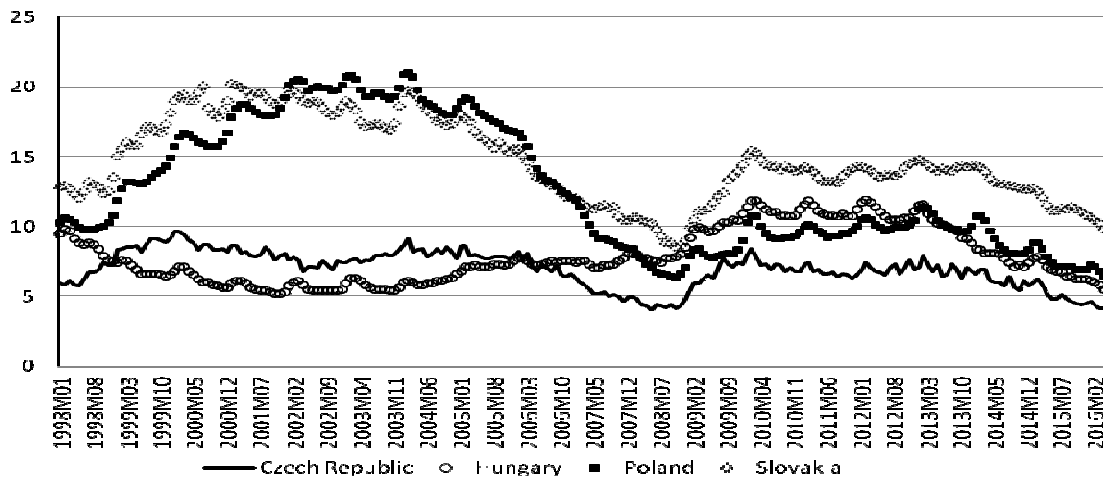
$$\varphi: D \rightarrow \mathbb{R}, \quad D_j = \{k2^j : k \in \mathbb{Z}\}, \quad D = \bigcup_{j \in \mathbb{Z}} D_j = \bigcup_{j=0}^{\infty} D_j.$$

Daubechies proved that the building block function  $\varphi$  does not admit any algebraic formula in terms of elementary mathematical functions.

### 3. Empirical analysis

The subject of the research is the unemployment rate in the Visegrad economies. In the analysis Eurostat monthly time series for the period: January 1998–April 2016 were used, which gave 220 observations. The data is presented in Figure 2.

Figure 2. Monthly unemployment rate in Visegrad Countries

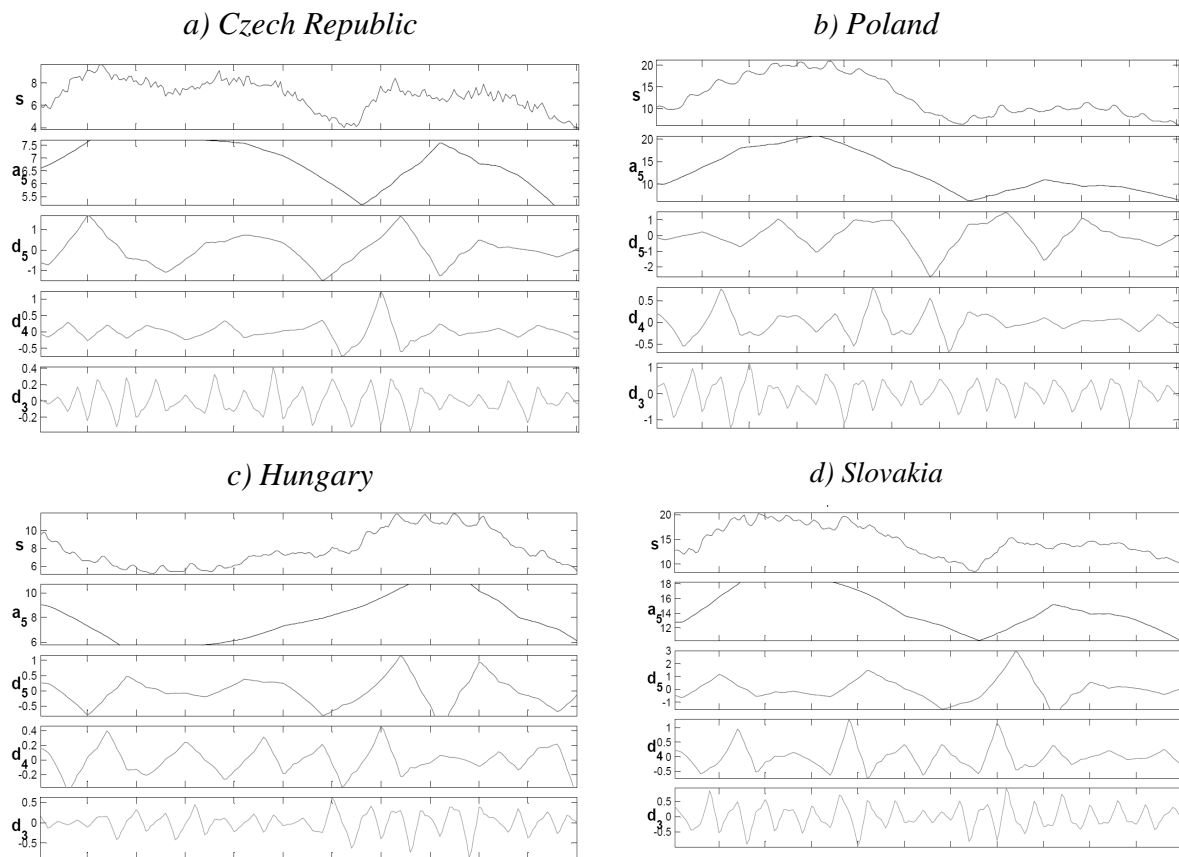


Source: Eurostat data. Retrieved from [http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=une\\_rt\\_m&lang=en](http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=une_rt_m&lang=en).

