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Economy and finance through the prism of globalization. Author's model application

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Abstract: *The aim of this article is to present and apply an author's model for time series prediction, presenting macroeconomic indicators, exchange rates, financial markets and similar indicators. The proposed model is based on wavelet analysis and the ideology of the exponential compensation model. The model allows you to estimate the future value of a time series, both in long and short periods of time. The model was applied to the prediction of time series presenting the globalization index, which measures three main dimensions of globalization: economic, social and political. Index refers to: actual economic flows, economic restrictions, data on information flows Economic globalization, characterized as long distance flows of goods, capital and services as well as information and perceptions that accompany market exchanges. The obtained results indicate that the author's model is the appropriate model for analysis of time series and in particular for the study of economy in the social and political aspects.*
Keywords: *economy, globalization, multi-resolution analysis, prediction, wavelet.*

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I. Introduction

Prediction of time series can be determined on the basis of various models. For example, they may be determined on the basis of the forecast models based on autoregression VAR models, and FAVAR (called Factor-Augmented Victor Autoregression). In addition, a tool providing synthetic information is a dynamic factor model DFM (Dynamic Factor Model) (See: [4]). One of the methods of forecasting and series analysisis is wavelet transform (See: [2, 6, 9, 11]). The starting point for the analysis of wavelet analysis is multi-resolution analysis. Generally, the multi-resolution analysis is implemented based on Mallat's algorithm [12], which corresponds to the computation of the Discrete Wavelet Transform. Several approaches have been proposed for time-series prediction by the wavelet transform, based on a neural network in ([7,13]). In [7] the undecimated Haar transform was used.

The model is based on wavelet analysis and the exponential compensation model. Previous studies have confirmed that wavelet analysis is an effective tool in time series analysis (see: [2, 5, 8, 9, 10, 11, 12, 14, 15]). Empirical study, ie the author's model, is presented on the index of globalization, because globalization is a very important issue of the present. In addition, it illustrates the economic, social and financial situation of the region.Globalization "is a process of interaction and integration among the people, companies, and governments of different nations, a process driven by international trade and investment and aided by information technology. This process has effects on the environment, on culture, on political systems, on economic development and prosperity, and on human physical well-being in societies around the world. In other words, globalization is an economic, political and social process that takes on various forms and concerns diverse areas, including: finance; markets and strategies, and mainly competition; technology, research and development and knowledge; life styles, consumption patterns, and the consequences of globalization of culture; rule of law; political unification of the world" [1, 3].

II. Research Method

The model described in this article is an author's model for time series prediction. The model is designed for prediction, based on a one-dimensional time series. The proposed model is based on wavelet analysis (wavelet Daubechies) and the exponential model alignment. The author's model consists of several essential stages, which are described in detail below.

The article not been discussion of wavelet analysis, because the basic information concerning wavelet analysis, are described in detail among others in positions [2, 6, 7, 8, 9, 10, 11, 12, 14, 15]. At the input of the model we introduce time series $y_1, y_2, \ldots, y_n$, n-elementary. We extend the series by the method which gives the smallest error estimation of wavelet coefficients (methods are described in [16, 17]). Next, we determine wavelet transform coefficients: $a_0,\ldots,a_{2^{n+1}-1}$, by replacing $2N = 2^{(n+1)}$ basic building blocks:

$$\tilde{f}(r) = \sum_{k=0}^{2^{(n+1)}-1} a_k \varphi(r-k),$$

by an equivalent combination of $N = 2^n$ slower building blocks $\varphi([r/2]-k)$ and $N = 2^n$ slower wavelets $\psi([r/2-1]-k)$:

$$\tilde{f}(r) = \sum_{k=0}^{2^n-1} a_k^{(n-1)} \varphi([r/2]-k) + \sum_{k=0}^{2^n-1} c_k^{(n-1)} \psi([r/2-1]-k)$$

where:

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

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

wherein:

$$\varphi(r) = 0 \text{ for } r \le 0 \vee r \ge 3,$$

$$D_j = \{k2^j : k \in Z\},\ D = \bigcup_{j \in Z} D_j = \bigcup_{j=0}^{\infty} D_j .$$

$$\sum_{k \in Z} \varphi(k) = 1$$

$$\psi(r) = 0 \text{ for } r < -1 \text{ or } r > 2,$$

Coefficients $a_k^{(n-1)}$ indicate a frequency lower than for the initial coefficients $a_k^{(n)}$, which can also be relabeled: $a_k^{(n)} \equiv a_k$. The function:

$$\tilde{f}(r) = \sum a_k^{(n)} \varphi(r-k)$$

is a linear combination of the columns $\varphi(r-k)$ of the matrix:

$$0{,}5 \cdot \begin{pmatrix} h_0 & h_1 & h_2 & h_3 & & & \cdots \\ h_3 & -h_2 & h_1 & -h_0 & & & \cdots \\ & & h_0 & h_1 & h_2 & h_3 & \cdots \\ & & h_3 & -h_2 & h_1 & -h_0 & \cdots \\ & & & & h_0 & h_1 & \cdots \\ & & & & h_3 & -h_2 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \end{pmatrix}$$

where:

$$h_0 = \frac{1+\sqrt{3}}{4},\ h_1 = \frac{3+\sqrt{3}}{4},\ h_2 = \frac{3-\sqrt{3}}{4},\ h_4 = \frac{1-\sqrt{3}}{4}$$

Consequently, calculating the wavelet Daubechies transform amounts to changing from the basic with $\varphi(r-k)$ to the basis with $\varphi([r/2]-k)$ and $\psi([r/2-1]-k)$, which give a new coefficient in rows products:

$$\left(a_0^{(n-1)}, c_0^{(n-1)}, a_1^{(n-1)}, c_1^{(n-1)} a_2^{(n-1)}, c_2^{(n-1)}, \ldots\right) = D_\Omega^{-1} \vec{a}^{(n)},$$

where:

$$D_{\Omega} = \begin{pmatrix} \varphi(r) \\ \varphi(r-1) \\ \varphi(r-2) \\ \varphi(r-3) \\ \varphi(r-4) \\ \varphi(r-5) \\ \vdots \end{pmatrix} \begin{pmatrix} h_0 & h_1 & h_2 & h_3 & & & \cdots \\ h_3 & -h_2 & h_1 & -h_0 & & & \cdots \\ & & h_0 & h_1 & h_2 & h_3 & \cdots \\ & & h_3 & -h_2 & h_1 & -h_0 & \cdots \\ & & & & h_0 & h_1 & \cdots \\ & & & & h_3 & -h_2 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \end{pmatrix}$$

Finally, we obtain the distribution of the $y_1, y_2, \ldots, y_n$ series in two parts: the so-called. approximation and detail. Approximation is subjected to the following divisions: approximation and detail, and details are not further divided. In this way, the series is presented as the sum of: the approximation of the last level and the details of all levels. With the so-called. approximation and detail of the $y_1, y_2, \ldots, y_n$ series, in the next step we determine the values of the series $\hat{g}_1, \hat{g}_2, \ldots, \hat{g}_N$ for the previously determined resolution level. Where the value $g_1, g_2, \ldots$ are so-called. approximation of the last resolution level. The values of series $\hat{g}_1, \hat{g}_2, \ldots$ are determined from the recursive formula:

$$\hat{g}_t = \alpha g_t + (1-\alpha)\hat{g}_{t-1}; \text{ for } \ t > 1;\ \alpha \in [0,1]$$

$$g_1 = \frac{\sum_{i=1}^{t} g_i}{N}$$

Similarly, we calculate the elements of the series $\hat{d}_1, \hat{d}_2, \ldots, \hat{d}_N$ for a predefined resolution level. $d_1, d_2, \ldots$ values are the so-called. details. The values of the $\hat{d}_1, \hat{d}_2, \ldots, \hat{d}_N$ series are determined by the recursive formula:

$$\hat{d}_t = \beta d_t + (1-\beta)\hat{d}_{t-1}; \text{for } \ t > 1;\ \beta \in [0,1]$$

$$\hat{d}_1 = \frac{\sum_{i=1}^{t} d_i}{N}$$

Next, we determine the forecast:

$$g_T^P = \hat{g}_N + H\Delta\hat{g}_N$$
$$d_T^P = \hat{d}_N + H\Delta\hat{d}_N$$

where: H - real time forecast ahead.

