PREDICTING CHANGES IN THE LABOR MARKET IN GLOBAL ASPECT

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Abstract

The labor market is one of the markets operating in any economy. The buyers of the labor market are employers, while sellers - employees. The main functions of the labor market are the allocation and reallocation of human resources, ensuring long-term balance between supply and demand for labor. The article focuses on the labor market in terms of both employers and employees, since the study presented in the article refers to the unemployment rate. It is a global problem. It applies to every country and region. The effects of too high a rate of unemployment are severe for both employers and employees. The aim of the article is the prediction of the unemployment rate. Unemployment can explore different methods and tools. In an article for the prediction of unemployment proposed artificial neural network and wavelet transform. Prediction, performed using a authorial algorithm. The algorithm was based on discrete wavelet. Used Haar wavelet the first row, ie. Daubechies wavelet. The results obtained are subject to low prediction error suggesting that the algorithm is efficient and can be used for further testing.

Key words: artificial neural networks, wavelet transform, prediction, labor market, unemployment.

JEL Code: G00, F65, B23

Introduction

Unemployment is one of the most difficult socio-economic problems. It has long been of interest to sociologists and psychologists, because due to its consequences is a serious social problem. Sociologists and psychologists focus their attention on the consequences of this phenomenon. With modern research shows that unemployment leads to deterioration of health, both mental and physical: the higher the level of incidence of heart disease, cases of alcoholism, suicide. One of the researchers of this subject, Dr. Hawey Breuner estimates that persisting in six years an increase in the unemployment rate by one percent would lead to the

premature deaths of the 37000. Research shows that involuntary joblessness is for many people the situation with a high impact traumatic.

However, apart from damage to human, social and psychological posed by periods lasting persistent involuntary unemployment are also economic losses, which are the largest documented waste in the modern economy.

Prediction of unemployment and other time series can perform a variety of methods (see Biernacki, 2007). The results of the researchers show that the use to prediction of a time series: artificial neural networks, wavelet analysis wavelet-neural network and other combinations of wavelets gives good results prediction (See: Hadaś-Dyduch, 2015a, 2015b, 2016). The unemployment rate can be studied by different methods (Sawicz, 2015a, 2015b) and ways. It may even be game theory (Sroczyńska-Baron 2013, 2014). On the labor market can also look through the prism of the models proposed in (Balcerzak, Pietrzak 2016a, 2016b, 2016c, 2016d, 2016e).

The aim of this article is check whether good predictive properties of wavelets are also appropriate for predicting the unemployment rate. To predict the unemployment rate applied discrete wavelet.

1. Wavelet transform

The wavelet is a function which, thanks to the operation shifting and scaling generates orthonormal basis space $\boldsymbol{L}^2$. "A wavelet is a wave-like oscillation with an amplitude that begins at zero, increases, and then decreases back to zero. It can typically be visualized as a "brief oscillation" like one might see recorded by a seismograph or heart monitor. Generally, wavelets are purposefully crafted to have specific properties that make them useful for signal processing. Wavelets can be combined, using a "reverse, shift, multiply and integrate" technique called convolution, with portions of a known signal to extract information from the unknown signal." [1].

1.1. Continuous Wavelet Transform

Continuous Wavelet Transform CWT is defined as follows:

$$CWT_f(a,b) = \int_{-\infty}^{\infty} f(t)\psi^*_{a,b}(t)dt \tag{1}$$

where:

$$\psi_{a,b}(t) = \frac{1}{\sqrt{|a|}}\psi\left(\frac{t-b}{a}\right), \quad a,b \in R, \quad a \neq 0 \tag{2}$$

and the condition must be fulfilled:

$$C_\psi = \int_{-\infty}^{\infty} \frac{|\Psi(\omega)|^2}{|\omega|} d\omega < \infty \tag{3}$$

$\Psi(\omega)$ - is the Fourier transform of $\psi(t)$. From the condition (3) it follows that there must be $\Psi(0) = 0$, so the average value of the function $\psi(t)$ must be zero:

$$\int_{-\infty}^{\infty} \psi(t)dt = \Psi(0) = 0 \tag{4}$$

$\psi(t)$ is called *mother wavelet*. The asterisk in the definition (1) is the complex conjugate, but commonly used wavelets are real functions, for which there is. $\psi^*(t) = \psi(t)$.

