Marko Martinović
University of Applied Sciences in Slavonski Brod
Dr. Mile Budaka 1,
35000 Slavonski Brod, Croatia
mmartinovic@vusb.hr
Phone: +38535492631

Željko Požega
Josip Juraj Strossmayer University of Osijek
Faculty of Economics in Osijek
Trg Ljudevita Gaja 7,
31000 Osijek, Croatia
zpozega@efos.hr
Phone: +38531224454

Boris Crnković
Josip Juraj Strossmayer University of Osijek
Faculty of Economics in Osijek
Trg Ljudevita Gaja 7,
31000 Osijek, Croatia
bcrnko@efos.hr
Phone: +38531224434

UDK: 336.745(4-67 EU:497.5)
Original scientific article

Received: September 18, 2016
Accepted for publishing: November 8, 2016

ANALYSIS OF TIME SERIES FOR THE CURRENCY PAIR CROATIAN KUNA / EURO

Abstract

The domestic currency Croatian kuna (HRK) was introduced in May 1995. To date, the Croatian National Bank (HNB), as a regulator and formulator of monetary policy in Croatia has operated a policy of stable exchange rate, typically referenced to the formal currency of the European Union euro (EUR). From the date of introduction of the euro 01/01/1999 until 01/01/2016 the value of the currency pair HRK / EUR changed in value by only 4.25% (HNB).

Although the value of the Croatian kuna is relatively stable, there are some fluctuations on an annual level (e.g. in the last few years because of the global crisis) as well as on periodic levels within a year.

The aim of this paper is to show the movement of the value of the currency pair since the beginning of 2002 to the present day (the time curve), analyze the correctness, trends and periodicity (seasonal behavior), if any exist.

The research will be done using the method of Time Series Analysis, assuming that the external (global economy) and internal factors (economic policy) remain similar or the same. According to the results, further assessment of price developments in the period followed will be made by using the obtained predicative models. In the event that the curve contains the component of periodicity, the observed patterns will be studied further.

Keywords: Croatian kuna, euro, time series analysis, HRK/EUR, prediction

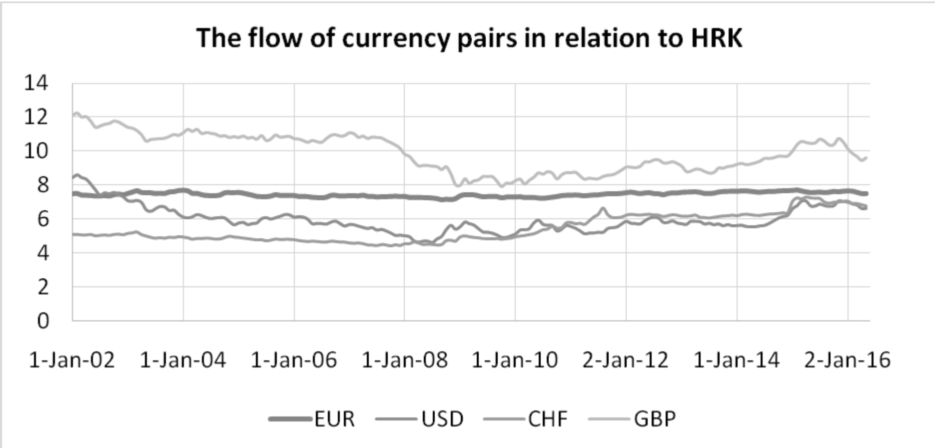
1. Introduction

The Croatian National Bank as an umbrella financial institution regulates the flow, i.e. the circulation of Croatian kuna (HRK) as a domestic currency. The Croatian National Bank regulates monetary policy, maintains financial stability, it is responsible for payment transactions, international relations, supervision, rehabilitation and management of international reserves (The Croatian National Bank, https://www.hnb.hr/). Although the domestic currency is not pegged to another currency, it behaves according to the law of supply and demand, the relative relationship to the euro (EUR) is quite stable because of occasional interventions by The Croatian National Bank (floating exchange rate policy). The price movements, due to the law of supply and demand in the money market, mainly depend on euro demand from abroad through foreign borrowing and payment of imports and on supply in the form of charging exports, inflow of foreign currency from the EU funds and debt repayment.

The stability of the euro towards the Croatian kuna can be seen from the fact that from January 2002 to May 2016 the average value of HRK/EUR changed only 0.1886%, while in the same reference period, the changes against other currencies were: the US dollar (USD) -21.7565%, Swiss Franc (CHF) 33.7153% and British pound (GDP) -20.7915% (data taken on 1 June 2016, before Brexit). In fact it can be said that the relative ratio of the Croatian kuna towards other currencies (except the euro) is consistent to the changes of the euro against other currencies. Stability of the Croatian kuna against the euro can be seen in Figure 1, which shows the movements of currency pairs in the past 14 years.

Despite occasional interventions of The Croatian National Bank, intervention points, i.e. lower and upper limits that need to be defended, are not prescribed. The pair HRK/EUR is stable but not fixed, and contains a component that acts according to the law of supply and demand in the foreign exchange market. Movements include seasonal and off-season dimension. In this paper several years of price movement will be analyzed and, of course, technical analysis will be carried out without tackling the reasons why these changes occur.

