

Hadas-Dyduch, Monika

Working Paper

Model - spatial approach to prediction of minimum wage

Institute of Economic Research Working Papers, No. 29/2016

Provided in Cooperation with:

Institute of Economic Research (IER), Toruń (Poland)

Suggested Citation: Hadas-Dyduch, Monika (2016) : Model - spatial approach to prediction of minimum wage, Institute of Economic Research Working Papers, No. 29/2016, Institute of Economic Research (IER), Toruń

This Version is available at:

<https://hdl.handle.net/10419/219812>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/3.0/>



Institute of Economic Research Working Papers

No. 29/2016

**Model – spatial approach to prediction
of minimum wage**

Monika Hadaś-Dyduch

Toruń, Poland 2016

© Copyright: Creative Commons Attribution 3.0 License

Monika Hadaś-Dyduch
monika.dyduch@ue.katowice.pl
University of Economics in Katowice

Model – spatial approach to prediction of minimum wage

Abstract

The aim of the article is to present the author's model for prediction of the minimum wage. The model is based on wavelet analysis and methods of adaptation. Use of multiresolution analysis for prediction of the minimum wage in combination with the method to compensate the exponential gave good results in terms of minimizing the error. Research the minimum wage is very important. It should be noted that, in 2014, the level of gross minimum wages across the EU Member States varied from 33 % to just over 50 % of average [gross monthly earnings](#) for those persons working in industry, construction or services.

Keywords: *wavelets, prediction, salary, minimum wage.*

JEL Classification: C5, F3

AMS Classification: 90C05

1 INTRODUCTION

In January 2016, 22 out of the 28 EU Member States (Denmark, Italy, Cyprus, Austria, Finland and Sweden were the exceptions) had a national minimum wage. As of 1 January 2016, monthly minimum wages varied widely, from EUR 215 in Bulgaria to EUR 1 923 in Luxembourg. There was also a national minimum wage in the following candidate countries of the EU: Albania, Montenegro, the former Yugoslav Republic of Macedonia, Serbia and Turkey. It should be noted that for those EU Member States outside of the euro area that have minimum wages (Bulgaria, the Czech Republic, Croatia, Hungary, Poland, Romania and the United Kingdom), as well as for Albania, the former Yugoslav Republic of Macedonia, Serbia, Turkey and the United States, the levels and ranking of minimum wages expressed in euro terms are affected by exchange rates. (see more in: Eurostat).

Research the minimum wage is very important. It should be noted that, in 2014, the level of gross minimum wages across the EU Member States varied from 33 % to just over 50 % of average [gross monthly earnings](#) for those persons working in industry, construction or services (activities of households as employers and extra-territorial organisations and bodies are excluded). The level of minimum wages in relation to the mean value of average gross monthly earnings was highest in Slovenia (51.3 %), Greece (50.1 %, 2011) and Turkey (50.0 %, 2010). At the lower end of the ranking, the United States (2013 data), the Czech Republic and Spain each reported that the level

of their minimum wage was less than 35 % of average gross monthly earnings. (see: Eurostat).

The article discusses the problem of prediction work a minimum. It proposed an original model to predict the short-term, based on multiresolution analysis and econometric methods. To research and predicting time series can be use a variety methods (Biernacki 2009). Research shows (Hadaś-Dyduch 2015a, 2015b, 2015c, 2016; Vidakovic, Mueller 1994) that wavelet analysis can be used on a variety of academic levels, among other things: to study the properties of economic processes, smoothing ranks, removing noise, study the relationship between processes of different time scales and so on.

2 MULTIREOLUTION ANALYSIS

A multiresolution analysis (MRA) or multiscale approximation (MSA) is the design method of most of the practically relevant discrete wavelet transforms (DWT) and the justification for the algorithm of the fast wavelet transform (FWT). It was introduced in this context in 1988/89 by Stephane Mallat and Yves Meyer and has predecessors in the microlocal analysis in the theory of differential equations (the ironing method) and the pyramid methods of image processing as introduced in 1981/83 by Peter J. Burt, Edward H. Adelson and James Crowley.