In the next step, having future values called. approximation and detail, we determine the real value of the function using the inverse wavelet transform. The values obtained are the values of the series: $y_1, y_2, \ldots, y_n$.

EMPIRICAL STUDY

Empirical study, that is the application of the previously described model, is presented in the globalization index, which refers to: actual economic flows, economic restrictions, data on information flows, data on personal contact, data on cultural proximity. The globalization Index measures the three main dimensions of globalization: economic, social and political. “Economic globalization, characterized as long distance flows of goods, capital and services as well as information and perceptions that accompany market exchanges” [1].

III. Presentation Of The Empirical Material

The research was based on the indicator of globalization, ie. KOF Globalization Index. “The KOF Globalization Index measures the three main dimensions of globalization: economic, social and political. In addition to three indices measuring these dimensions, we calculate an overall index of globalization and subindices referring to: actual economic flows, economic restrictions, data on information flows, data on personal contact, and data on cultural proximity. (…) In constructing the indices of globalization, each of the variables introduced (...) is transformed to an index on a scale of one to hundred, where hundred is the maximum value for a specific variable over the 1970-2014 period and one is the minimum value (...)" [1]. Higher values denote greater globalization. In Fig. 1 - Fig. 4, the globalization index has been showing since 1970, for Asia, Europe, Africa and Oceania. In each of these regions, the index of globalization increases year by year.

