JEL classification: C1: Econometric and Statistical Methods and Methodology: General; C5: Econometric Modeling; F31 Foreign Exchange; G15: International Financial Markets

CONSTRUCTING AN EXCHANGE RATE MODEL OF THE LOCAL CURRENCY IN R PROGRAM

N. B. Ussenbayev,
Associate professor,
University Narxoz,
Almaty, The Republic of Kazakhstan
T. B. Akhmetov,
PhD, Associate professor,
University Narxoz,
Almaty, The Republic of Kazakhstan
A.O. Agymbai,
Candidate of economic sciences,
University of Foreign Languages and Business Career,
Almaty, The Republic of Kazakhstan
Y. M. Raushanov,
PhD student,
Narxoz University
Almaty, The Republic of Kazakhstan

ABSTRACT

Purpose – The main purpose of this paper is to reveal core factors influencing the exchange rate of the national currency in Kazakhstan, a commodity currency, using R program. The other purpose is to understand the applicability of an Autoregressive Integrated Moving Average (ARIMA) model for constructing such exchange rate model in a short-term period.

Methodology – The paper develops a forecasting ARIMA model of exchange rate based on econometric, statistical and time-series analysis. It includes some data of the exchange rate and prices of oil, mineral and agricultural products and some aspects reflecting a construction of a solid model according to conventionally accepted criteria.

Originality/value – Authors, according to their belief and to their extent of expertise, tried to consider all relevant factors influencing the exchange rate and conducted a research that revealed variables influencing on the value of the national commodity currency and forming its exchange rate.

Findings – One of important results of this paper was development of an ARIMA model, which could be applied to forecast the exchange rate of the local currency in a short-term period. The strong correlations were confirmed among such financial components as: exchange rate, oil, wheat, some metals and the Russian ruble. A forecast for the exchange rate of the local currency is provided.

Keywords – Kazakhstan, depreciation, devaluation, local currency, exchange rate, oil, metal, commodity, the Kazakh tenge, the Russian ruble, ARIMA, correlation, forecast, AIC, normality test, autocorrelation test, homoskedasticity test, t-test.

INTRODUCTION

Kazakhstan is a young country with a population of 17 million people and possesses huge deposits of minerals and a great potential for agriculture. The main sectors of the economy are the oil and gas industry, ferrous and non-ferrous metallurgy, as well as the business of concentrates and mixtures. As for grain production, Kazakhstan ranks third in the CIS after Russia and Ukraine. Most of the export goods consist of a supply of raw materials or items derived from them. The share of exports of goods with deep processing is relatively low [1]. That is, with a drop-in world prices for export goods, one can expect a significant drop in the country's income.

In an open economy, which operates under market laws, demand and supply must be balanced. As it is known, the main financial quotes on the world financial markets are presented in the U.S. currency. The fall in revenues, in the form of sales, taxes, duties and others, will lead to a decrease in demand, i.e. a reduction of the local economy, and, if the import content in it is high enough and inelastic, this can lead to depreciation of the local currency in the process of balancing supply and demand. In this case, to stimulate the local economy, fiscal or monetary solutions can be used, which can affect the welfare of the population and business and the prices of goods.

In the commodity and import-dependent economy there is an instant link between the decline in the value of goods and that in the well-being of the population. One of the solutions in this situation is the diversification of the economy to be implemented through a strategic development plan in which the supply of commodities and raw materials must constitute an insignificant part.

According to theory and practice, the other economic factors in the formation of the exchange rate of any local currency can be relative interest rates, purchasing power parity, demand for capital and its supply, and economic conditions characterized by such indicators as the balance of payments, economic growth, inflation, money supply, unemployment, tax rates, etc.

With regards to above mentioned factors, in the case of Kazakhstan for 2014-2016, it is worth to say about a relation between the inflation and exchange rate. The accelerated growth of the money supply helps to reduce the exchange rate, i.e. depreciation of the local currency. The increase in the money supply in the conditions of a real decline of production leads to an increase of price level and promotes an increase in the currency efficiency of imports. As consequence, it leads to an increase of demand for foreign currency and a depreciation of the local currency.

Inflationary expectations are also an economic factor for the exchange rate. In anticipation of changes in the exchange rate, investors can make unforeseen decisions, which can result in both an increase and decrease in demand for currency, causing the growth and fall of the exchange rate. However, since Kazakhstan is considered to have a commodity and import-dependent economy, further we shall review aspects of dependence of exchange rate on export, excluding inflation and inflationary expectation and other economic factors.

The official exchange rate of the national currency “Kazakh tenge” (hereafter – the local currency KZT) to the U.S. dollar is set considering general macroeconomic factors, while it is known that the economy of Kazakhstan is highly dependent on oil prices [2]. After a very sharp fall in oil price in 2014-2015 years, perhaps not surprisingly, we observed a shift from a fixed exchange rate to a floating exchange rate. At the same time, many sources indicated that devaluation of the local currency was inevitable [3]. If to look closely at the numbers, one can see that in 2015 and 2016, oil prices fell by almost 47% and 17% compared with the corresponding past periods. However, in 2017 oil rose in price by almost 25%. In 2015 and 2016 the depreciation of the local currency also reached, on average, 20% and 35% respectively, compared with previous periods. In 2017, it appreciated by 5%. This trend indicates some correlation, which confirms dependence of the exchange rate of the Kazakh tenge to the U.S. dollar (hereafter – the exchange rate) on oil price.