„Wavelets are functions that satisfy certain requirements. The very name wavelet comes from the requirement that they should integrate to zero, „waving“ above and below the x-axis. The diminutive

connotation of wavelet suggest the function has to be well localized. Other requirements are technical and needed mostly to insure quick and easy calculation of the direct and inverse wavelet transform. There are many kinds of wavelets. One can choose between smooth wavelets, compactly supported wavelets, wavelets with simple mathematical expressions, wavelets with simple associated filters, etc.“ (Vidakovic, Mueller 1994). The most simple wavelet is the Haar wavelet. The Haar as a special case of the Daubechies wavelet, the Haar wavelet is also known as Db1. "In contrast to Haar's simple-step wavelets, which exhibit jump discontinuities, Daubechies wavelets are continuous. As a consequence of their continuity, Daubechies wavelets approximate continuous signal more accurately with fewer wavelets than do Haar's wavelets, but at the cost of intricate algorithms based upon a sophisticated theory. The Daubechies wavelets, are a family of orthogonal wavelets and characterized by a maximal number of vanishing moments for some given support. With each wavelet type of this class, there is a scaling function which generates an orthogonal multiresolution analysis. Furthermore, each Daubechies wavelet is compactly supported. The Daubechies wavelets are neither symmetric nor antisymmetric around any axis, except for db1, which is in fact the Haar wavelet. Satisfying symmetry conditions cannot go together with all other properties of the Daubechies wavelets.” (Daubechies, 1992).

3 MODEL

The proposed algorithm for the prediction can be described as follows. In the first place, determined by the corresponding coefficients a_k , according to the following relationship::

$$a_k = \sum_{r=k+0}^{k+3} \varphi(r-k)p_r, k \in \{0,1,2,\dots,2^n-1\}. \quad (1)$$

where: φ is a scaling function of Daubechies wavelet.

Followed by an application function approximating, the form (assuming that the initial number of the form: $p_0, p_1, \dots, p_{2^n-2}, p_{2^n-1}$):

$$\begin{aligned} \tilde{f}(r) = & a_{-2}\varphi(r+2) + a_{-1}\varphi(r+1) + a_0\varphi(r) + a_1\varphi(r-1) + a_2\varphi(r-2) \\ & + \dots + a_{2^n-1}\varphi(r - [2^n - 1]) \end{aligned} \quad (2)$$

where: φ is a scaling function of Daubechies wavelet (Fig. 1).

The Daubechies wavelets, based on the work of Ingrid Daubechies, are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some given support. With each wavelet type of this class, there is a scaling function (called the father wavelet) which generates an orthogonal multiresolution analysis.

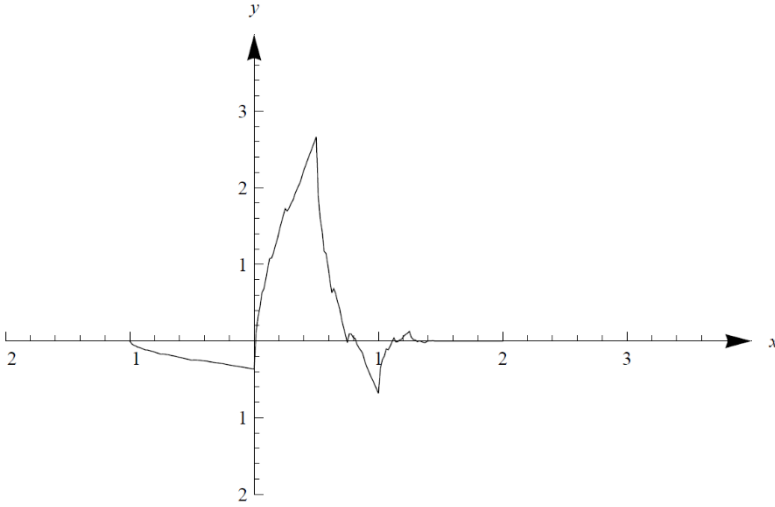


Fig. 1. **Daubechies wavelet.**

Source: Own elaboration.

Using Daubechies wavelet functions

$$\varphi_{D,M_n}^p(x) = 2^{\frac{M}{2}} \varphi_D^p(2^M x - n), \quad \psi_{D,mn}^p(x) = 2^{\frac{m}{2}} \psi_D^p(2^m x - n)$$

and given certain conditions (see: Hasiewicz, Śliwiński 2005), we get the following models decomposed wavelet (see also: Hasiewicz, Śliwiński 2005):

$$\hat{g}_D^p(x, K) = \sum_{n=\lfloor 2^M x \rfloor - 2p+1}^{\lfloor 2^M x \rfloor} \hat{\alpha}_{D,Mn}^{p,g} \varphi_D^p(2^M x - n) + \sum_{m=M}^{K-1} \sum_{n=\lfloor 2^M x \rfloor - p}^{\lfloor 2^M x \rfloor} \hat{\beta}_{D,mn}^{p,g} \psi_D^p(2^m x - n)$$