1.2. Discrete Wavelet Transform

Discrete wavelet transform allows introduce a signal in the form of a linear combination of factors $c_{j_0}(k), d_j(k)$:

$$f(t) = \sum_k c_{j_0}(k) 2^{j_0/2} \phi(2^{j_0}t - k) + \sum_k \sum_{j=j_0}^{\infty} d_j(k) 2^{j/2} \psi(2^j t - k) \tag{5}$$

Comparing the expression (1.5) from (1.2) it can be seen that the coefficients are selected as powers of 2. Substituting $\boldsymbol{a = \frac{1}{2^j}, b = \frac{k}{2^j}}$ $\boldsymbol{j, k \in Z}$ (Z - set of integers) to (2) we get:

$$\psi_{j,k}(t) = 2^{j/2}\psi\left(2^j t - k\right), \quad j,k \in Z \tag{6}$$

A similar convention recording are used for the scaling functions:

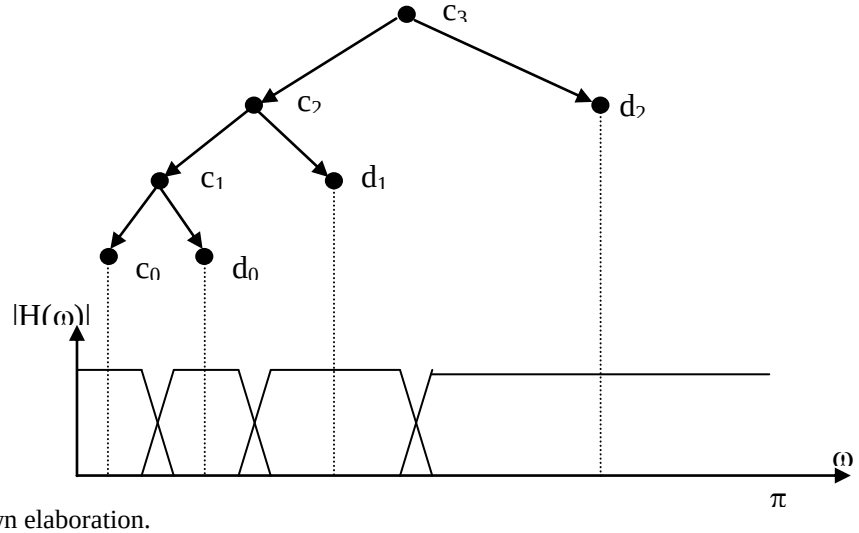
$$\phi_{j,k}(t) = 2^{j/2}\phi\left(2^j t - k\right), \quad j,k \in Z \tag{7}$$

The formula (5) can be written:

$$f(t) = \sum_k c_{j_0}(k)\phi_{j_0,k}(t) + \sum_k \sum_{j=j_0}^{\infty} d_j(k)\psi_{j,k}(t) \tag{8}$$

Expansion of the function $f(t)$ in the series is done on the basis of two members of the functions of the base: wavelet $\psi(t)$ and the scaling function $\phi(t)$. The coefficients $d_{j,k}$ contain information about the higher frequencies, ie. - details. Whereas the coefficients c_k contain low-pass information together with a constant component.

Fig. 1 Multilevel analysis



Source: Own elaboration.

The scaling and wavelet satisfy the following relations:

$$\phi(t) = \sum_n h(n)\sqrt{2}\phi(2t-n), \quad n \in Z \tag{9}$$

$$\psi(t) = \sum_n h_1(n)\sqrt{2}\phi(2t-n), \quad n \in Z \tag{10}$$

These equations allow to calculate how both waves and a scaling function level "$j-1$" based on knowledge of the scaling function level "j".