Figure 1 Trends in currency pairs in relation to HRK for the period 01/01/2002 - 06/01/2016



Source: Made by the authors according to the data from The Croatian National Bank, available at: https://www.hnb.hr

1.1 *Data and data processing*

All the original data are taken from the website of The Croatian National Bank (https://www.hnb.hr) and refer to the middle exchange rate for foreign currency. The prices of currency pairs are given the six decimal places form ''X.abcdef", where X is an integer, and the rest of those ''.abcdef" are 6 decimal places. The aim of the paper is to analyze the relationship between the HRK and EUR. The research hypothesis is that there is a correlation between the ratio of the HRK/EUR with the trends in the Croatian economy.

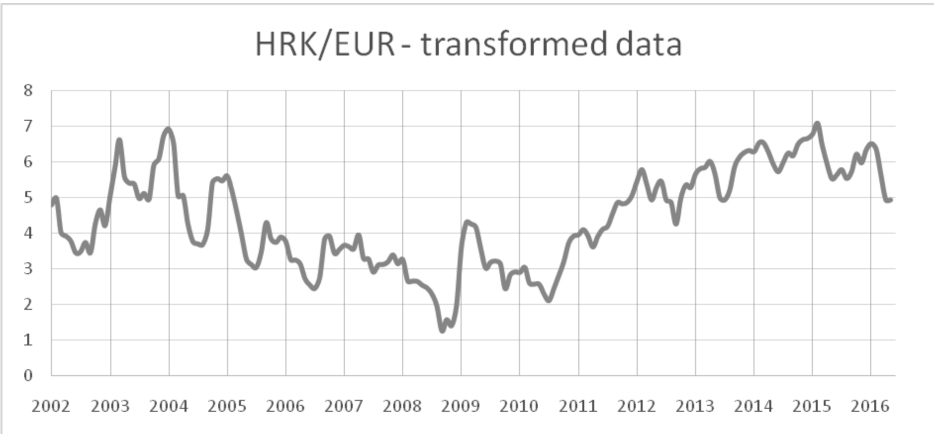
The Minimum Position of currency price change on the foreign exchange market is often called the "Percentage in Point" or PIP. In the FOREX terminology, the most important currency pairs are traded with four decimal places (0.0001), while the handful of brokerage trading platforms operate with fractions of 1/10 of one of the PIP, which is actually a precision of five decimal places (0.00001).

Consequently, the currency pairs HRK/other currencies, although the original data are shown in hexadecimal (e.g., 7.614419) when trading on FOREX, relevant are only the first four decimal places (i.e. 7.6144). If the change in price of a currency pair HRK/EUR for the reference period 2002 to 2016 (Figure 1) showed the PIP points, the difference at the end of the period compared to the beginning is the following: Euro (EUR) 19 points; US Dollar (USD) -2176 points; Swiss Franc 3372 points; and the British pound -2079 points.

In order to illustrate the absolute value of the change of exchange rate price more clearly, the contrast between the medium selling and buying rate at the Croatian National Bank should be considered. For example, on 5 July 2016 the buying exchange rate was 7.485902, while the sales exchange rate was 7.530952. The difference between the sales and purchase is 0.04505, which represents 451 PIP points. By FOREX trading with the most popular currency pairs (e.g. EUR/USD, EUR/GDP, AUD/USD) the differences between selling and buying rates are 1-5 PIP points. On this example it can be seen how much margin banks or institutions pay for the trade with domestic currency at The Croatian National Bank. Due to the frequent interventions of The Croatian National Bank, the traditional correlation of the Croatian kuna with the euro and the above mentioned big difference of buying and selling rate, on most foreign exchange markets and trading platforms there is no trading with the currency pair HRK/EUR.

In order to construct the precise model, analysis of time series with all six decimal digits will be carried out in the paper. Due to the high stability of HRK against EUR and the minimum change of the currency pair in basis points, transformation of the input data according to the formula $Y_t = (O_t - 7) *10$ has been made, where Yt represents transformed time series and Ot represents original data collected by The Croatian National Bank. From the original HNB data for HRK/EUR the number 7 is subtracted (which is all the time a constant number, i.e. there is no exchange rate in the observed time period of 14 years where the first digit changes its value) and the remaining decimal fraction is multiplied by 10. For example, the original value of 7.614419 as input to the model is transformed into a number 6.14419. In this way, a better sensitivity of price changes is being used in further analysis.

Figure 2 Movement of transformed original set of rates for the currency pair HRK/EUR for period 01/01/2002 - 01/06/2016



Source: Made by the authors according to the data from The Croatian National Bank, available at: https://www.hnb.hr

2. Analysis of time series

The vertical lines in Figure 2 represent the second annual delimiter from 2002 to 2016 (the first 5 months of 2016 included). On closer look, two features are prominent: the first refers to the periodicity (peaks that appear on the borders between years and valleys that are located in the middle of the year), and the second relates to the trend (or several trends combined in one Figure).

The periodicity can be displayed as a unique pattern of change within the interval of one year (in this paper it will be presented with the symbol P), whereas trend (symbol T) can be displayed as a function of the curve that best describes the data displayed. The trend functions model will be designed so that it better captures the presented data. From Figure 2 it appears that from 2003 to 2008 the price of the euro falls and then rises until 2015. Therefore, there is probably a model that better describes the long-term trend of simple linear regression.