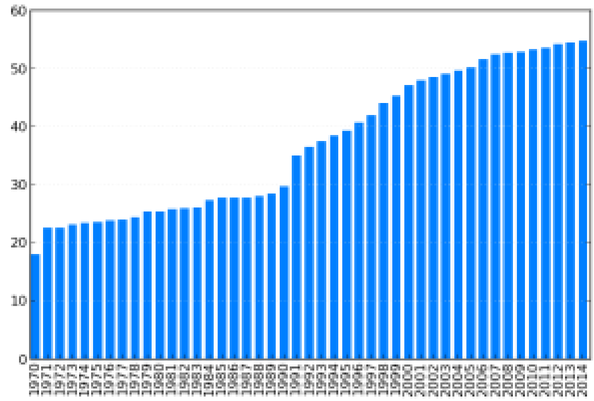


Figure1 - Index of Globalization – Asia.
Source: KOF Swiss Economic Institute

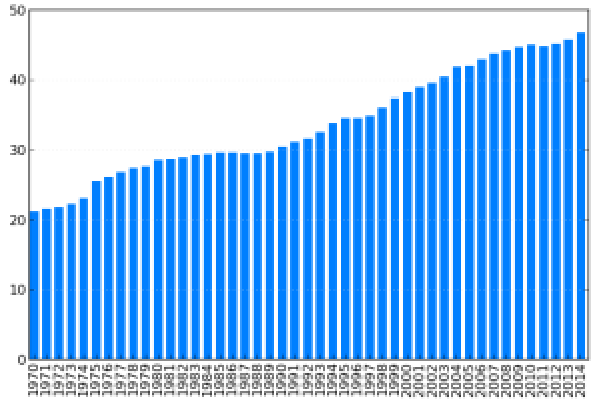


Figure 3 - Index of Globalization – Africa.
Source: KOF Swiss Economic Institute

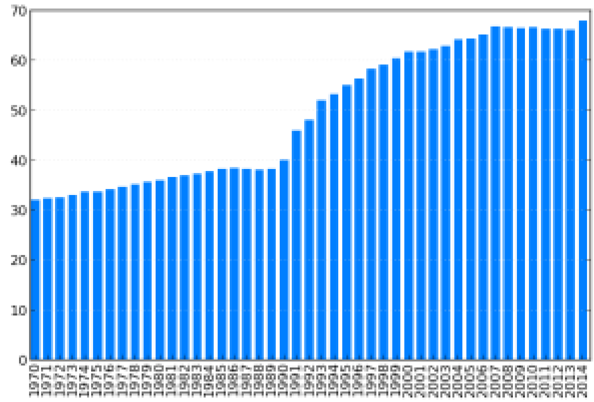


Figure 2 - Index of Globalization – Europe.
Source: KOF Swiss Economic Institute

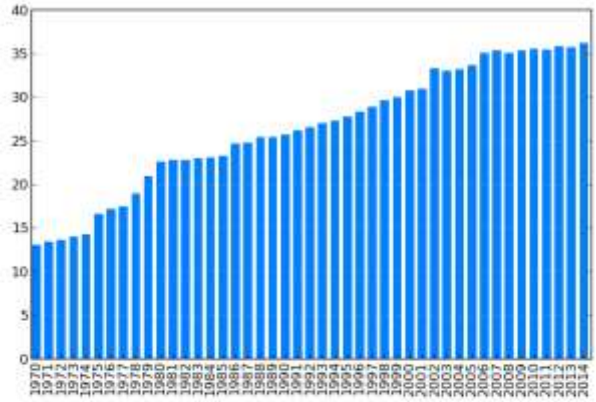


Figure 4 - Index of Globalization – Oceania.
Source: KOF Swiss Economic Institute

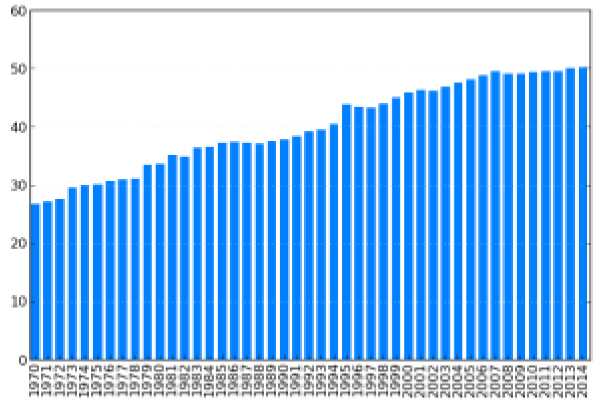


Figure 5 - Index of Globalization - North America.
Source: KOF Swiss Economic Institute

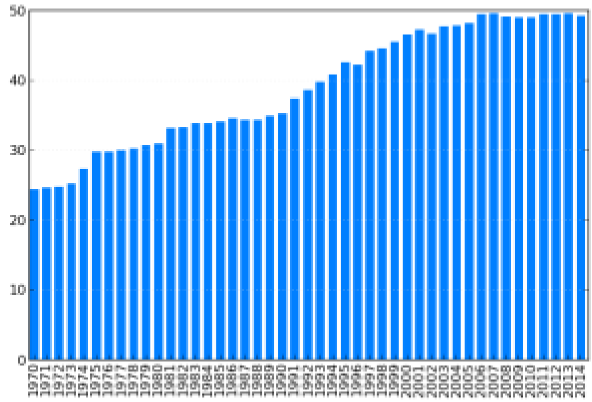


Figure 6 - Index of Globalization - South America.
Source: KOF Swiss Economic Institute