2. Study

The study, which aims to forecast the unemployment rate fraught with minimum error based on a model integrating neural network and wavelet analysis can be described in four main stages:

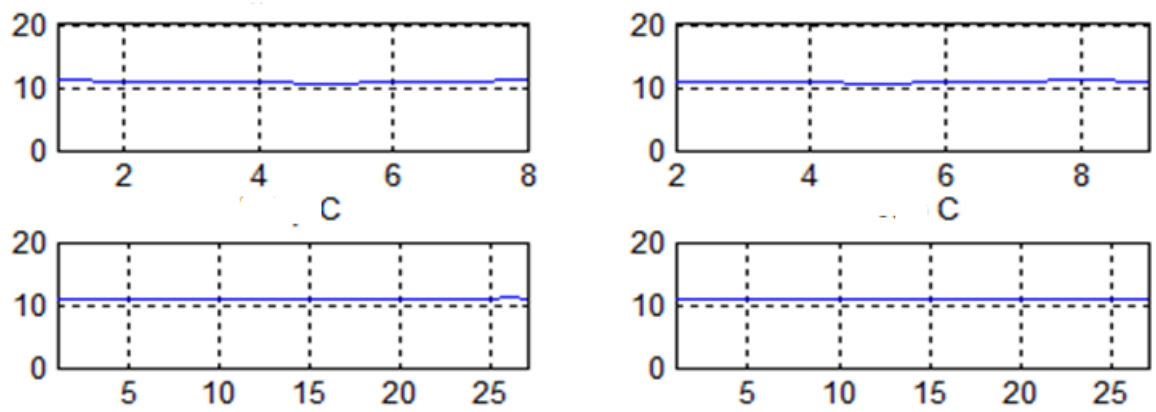
- **Stage 1** division series on the sub-series.
- **Step 2** wavelet transform sub-series - effect - wavelet coefficients for the different sub-series.
- **Step 3** Generation wavelet coefficients for successive moments of time, that is, for the moment the forecast using artificial neural network.
- **Step 4** The inverse wavelet transform - effect - the unemployment rate projected for moments in time.

The study was conducted on time series presenting the level of unemployment in the period 12.01.1990 - 01.12.2015 year. Any computer simulations and calculations performed in MATLAB based on their own original programs.

Stage 1. In the proposed algorithm in the first place divided into a number of sub-series of 8-element. The first sub-series contains the following elements of series about numbers: $t = 1,2,3,4,5,6,7,8$; The second sub-series contains the following elements of series about numbers: $t = 2,3,4,5,6,7,8,9$. From the resulting set of sub-ranks, we reject at the start of the last 5 sub-ranks, in order to make verification of the algorithm, which is to check compliance of the projected value of the unemployment rate with the actual value of the unemployment rate.

Stage 2. Each of the separate sub-series of 8-elemental surrender wavelet transform, which allows to provide a signal in the form of a linear combination of coefficients $\boldsymbol{c_p(t), d_p(t)}$. For sub-series of the first and second as a result of wavelet transform receive appropriate coefficients C shown in Figure 2.

Fig. 2 The coefficients C obtained with a wavelet transform, a sub-series 1 and 2.



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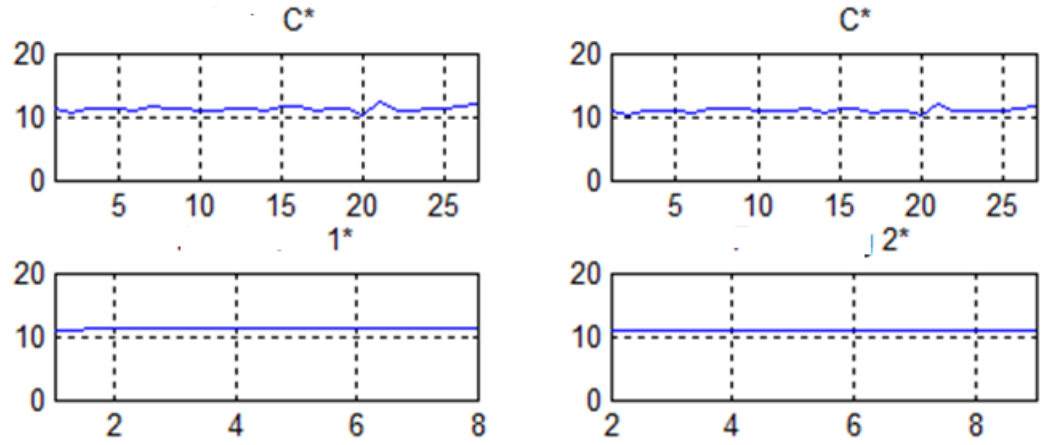
Analogously we obtain the coefficients for all sub-series.

Stage 3. As a result of inverse wavelet transform for the sub-series 1 and 2 obtain series shown in Figure 3.