When using the method of temporal values analysis, it is not the intention to find the reason for causality, but from the presented information construct an efficient model that best describes the supplied data and/or that best predicts further time sequence. With the designed model it is possible to make a prediction of the curve in the future period and in accordance with the error to optimize (validated) the model. Optimization of the model in this case will be finding solutions that best describe the existing data, i.e. whose prediction fault is minimal.

To make a model validation, the data are divided into sample data and data for model validation. The sample data are used to construct the best model and the same tests are used on the rest of the retained data (test data).

Table 1 Distribution of data on the sample and retained set of three varieties

Variants	sample	record number	test data	record number	record total
1.	*1-Jan-02 – 1-Jan-13*	132	*1-Jan-13 – 1-Jun-16*	41	173
2.	*1-Jan-02 – 1-Jan-15*	156	*1-Jan-15 – 1-Jun-16*	17	173
3.	*1-Jan-02 – 1-Jan-16*	168	*1-Jan-16 – 1-Jun-16*	5	173

Source: Made by the authors according to the data from The Croatian National Bank, available at: https://www.hnb.hr

Based on the test results from the narrower set of submitted data the model that makes the smallest mistake is taken. In this particular case, several ratio varieties of the input data between data samples were taken. The variants are shown in Table 1. The total size of the data set is 173, which represents the number of the original records.

The first variant includes the largest collection of validation data (41) and the minimum sample of 132 records. Another variant for the construction of the model uses a set of 156 data and 17 for validation, and is testing the accuracy for 2015 and the first five months of 2016. In the latest variant, which will be used in this paper, the number of retained data for testing is 5, while the size of the set of samples is 168. Using these variants, the prediction for the first five months of 2016 will be tested. By working variants out, one can get a better insight into the accuracy and reliability of the time series analysis methodology that is used in this study. In addition, the analysis will be conducted on the latest variant, while in research other models were designed. So, all the records (168) except those from 2016 will be used for training, and the first five months of 2016 (5 records) will be used to validate the model.

Time series data[1] Y_t means all the data (all available prices), where the index t = 1,2 ... 173, marks the date for the month. The index t = 1 is the date = 01/01/2002, the index t = 2 is the date = 01/02/2002, ... Index t = 173, date = 05/01/2016.

Curve time series can be described by the formula Yt = (Pm * Tt) + E; where E is a random component data that cannot be ''explained" with the presented model.

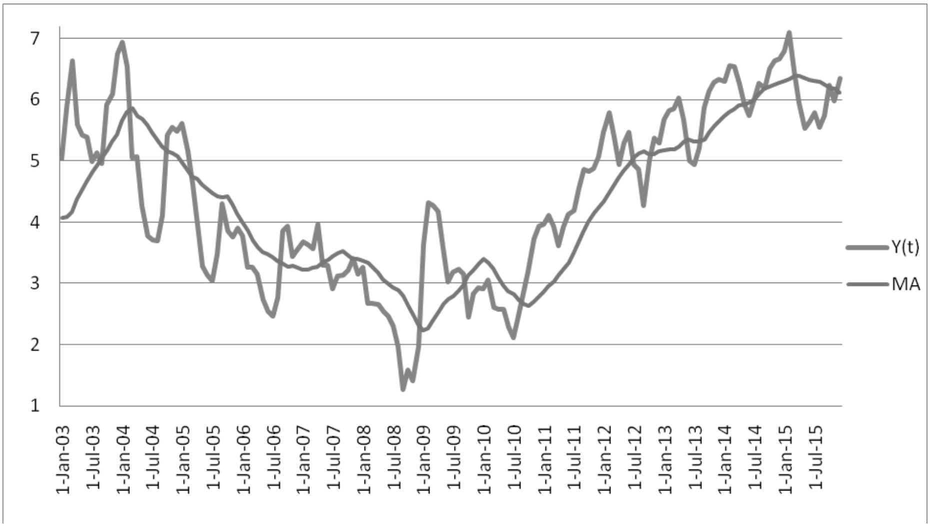
In order to construct an effective model, it is necessary to accurately determine parameters P_m and T_t and optimize them with the best results (with the smallest error). The new constructed model does not include random component errors, nor is it able to accurately describe the parameters P_m and T_t, so the original set of data $Y_t = P_m * T_t + E$ reduced the model described expression $Y'_t = P'_m * T'_t$, where Y'_t represents a calculated function model which is necessary to get closer to the original function of Y_t, so that the model parameters T'_t and P'_m representing the trend and periodicity are estimated to be as close to ideal parameters T_t, P_m.

The first step is to find a periodic pattern P'_m and then calculate the estimate of the trend models $T'_t = Y'_t / P'_m$. After this procedure, one does the trend function estimation.