For the given time series five stage wavelet decomposition was conducted. In the research db3 wavelet was applied. The results of wavelet decomposition for the four Visegrad countries are presented in Figure 4. Based on the five-level wavelet decomposition approximation a5 and details d5, d4, d3 were chosen. Approximation a5 is the most smooth series. As a result, it presents long term tendencies of unemployment rate for analysed countries. On the other hand, the details d5, d4 and d3 describe the fluctuations of unemployment rate around the long term trend. Detail d5 describes the fluctuations around the trend in the period 16 to 32 months, and the detail d3 the fluctuations from 8 to 16 months.

An analysis of time series given in Figure 2 and approximations a5 presented in Figure 3 enables assessing long term tendencies for the unemployment in the years 1998-2016. From the long term perspective the best situation of a labour market can be found in Czech Republic, where unemployment rate varies from 4 to 10%, whereas in the case of Poland and Slovakia it is 7–21%. However, the most interesting difference between the countries can be seen in the case of Hungary. For Poland, Czech Republic and Slovakia the period after accession to the EU is a time of constant improvement of the situation on the labour markets, which was interrupted by the global financial crisis. However, the Hungarian labour market was not benefiting so much from the accession to the EU, as the unemployment rate was growing after the year 2004. Figures 2 and 3 also confirm the negative effect of the global financial crisis on the labour markets of the region, where the worst situation could be found in Slovakia.

Figure 3: Wavelet decomposition for Visegrad countries



Source: own calculation.

However, really interesting information on the given labour markets can be obtained after analysis of details  $d_5$ ,  $d_4$  and  $d_3$ . Due to the fluctuation periods it can be established that the detail  $d_5$  indicates fluctuations around the long-term cycle (3-5 years). Detail  $d_4$  indicates fluctuations around the medium-term cycle (2-3 years), and detail  $d_3$  presents the annual variations. Taken into consideration the detail  $d_3$ , it is clear that the smallest fluctuations could be found on the Czech market, whereas the largest ones were present in Poland. This indicates that in Poland the labour market is strongly disturbed by annual variations of other macroeconomic economic factors, whereas in Czech Republic the negative consequences of these distributions are much lower. As a result, the Czech labour market is characterized with high stability with relatively low level of unemployment. From the perspective of social sustainability this stability hand in hand with relatively low level of unemployment can be considered as a strong point of Czech economy (see Pietrzak & Balcerzak, 2016b; Balcerzak & Pietrzak, 2016c).

Detail  $d_4$  volatility indicates that after the global financial crisis, there was a significant reduction in the 2-3 years fluctuations, which is the result of a stabilization of the labour market in Visegrad countries. For detail  $d_4$  in the case of Czech Republic one can find only one high peak associated with the global financial crisis.

Detail d5 analysis allows to conclude that as a result of the global financial crisis in Slovakia an increased fluctuations peak of the period 3-5 could be seen, which was significantly higher than in other countries. This factor confirms that the Slovak labour market was the most vulnerable in the region to exogenous global macroeconomic shocks.

In the end, it is also evident that the greatest downward peak, which was the result of an improvement in the labour market appeared for Poland in the period 2004-2007, and the lowest one for Hungary.

#### **4. Conclusion**

The article concentrated on the empirical analysis of unemployment rate for the Visegrad countries in the years 1998-2016 with application of wavelets. Simultaneous analysis of Polish, Czech, Hungarian and Slovak labour markets can be justified due to macroeconomic, institutional and historical similarities of these countries. The whole group was able to transform successfully their economies from central planned to market oriented systems, where the labour markets reforms were the crucial element of this process. Additionally, the simultaneous research on the labour markets of the group can be useful in assessing differences in their vulnerability to global exogenous shocks, which is useful in finding good policy practices and guidelines for potential reforms.

In the paper based on the wavelet analysis long-term tendencies for the unemployment rate were identified and the middle and short term fluctuations from the established trends were analysed. The research has revealed significant differences in the functioning of the labour market in the group and confirmed that the markets are characterized with a different stability.

In the group of analyses countries the best situation on the labour market can be found in Czech Republic, which is characterized not only with relatively low level of unemployment rate, but the market can be characterized with relatively high stability. On the other hand, the lowest effectiveness of the labour markets can be found in the case of Poland and Slovakia.

In the end, it can be also seen that after the disturbances resulted from the global financial crisis the situation on the labour markets of the Visegrad countries appears to be stabilizing.

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