Fig. 3 Sub-series 1 and 2 obtained by the inverse wavelet transform.



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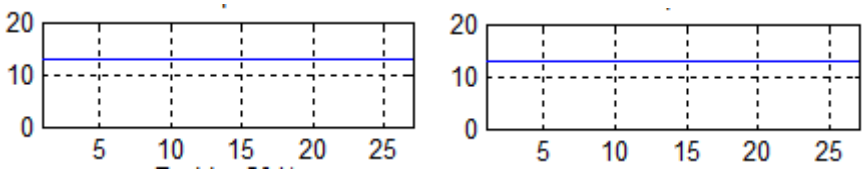
Stage 4. The main instrument presenting the algorithm is an artificial neural network, which is used in the presented algorithm to generate wavelet coefficients. Generated by an artificial neural network wavelet coefficients are used to design future (new) value of the unemployment rate. Artificial neural network learns from the earlier separate sub-series. The network learns that the series of under-1 wavelet coefficients take the values shown in Figure 2, obtained by the wavelet transform. Thus, the network receiving the input coefficients of the series of-1 should generate wavelet coefficients at the output presented to the sub-series of the Figure 3, etc. for the other sub-series. For the last two sub-series (two of the five rejected at the start) obtained coefficients C show Fig. 4.

Fig. 4 Wavelet coefficients generated by an artificial neural network for the last two sub-series.



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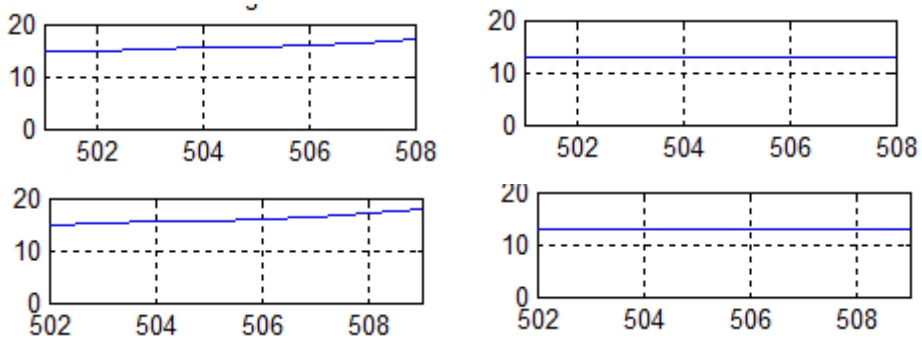
Stage 5. Thus, according to the present algorithm, using wavelet coefficients generated by the artificial neural network is calculated using inverse wavelet transform, the last two sub-series. Collected values of the last two sub-series are received in error.

Results

Comparing on the figure 5 received the unemployment rate based on an algorithm with the actual values can be stated that the algorithm generated to the unemployment rate are subject to a small error and, therefore, the proposed algorithm is as an effective tool in predicting the unemployment rate.

Fig. 5 The values of the unemployment rate obtained from the inverse wavelet transform (the latter two sub-series) and the actual value of the unemployment rate.



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The proposed method of predicting the unemployment rate is not the only method of prediction. To predict macroeconomic indicators can be used a variety of models, as shown by numerous research scientists (Hadaś-Dyduch 2016a, 2016b). Forecasts of macroeconomic indicators are essential not only for the economy but also in capital investment (Hadaś-Dyduch 2014).

It should be noted that the proposed model can also be based on other wavelets. In the literature there have been many types of wavelets.

Conclusion

The paper presents a forecast of the unemployment rate using a model based on wavelet analysis and artificial neural network. Focused around the idea of presenting the algorithm of forecasting the unemployment rate by wavelet analysis. Been proposed a model for predicting means based on the series of wavelet coefficients generated by the neural network. The results show that the observations generated by the proposed model reliably reflect the actual time series, ie, the model is an effective tool in forecasting.

To estimate the value of the unemployment rate and related determinnat has an impact a lot of factors. One of the factors might be a change in fiscal policy, which has been widely described in (Balcerzak, Pietrzak, Rogalska (2016)).

The studies show that artificial intelligence and wavelet analysis can be applied in many fields. In the present case in modeling the labor market. The studies are the basis for further research and analysis. Wavelets can be used with other methods of prediction, creating even better tool for prediction in the sense of minimizing the prediction error.

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