In defining the periodicity of the sample, it is necessary to assume at what level, i.e. time frame ,the periodicity exist (window of periodicity). Figure 2 shows the periodicity on an annual basis, where recurring peaks are visible at the boundaries between the years and the troughs are located in the middle. Taking a multi-year average of the periodic behavior of the observed sample years from 2002 to 2015, it is necessary to calculate a one-year periodicity of the pattern P'_m (m = 1,2,3 ... 12), where the index m represents the number of months within the year, i.e. within constructed form of periodicity. With it, the projection of time series of prices of a currency pair for the first five months of 2016 will continue to operate. In order to reach the periodicity patterns, it is first necessary to smooth the original data using the smoothing function, which is the basis of the curve time series according to which periodic deviations will be counted.

The method of moving averages with a window size of 12 time units (12 months) is used, which is described by the following expression: MA[moving average] (t) = [sum of the previous 12 value] / 12 = (Y(t-1) + Y(t-2) + .. + (Y(t-12)) / 12., where Y(t) is the original value of the time series for the given month t.

Figure 3 Calculation of moving averages of data



Source: Made by the authors according to the data from The Croatian National Bank, available at: https://www.hnb.hr

Figure 3 shows how certain periodicities differentiate from the baseline. From the ratio of smoothed functions and time series data for all the data together it is possible to calculate the difference displayed. For example, the function of the moving average for the date MA(09/01/12) is 4.26569, while Y(09/01/12) = 5.1516. The ratio of 5.1516/4.26569 = 1.2077 represents 20.77% higher value than the nominal value. In other words, the periodicity or deviation in the nine months of 2012 is over 20% above the average. The ratios R(t) = Y(t)/MA(t) are calculated for the entire data set (sample) except for the first five months of 2016 (test data). In order to obtain a complete calculation of the form of periodicity for each month of the year (12 components) it is necessary to calculate the average monthly values for all of these years and each month. Thus, for example, the amount for September is the average value in September through all 13 years of the observed sample (from 2002 to 2015). R_m = (R(01/09/2002) +R(01/09/2003)+..+R(01/09/2015)) / 13.

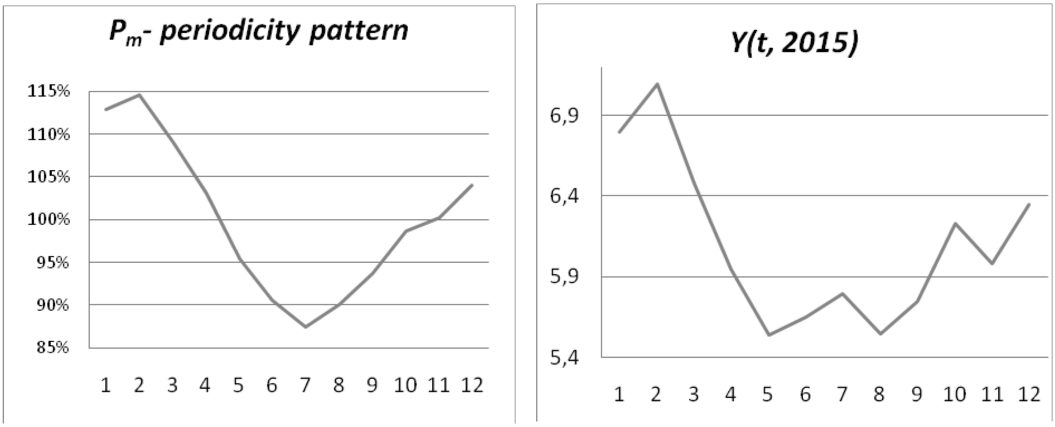
R_m quotients should be calculated for all 12 components of the year (months), after which they need to be scaled so that the average of the form components Rm, m ∈ {1,2,3…12} for all months of the year amounts to 100% (the average of the components ranges approximately around 100%). Components are standardized to calculate the general pattern periodicity applicable for all future values of a time series. The normalized components of R_m represent the aforementioned component periodicity model P'_m, (where the model is $Y'_t = P'_m * T'_t$). Thus, the norm (R_m) = P'_m, where norm () is a scaling function. The final results are presented in Table 2.

Table 2 Non-standard and normalized periodicity pattern models

	January	February	March	April	May	June	July
$\overline{R}$	115.81%	117.57%	111.90%	105.80%	97.84%	92.94%	89.69%
P'_m	112.92%	114.63%	109.11%	103.16%	95.40%	90.62%	87.45%
	August	**September**	**October**	**November**	**December**	**Average**	
$\overline{R}$	92.42%	96.07%	101.17%	102.86%	106.66%	**102.56%**	
P'_m	90.11%	93.67%	98.65%	100.29%	104.00%	**100.00%**	

Source: Made by authors

Figure 4 Periodical pattern of P'_m model and example of value of the original series Y (t) for the year 2015



Source: Made by authors

Figure 4 shows the final shape of the periodic components of the model (graph on the left), and the original data Y(t, 2015) for the year 2015 (from 01/01/15 to 01/01/16). It is clearly visible form the periodicity of the actual data viewed through one year (in this case 2015). Also, from the form of periodicity, it is evident that the peaks of charts are the highest at the beginning and at the end of the year, giving a "U" shape.

Although time analysis does not show causal relationships, it could be hypothesized that periodicity is associated with supply and demand in the foreign currency exchange market HRK/EUR within specific seasonal trends associated with the export of tourism services. Peaks are connected with greater demand for foreign currencies, while during the tourist season, the situation is reversed. The lowest point of the euro prices against the Croatian kuna is in component form under number 7, which indicates the month of July, which is in line with tourist activities. For more detailed causal relationships of supply and demand an in-depth analysis should be made.