IV. Result Of The Reserch

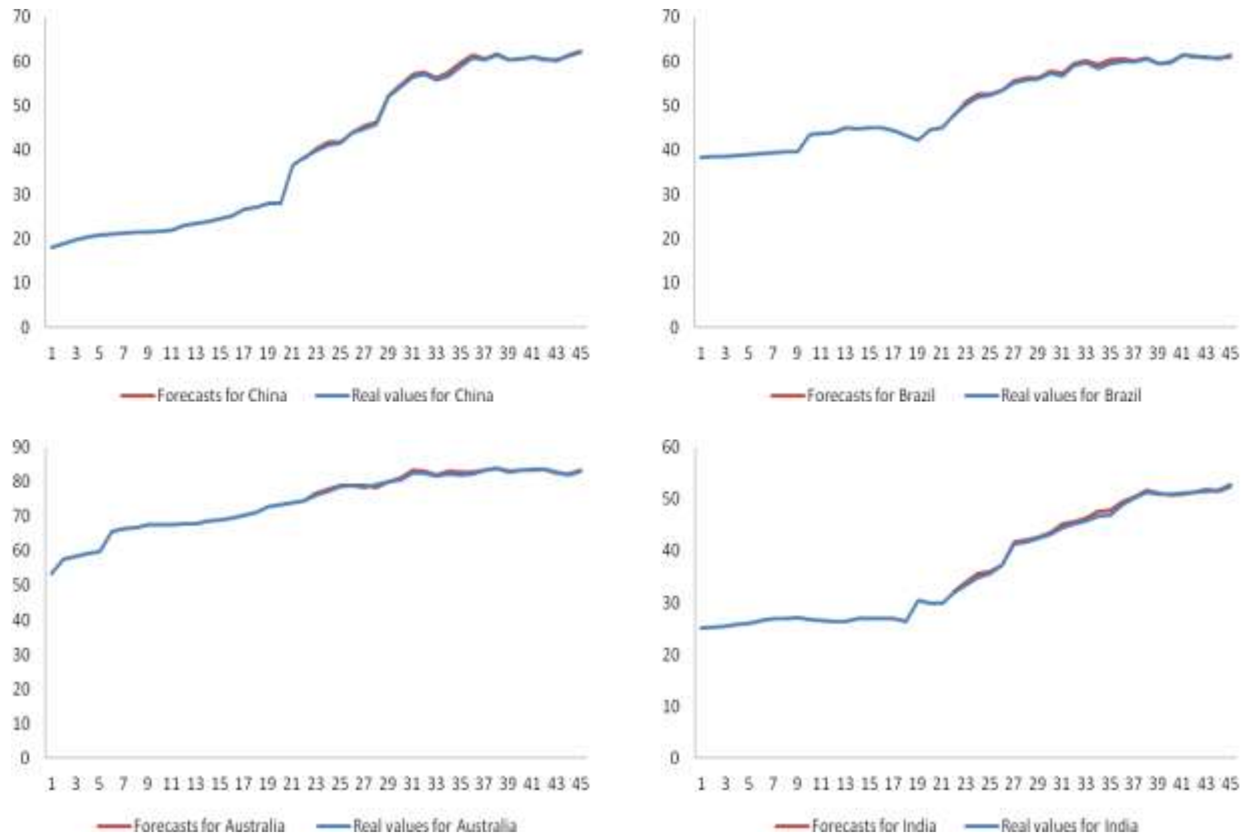
The author's model was applied to determine the globalization index of 147 countries. Each series was first expanded and then determined using wavelet transform, so-called detail and approximation. In the next step, the resulting series were smoothed and the optimal alpha and beta parameters were finally determined. In the last stage of the model, predicted value and estimated ex post prediction errors were estimated. The values obtained do not overlap one hundred percent with the actual value.

In the last stage, the predicted value was estimated and the ex post prediction errors were estimated. RMSPE calculated for one forward term, for all 147 countries, was 1.191%. The error is acceptable. Detailed results for selected countries are provided below in Table 1 and Fig. 6.

Table 1: Predict errors

Error	China	Australia	Brazil	India	Japan	Thailand	South Africa	Indonesia	Poland	Mexico
ME	-0.229	-0.272	-0.226	-0.234	-0.257	-0.227	-0.243	-0.183	-0.272	-0.236
MPE	-0.672%	-0.398%	-0.469%	-0.646%	-0.490%	-0.549%	-0.512%	-0.387%	-0.486%	-0.466%
MAE	0.355	0.456	0.410	0.366	0.378	0.358	0.380	0.324	0.456	0.362
MAPE	0.889%	0.612%	0.812%	0.994%	0.683%	0.801%	0.796%	0.773%	0.740%	0.697%
RMSE	0.445	0.571	0.512	0.458	0.472	0.453	0.481	0.418	0.571	0.448
RMSPE	1.113%	0.767%	1.015%	1.244%	0.852%	1.012%	1.009%	0.994%	0.926%	0.863%

Source: Based on your own calculations and simulations.