$$\hat{f}_D^p(x, K) = \sum_{n=\lfloor 2^M x \rfloor - 2p+1}^{\lfloor 2^M x \rfloor} \hat{\alpha}_{D,Mn}^{p,f} \varphi_D^p(2^M x - n) + \sum_{m=M}^{K-1} \sum_{n=\lfloor 2^M x \rfloor - p}^{\lfloor 2^M x \rfloor} \hat{\beta}_{D,mn}^{p,f} \psi_D^p(2^m x - n)$$

where:

$$\hat{\alpha}_{D,Mn}^{p,g} = 2^M \sum_{\{k:u_{Mn,k} \in [0,2^p-1]\}} y_k \varphi_D^p(u_{Mn,k}),$$

$$\hat{\alpha}_{D,Mn}^{p,f} = 2^M \sum_{\{k:u_{Mn,k} \in [0,2^p-1]\}} \varphi_D^p(u_{Mn,k})$$

$$\hat{\beta}_{D,Mn}^{p,g} = 2^m \sum_{\{k:u_{mn,k} \in [1-p,p]\}} y_k \psi_D^p(u_{mn,k}), \quad u_{mn,k} = 2^m x_k - n,$$

$$\hat{\beta}_{D,Mn}^{p,g} = 2^m \sum_{\{k:u_{mn,k} \in [1-p,p]\}} \psi_D^p(u_{mn,k})$$

φ - is a scaling function of Daubechies wavelet,

$$\int_{-\infty}^{+\infty} \varphi(x) dx = 1,$$

$$\psi - \text{ is a Daubechies wavelet, } \int_{-\infty}^{+\infty} \psi(x) dx = 0$$

Featuring a smoothed time series, which aim to simplify, written as:

$\hat{y}_1, \hat{y}_2, \hat{y}_3, \dots, \hat{y}_n$, undertakes to solution a simple task:

$$\text{Min} \left\{ \sqrt{\frac{1}{n} \sum_{t=1}^n ((\alpha \hat{y}_t + (1-\alpha)y_{t-1}) - y_t)^2} \right\},$$

$$\alpha \in \langle 0,1 \rangle \quad (3)$$

The forecast for one period forward is determined by the formula:

$\hat{y}_{t+1}^p = \alpha \cdot \hat{y}_t + (1-\alpha) \cdot y_t$. Wherein \hat{y}_t value smoothed by the trend creepy-wavelet, and parameter $\alpha \in [0,1]$ - called the smoothing constant, finessed so as to minimize errors *ex-post* prediction.

4 RESULT

Application copyright model for the production of short-term done for monthly minimum wages - bi-annual data, based on Eurostat data. Data on gross monthly earnings, which is based on the study, cover remuneration in cash paid before any tax deductions and social security contributions payable by wage earners and retained by the employer, and restricted to gross earnings which are paid in each pay period. (see: Eurostat). The model described in chapter 3, were applied to the monthly minimum wages - bi-annual data. The model was applied to countries: Belgium, Bulgaria, Czech Republic, Estonia, Ireland, Greece.

Based on the described algorithm determined wages forecast for randomly selected countries, namely: Belgium, Bulgaria, Czech Republic, Estonia, Ireland, Greece. The values obtained do not cover one hundred percent of real value, they are burdened with some errors. For alpha minimizing an error forecasts expired, prediction one period forward has the following errors:

- For Belgium: APE – 0,35%.
- For Bulgaria: APE – 0,33%.
- For the Czech Republic: APE – 0,39%.
- For Estonia: APE – 0,44%.
- For Ireland: APE – 0,39%.
- For Greece: APE – 0,42%.

The results of prediction are acceptable. Errors forecasts wages selected countries obtained from a copyright prediction model are low compared with other prediction methods in the same category.

5 CONCLUSION

Research the minimum wage is an important issue for a substantial part of the population. The proportion of workers whose earnings are equal to the minimum wage is very different depending on the country. Studies show that, In 2014, the level of gross minimum wages across the EU Member States varied from 33 % to just over 50 % of average gross monthly earnings for those persons working in industry, construction or services (activities of households as employers and extra-territorial organisations and bodies are excluded) as covered by NACE Rev. 2 Sections B–S (NACE - The Statistical classification of economic activities in the European Community, abbreviated as NACE, is the classification of economic activities in the European Union (EU); the term NACE is derived from the French Nomenclature statistique des activités économiques dans la Communauté européenne. Various NACE versions have been developed since 1970. NACE is a four-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) and in other statistical domains developed within the European statistical system (ESS). NACE Rev. 2, a revised classification, was adopted at the end of 2006 and, in 2007, its implementation began. The first reference year for NACE Rev. 2

compatible statistics is 2008, after which NACE Rev. 2 will be consistently applied to all relevant statistical domains (Eurostat)). The minimum wage is related to investments and savings. It is worth in this context, to analyze the position of [Hadaś-Dyduch, 2014].