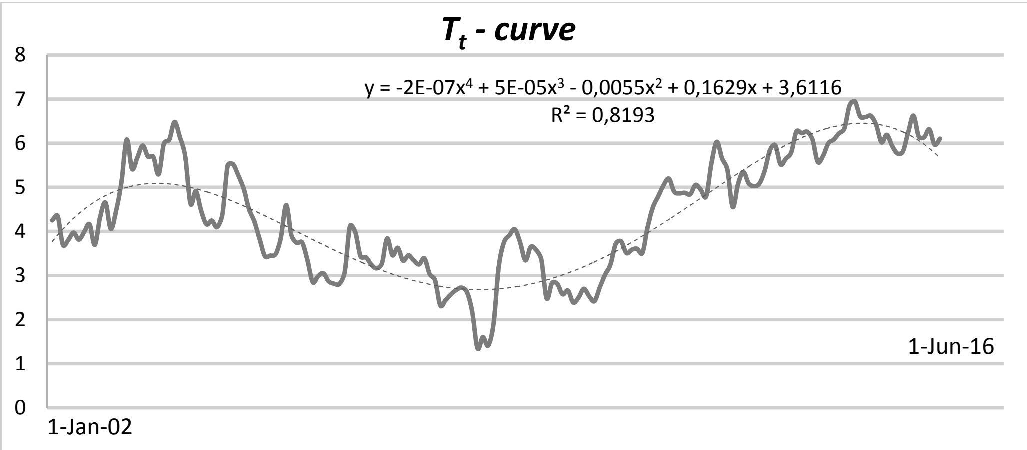
It is interesting to note that the difference between the highest and lowest points of the components of the periodic pattern is almost 30% of transformed prices. In order to calculate the absolute difference in rate, it is necessary to convert the data back to the original form O(t) = Y(t)/10 + 7. For example, if Y(t) = 4.2526, then O(t) = 7.42526. The variation of 30% on the data Y(t) means the variation (30 *

4.2526)/100 = 1.2758, which further represents (0.12758 / 7.42526) * 100% = 1.7182% of the original price O(t) = 7.42526. If this information is interpreted through the FOREX terminology, the change is 1276 PIP points. As the previously calculated difference between the buying and selling rate is about 450 PIP points, using the periodic variation in average, it is possible to achieve an advantage of about 800 PIP points.

To calculate the trend of T'_t, model, it is necessary to remove the calculated periodic component (P'_m) from the original series, and then evaluate the trend line/function that fits your results: $Y'_t = P'_m * T'_t \Rightarrow T'_t = Y'_t / P'_m$ the best. Model Y'_t is the subject of research, and as it is at this moment unknown, instead of it, the original series Y_t will be used, but this will bring a certain error. $T'_t \approx Y_t / P'_m = (P_m * T_t + E) / P'_m = (P_m / P'_m) * T_t + E / P'_m$. If the assumption is that $P_m \approx P'_m$, their ratio is ≈1, and the last phrase that contains the error E/P'_m can be ignored (because it cannot be described by the model), finally we have $T'_t \approx T_t$. In other words, if we calculate the trend of the original series, we get approximately the trend and models.

If the observed and regular periodic components ($P_m \approx P'_m$) are removed from the original time series $Y_t = P_m * T_t + E$, what remains is the time series trend and component of random error E (which the model cannot fully describe) by the formula: $T'_t \approx T_t = Y_t / P_m - E/P_m$, and the resulting curve of the trend is shown in Figure 5.

***Figure 5 Only processed data T_t after removing P_m components*[2]**



Source: Made by authors

The next step is the construction of the model $Y'_t = P'_m * T'_t$. In Figure 5, a general direction of movement of the time series can be seen, where the first part has a falling tendency, and growing tendency is visible in the second part. Since this is a period of 13 years, it is not easy to fit the data to a linear trend, which is commonly applied within shorter time intervals. Selection of trend line that best describes the data displayed is governed by selecting the curve which will make the smallest error with respect to the original data, i.e. which best describes the variance of the analyzed data. In this paper polynomial regression fourth degree was selected, which is shown in Figure 5 with the red dotted line. On top of the line, there is a polynomial equation that describes the trend. For this example, it could be assumed that there is a periodicity of 10-years level, which represents the distance between the peaks of two shown polynomial functions. But as many years periodicity is difficult to prove in a time of scarce data for such a long period (a minimum of 30 years) as the final solution was chosen the polynomial regression.

All coefficients of a polynomial model are statistically significant and shown in Table 3 together with the coefficient of determination R^2.