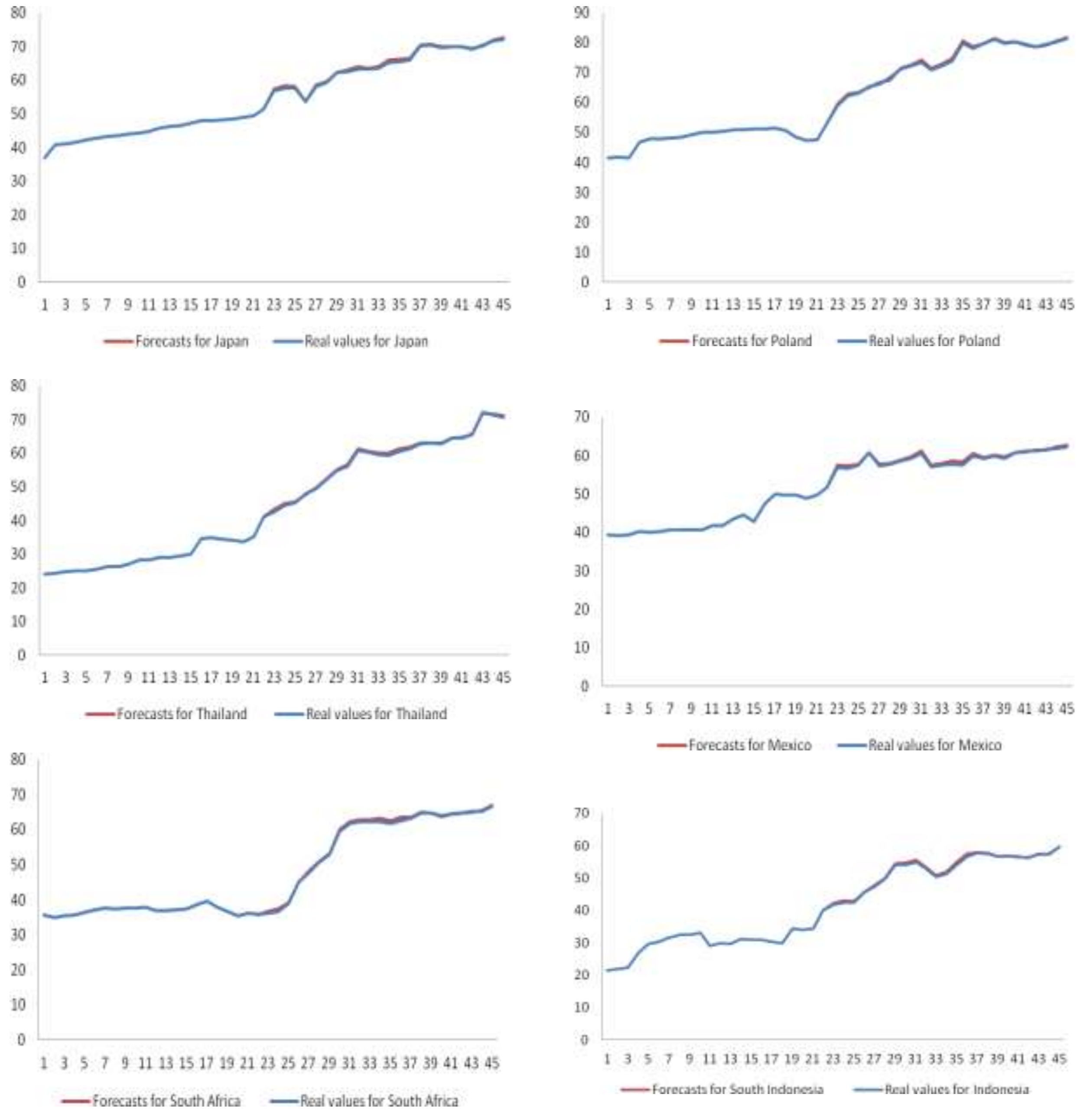


Figure 6 - Actual values and forecast values.
Source: Based on your own calculations and simulations.

V. Conclusion

Obtained results show that the author's model is an effective tool for time series prediction. The model was applied to determine the globalization index of 147 countries. Estimated prediction errors oscillate around 1.3%.

The study was applied Daubechies wavelets. However, there are many families and varieties of analyzing wavelets, such as Meyer, Morlet, Daubechies, Haar or "Mexican hat" . Wavelet must have finite energy and the average value of zero. Depending on the used wavelets analyzing, you can specify various properties of the test signal. For example, wavelet "Mexican Hat" is useful to assess the distribution and values of local minima and maxima of the signal and Morlet wavelet to the amplitude and frequency included in the signal.

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