Research the minimum wage, conducted for the application model prediction. The test can be conducted from a different perspective, a more spatial, in a manner clearly different, eg. as presented in research (Balcerzak, Pietrzak 2015a, 2015b, 2016a, 2016b).

References

- [1] Biernacki, A.: Numerical Evaluation of the Random Walk Search Algorithm. In: *Man-Machine Interactions*, Springer Berlin Heidelberg, 2009.
- [2] Balcerzak, A. P. & Pietrzak, M. B.: Application of TOPSIS Method for Analysis of Sustainable Development in European Union Countries In T. Loster & T. Pavelka (Eds.). *The 10th International Days of Statistics and Economics. Conference Proceedings*. September 10–12, 2015. Prague. Czech Republic, 2015a.
- [3] Balcerzak, A. P. & Pietrzak, M. B.: Human Development and quality of life in highly developed countries, [in:] M.H. Bilgin, H. Danis, E. Demir, U. Can (ed.), *Business Challenges in the Changing Economic Landscape - Vol. 1. Proceedings of the 16th Eurasia Business and Economics Society Conference*, Springer, 2015b.
- [4] Balcerzak, A. P. & Pietrzak, M. B.: Assessment of Socio-Economic Sustainable Development in New European Union Members States in the years 2004-2012, [in:] M. Papież, S. Śmiech (ed.), *Proceedings of the 10th Professor Aleksander Zelias International Conference on Modelling and Forecasting of Socio-Economic Phenomena*, Foundation of the Cracow University of Economics, Cracow, 2016a.

- [5] Balcerzak, A. P. & Pietrzak, M. B.: Structural Equation Model in Evaluation of Technological Potential of European Union Countries in the years 2008-2012, [in:] M. Papież, S. Śmiech (ed.), *Proceedings of the 10th Professor Aleksander Zelias International Conference on Modelling and Forecasting of Socio-Economic Phenomena*, Foundation of the Cracow University of Economics, Cracow, 2016b.
- [6] Daubechies, I.: *Ten lectures on wavelets*. Philadelphia: Society for industrial and applied mathematics, 1992, Vol. 61.
- [7] Hadaś – Dyduch, M.: *The market for structured products in the context of inflation*, [in:] Papież M. and Śmiech, S. (eds.), *Proceedings of the 8th Professor Aleksander Zelias International Conference on Modelling and Forecasting of Socio-Economic Phenomena*, Cracow: Foundation of the Cracow University of Economics, 2014.
- [8] Hadaś – Dyduch M.: Prediction of wavelets analysis. [in:] *Financial management of Firms and Financial Institutions, Proceedings (Part I.) 10th International Scientific Conference*, VSB-Technical University of Ostrava, Faculty of Economics, Department of Finance, Ostrava, Czech Republic. 7 -8.09.2015., 2015a.
- [9] Hadaś – Dyduch M.: Polish macroeconomic indicators correlated-prediction with indicators of selected countries, [in:] Papież M. and Śmiech, S. (eds.), *Proceedings of the 9th Professor Aleksander Zelias International Conference on Modelling and Forecasting of Socio-Economic Phenomena*,. Conference Proceedings. Cracow: Foundation of the Cracow University of Economics. 2015b.
- [10] Hadaś-Dyduch M.: *Wavelets in prediction. Theory, Method, Simulation*. Scholar's Press, Saarbrucken, Germany, 2015c.
- [11] Hadaś–Dyduch M.: Wygładzenie falkowe jako kluczowy instrument w predykcji krótkookresowej. Alignment wavelets as main instrument in the short-time prediction. *Hradec Economic Days. Double-blind peer reviewed proceedings of the international scientific conference Hradec Economic Days 2016*. Editor: Pavel Jedlička, University of Hradec Králové, Czech Republic, 2016.
- [12] Hasiewicz, Z., Śliwiński, P.: *Falki ortogonalne o zwartym nośniku*, Akademicka Oficyna Wydawnicza EXIT, 2005.

- [13] Vidakovic, B., & Mueller, P.: Wavelets for kids. *Instituto de Estadística, Universidad de Duke*, 1994.