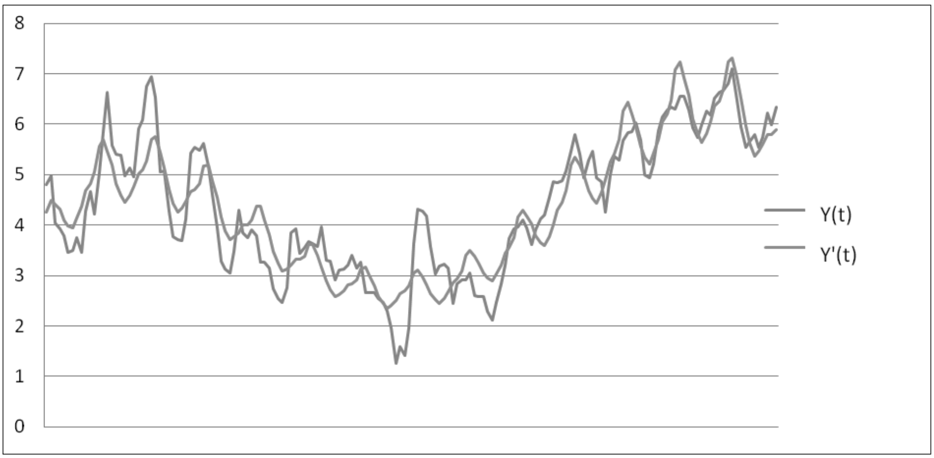
Table 3 Polynomial trend line coefficients

Pol^4	b4	b3	b2	b1	b0
	-1.575E-07	*5.365E-05*	*-0.0055*	*0.1629*	*3.6116*
R	*0.905172588*				
R^2	*0.819337415*				

Source: Made by authors

Figure 5 shows that the trend had changed three times, at the beginning of the graph, in the middle and at the end. Technical analysis does not go within the grounds of macroeconomic exchange movements, but it can be noted that from 01/12/03 to 01/09/08 the Croatian kuna recorded an upward trend (euro downward trend) for the time when the Croatian GDP has been growing constantly, but then falling trend (euro upward trend) from 09/01/08 when GDP continued to fall. The lowest point of the curve is in September 2008 which approximately agrees with the effects of the global economic crisis began to be felt in the Republic of Croatia. The recession into which Croatia entered and which caused a decrease in domestic demand resulted in a surplus of local currency. On the other hand, the new borrowing caused additional pressure of euro demand. From 01/01/15 the trend curve changed again when the GDP trend was reversed. Figure 6 shows the original time series Y_t in blue, and newly designed model Y'_t in orange. It is evident that the trend and periodicity model "follow" the real data, but one can also see model the deviations that cannot be described by the model because of the random error and imperfect estimation of model parameters. The biggest deviations of the sample are at the beginning and in the middle of the sample, while in the second half of the time series deviation is minimal. Following the constructed model, a further price movement prediction will be made.

Figure 6 The original time series Y_t and newly constructed Y'_t models



Source: Made by authors

3. Research results

For assessment model function three levels of budget errors are used: MAE (mean absolute error), MSQE (mean square error) and MAPE (mean absolute error in percentage).

Table 4 Calculation of the accuracy of the model regarding the observed pattern

		Y'(t)	Y(t)		MAE	MSE	MAPE
					0.212837	**0.052434**	**3.85%**
2016							
January		6.261156	6.52777		0.266614	0.071083	4.08%
February		6.203585	6.36668		0.163095	0.0266	2.56%
March		5.74766	5.66498		0.08268	0.006836	1.46%
April		5.274099	4.94619		0.327909	0.107524	6.63%
May		4.718345	4.94223		0.223885	0.050124	4.53%

Source: Made by authors

The first two columns show original values Y_t and values obtained with model Y'_t for the first five months of 2016. They represent the retained test set (five tracks) by which validated model will be made of. It is noticeable that the model results Y'_t are similar to the original data, and error calculations will show how similar they are. Error indicator MAE (mean absolute error) is calculated as the average of the absolute differences of the original series and the model for all the observed test records (in this case five records).

$$MAE = \frac{\sum_{t=1}^{N} |Y_t - Y'_t|}{N} = 0{,}212837$$

MSE assessment is the average of the square of the differences:

$$MSE = \frac{\sum_{t=1}^{N} (Y_t - Y'_t)^2}{N} = 0{,}052434$$

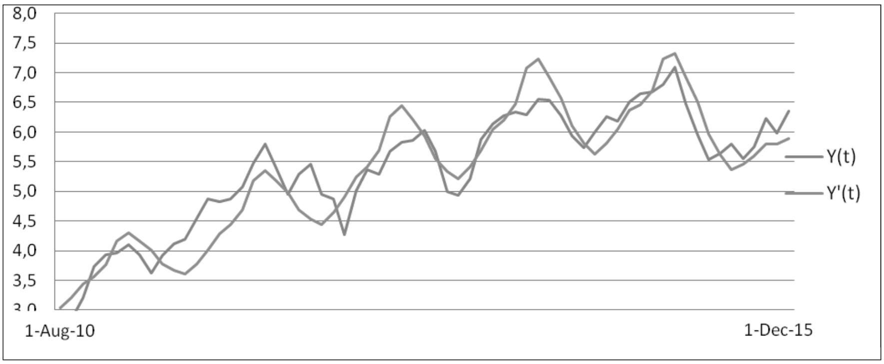
and finally the mean absolute error in percentage shows how much is actually, in the percentage, deviation from the original data:

$$MAPE = \frac{\sum_{t=1}^{N} \frac{|Y_t - Y'_t|}{Y_t}}{N} = 3{,}85\%$$

In the last three columns of Table 4, one can see the amount of error at the level of the record and as a whole. For the interpretation the most indicative is the indicator MAPS, which is expressed as a percentage. In this case, solution MAPE = 3.85%, which interprets that set of values of model Y'_t make the average deviation of the original data for less than 4%. Thus, the prediction of transformed original National Bank data movements is within 3.85% error. If one turns back the transformed data to the original form of CNB O (t) = (Y (t)) / 10 + 7, the error of 3.85% is reduced to 0.67%.

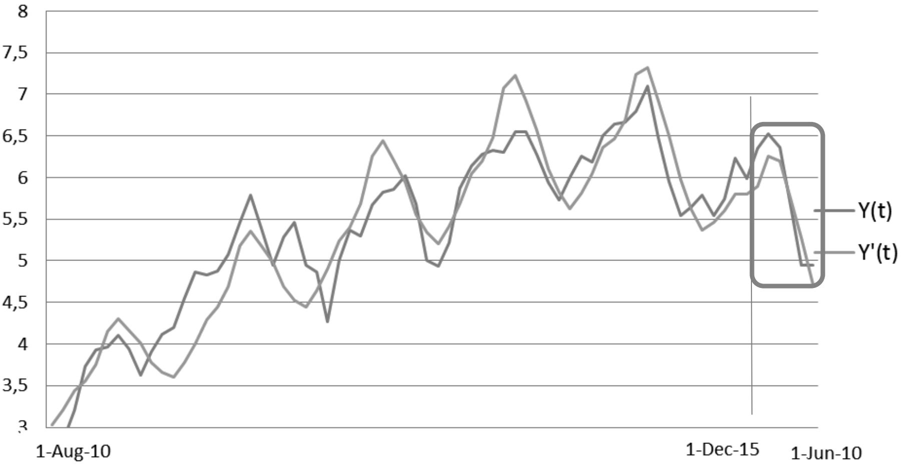
The selected solution on a sample is not necessarily the best model for prediction (it depends on the selection of T'_t and P'_m). Retained data set of five months in 2016 represents a control set of data with which final model validation is made. The final results of the time series motion prediction for a period of five months in 2016 are shown in Figure 7.

Figure 7 Time series prediction of Y'(t) movement for the first 5 months in 2016 (a)



Source: Made by authors

Figure 8 Time series prediction of Y'(t) movement for the first 5 months in 2016 (b)



Source: Made by authors

Figure 7 shows the parallel solution models and original series ranges from 08/01/10 to 12/01/15 (inclusive). Figure 8, besides that, shows the prediction model (outlined in red) in the next period of five months in 2016 that tells us how well the predicative model follows the actual time series.

Interpretation of the final model $Y'_t = [-1.5746*10^{-7}*t^4 + 5.365*10^{-5}*t^3 - 0.005546*t^2 + 0.16288*t + 3.61162] * P'_m$, for t = 1,2,3 .. 173, m = 1,2,3, … 12, where = P'_m $_=$ {112.92% 114.63% 109.11% 103.16% 95.40% 90.62% 87.45% 90.11% 93.67% 98.65% 100.29% 104.00%.}. The average error of the model on the test group was 3.85%. If the prediction is made for a particular month in the test set, for example, March 2016, the error should be about 3%. In this case, the setpoint for March is 5.74766, while the actual value is 5.66498, which represents the absolute error of 1.46%.

Finally, to show the possible model utility, an example of an investor who would be using this model for trading on the foreign exchange market with currency pair HRK/EUR was shown. Although the referent currency pair cannot be found in foreign markets with FOREX, it is possible to trade via private banks and at the local exchange. Although profit margins (spreads) are about 100 times greater than that of FOREX trading with the most liquid pairs like EUR/USD, it is possible to achieve a certain gain. The difference between the buying and selling rate (spread) for HRK/EUR is around 450 PIP points (at the Croatian National Bank), while the "spread" of the pair EUR/USD on the FOREX market is the framework of 1-10 points. To make a profit, it is necessary to realize the difference of more than 450 points. The differences of middle exchange rates for the currency pair HRK/EUR between December 2015 and May 2016 amount to: 7.634682 - 7.494223 = 0.140459. If converted to the FOREX terminology, the difference is: 0.140459 * 10,000 = 1404.59 PIP points. If margin ("spread") is subtracted from that number, the final difference is 1404.59 - 450 = 954.6 points. The estimated cost of the rate for May is O (May, 2016). = 7.47183 (calculated from Y (May, 2016) = 4.71834). Therefore, the expected drop in euro prices by 1628.47 PIP points is predicted. The first benefit that an investor can profit from this model is predicting the direction of movement, i.e., falling prices, the other is the intensity of the fall, which indicates that it should be greater than 450 points (spread) to achieve a positive difference at all. A trader who decided to bet (short), on the basis of the presented models, on decrease of the value of the currency in anticipation of the fall in the value of 1600 points, would achieve a difference of 1404 points which would finally with the imputed exchange rate difference (spread) bring net 954 points. If the retailer set point value 1 PIP=1 EUR, the final earning would amount to 954 euros. Furthermore, as the prediction is made only for May, a further fall in June and July is expected, so the final difference could be much higher.

4. Conclusion

Trend and periodicity of time series is common in time series analysis. Using the appropriate methods of analysis and developing a series of appropriate models, it is possible to significantly predict further movement of the observed values with appropriate accuracy. In this paper, an example of a time curve of currency pair HR/EUR prices at the foreign exchange market is shown. Although relations of the shown curve (supply/demand) are not deeply analyzed, it is clear that there are observable regularities and series features through which it is possible to construct a model to describe the available data. This paper technically analyzes the price curve of a currency pair, indicating the observed characteristics (trend and periodicity), selects the appropriate model to describe the data and forecasts further price movements (in this case, for the first five months of 2016). The first part of the analysis refers to finding the model that best describes the data in the test sample, and the second refers to forecasting a further set of values. Forecasting has been done to hold the original values that were not included in the modeling. The polynomial model of the fourth degree that uses polynomial regression trend proved to be the most appropriate.

It is also evident that in the form of price periodicity of a currency pair HRK/EUR there are extremes that are in a particular area in February (maximum) and July (minimum), which may be explained by the tourist season in Croatia. Tourist activities are most pronounced during the summer months, with much less activity in winter.

The change of the falling euro trend curve in relation to the Croatian kuna occurs at a point with the lowest value in September 2008, followed by growth of the euro until early 2015. These changes could be interpreted through the consequences of Croatia going into recession (2008) due to the global economic crisis, and coming out of recession (2015).

As further research, a detailed analysis of time series for other currency pairs could be made, e.g. for HRK/USD, HRK/CHF or HRK/GDP in order to spot any regularities, trends or periodicities. The overall picture would probably provide a wider access to additional explanations and the results that are given in this paper. Also, current models could be improved if calculations could include the remaining five values of 2016 and make a prediction for the rest of the year.

References

1. Martinović, M., Samardžić, I., Stoić, A. (2016), ''Analysis of laptop demand curve through the internet search'', in Proceedings of the 4th International Conference: Inovacije, tehnologije, edukacija i menadžment, Vol. 4, No. 4, pp. 523-537.
2. Šošić, I. (2006). Primijenjena statistika. Zagreb: Školska knjiga.

Bibliography

1. Academy of Finantial Trading, available at: http://www.academyft.com/ (Accessed on: July 19, 2016)
2. Delaney, J. (2012), Deasonalizing and Forecasting, available at: https://www.youtube.com/watch?v=QrEKlHWakoE (Accessed on: July 6, 2016)
3. Delaney, J. (2012), Trend Estimation, available at: https://www.youtube.com/watch?v=0h8QCGnxPsI (Accessed on: July 12, 2016)
4. Gartner Inc., available at http://www.gartner.com/technology/home.jsp (Accessed on: July 17, 2016)
5. Statistic Brain Research Institute, available at: http://www.statisticbrain.com/ (Accessed on: July 19, 2016)
6. The Croatian National Bank, available at: https://www.hnb.hr/ (Accessed on: July 15, 2016)
7. The Statistics Portal, available at: http://www.statista.com (Accessed on: July 19, 2016)

(Endnotes)

1 The original time series data Yt in the following text will be uniformly used as the term Y(t). Furthermore, symbol Y'(t) or Y't means time series of a newly constructed data model.

2 Figure 5 can still interpret any periodic regularity, although the design has exempted the periodic component. The reason for this is that the periodicity is not necessarily on an annual basis (this is an assumption of this model), because the method of calculating periodic components cannot fully describe the "real" periodicity Pm <> P'm, and especially many random values can be mistakenly interpreted as periodic.

Marko Martinović
Željko Požega
Boris Crnković

ANALIZA VREMENSKOG NIZA VALUTNOG PARA HRVATSKA KUNA / EURO

Sažetak

Domaća valuta hrvatska kuna uvedena je u svibnju 1995. godine. Do danas, Hrvatska narodna banka (HNB) kao regulator i nositelj monetarne politike u RH vodi politiku stabilnog tečaja, obično referiranog prema formalnoj valuti Europske unije Euro (EUR). Od dana uvođenja eura 1.1.1999. pa do 1.1.2016. vrijednost valutnog para HRK/EUR promijenio se u vrijednosti svega 4,25% (HNB).

Iako je vrijednost hrvatske kune relativno stabilna, postoje određene fluktuacije, kako na godišnjoj (npr. zadnjih nekoliko godina zbog globalne svjetske krize), tako i na unutar godišnjoj periodičkoj razini.

Cilj rada jest prikazati kretanje vrijednosti valutnoga para od početka 2002. do danas (kroz vremensku krivulju), analizirati pravilnosti, trendove i periodičnosti (sezonsko ponašanje) ukoliko postoje.

Istraživanje će biti napravljeno koristeći se metodom "Time Series Analysis" (Analiza vremenskog niza) pod pretpostavkom da će vanjski (globalna ekonomija) i unutarnji čimbenici (ekonomske politike) ostati slični ili jednaki. Sukladno rezultatima bit će napravljena daljnja procjena kretanja cijena u periodu koji slijedi koristeći se dobivenim predikacijskim modelom. U slučaju da krivulja sadrži komponentu periodičnosti, dodatno će se proučiti uočeni uzorci.

Ključne riječi: hrvatska kuna, euro, analiza vremenskog niza, HRK/EUR, predikcija