Other major export commodities of Kazakhstan are copper, iron, zinc, aluminum, and wheat (cereals) being the largest agricultural export item [1]. In such circumstances, it is also natural to consider the strong dependence of the exchange rate on the prices of these goods. In 2014-2015, due to the insufficient of demand, world production of a large number of Kazakhstan’s main commodity exports continued to grow leading to a sharp decline in prices. For example, during two years before March 2016, the world prices for copper and wheat fell by 25% and 35% correspondingly [4]. As it can be seen, along with decline of these commodity prices, the exchange rate rose, i.e. the Kazakh tenge depreciated.

At the same time, currently according to many analysts, the exchange rate of the national currency is affected not only by current and expected level of prices in oil and other commodity market, but also by the exchange rate of the currencies of the trading partner countries, particularly the exchange rate of the Russian ruble to the U.S. dollar [5].

According to one of the local analysts [6], the change in the exchange rate of the local currency in Kazakhstan has recently been more correlated with the change exchange rate of the Russian ruble to the U.S. dollar rather than with the dynamics of oil prices. This might indicate that in the case of the Kazakh tenge it is reasonable to take into account not only the commodities' prices, but also the value of other commodity currency such as the Russian ruble.

Theoretical framework of exploring the impact of oil and other commodities' prices on exchange rate of exporting countries, including that of Kazakhstan, is well developed.

Our literature review showed that forecasting an exchange rate in the commodity economies is a very relevant research field with practical values. Forecasting exchange rate for mentioned countries is important for state and enterprise budget planning, strategic economic program development, etc.

There are number of studies employing various techniques to forecast exchange rate [7, 8, 9, 10, 11]. Most of studies are devoted to Russia, Azerbaijan and other countries, while Kazakhstan is less explored from time series aspect [2]. In these papers and many others, oil prices and more general commodity prices are considered as exchange rate determinants, "but mostly as in-sample explanatory variables for real exchange rates" [12].

Some of the frequently encountered drawbacks of existing works are misspecification problem due to absence of other relevant factors, small sample bias issue, use of descriptive analysis without deriving specific parameters and econometric methods, etc.

In the reviewed works the main factor in formation of an exchange rate is the oil prices, while influence of other commodities on it is much less considered. On the contrary, in some works the prices for wheat, corn, and soybean are interrelated with the oil prices and exchange rates, i.e. the formers can be viewed as endogenous variables [13].

While many researchers confirm the in-sample empirical evidences of explanatory power of commodity prices for real exchange rates [12, 14], some papers focus on predicting nominal exchange rates through use of macroeconomic fundamentals and commodities and provide evidences of solid predictive ability of latters at longer horizons, i.e. at quarterly basis [12, 15].

According to Ferraro et. al., the out-of-sample empirical evidences in favor of a convincing short term predictive ability of commodities and other macroeconomic fundamentals on exchange rates are not well demonstrated, whereas there exist works confirming a long term predictive ability for out-of-sample cases [12, 16]. From this point of view, it is interesting and relevant to develop an exchange rate model having an out-sample relationship between variables and a good short term predicting ability.

To explain the choice of such statistical tools as an ARIMA model to forecast exchange rate, one can say that it is be very difficult to analyze changes of exchange rate changes and, even harder to forecast them. Many authors [17, 18, 19] developed various ARIMA models on the daily and monthly bases and confirmed that ARIMA models are comparatively accurate models to predict the exchange rates. Usually, the performance of ARIMA models is evaluated through mean absolute percentage error (MAPE) and root mean square errors (RMSE). Some other authors select "the best" ARIMA model using Akaike's Information Criterion (AIC) or Bayesian Information Criterion (BIC) – Maximum Likelihood Estimation methods.

Additional explanation for exploring the applicability of ARIMA models is a wish of the authors to test a special advanced function in R program, which automatically searches for the best ARIMA model.

In the work below, we will consider prices for main exports of Kazakhstan and the Russian ruble as exogenous variables and will try to demonstrate an out-of-sample predictive ability of its main commodities to forecast nominal exchange rates in a short-term period in the frame of the ARIMA model construction process in the R program.

METHODOLOGY AND RESULTS

To construct an exchange rate model, we selected data covering time periods: 2015M9-2018M07 and 2015M9D01-2018M07D27 [20, 21]. The choice of such time periods is based on three reasons. First, the transition of the exchange rate from a fixed regime to floating one was made in August 2015, which should represent a structural change in the corresponding data. Second, there were several significant artificial devaluations of the Kazakh tenge in the frame of the fixed exchange rate regime during 2008-2014. Third, we are primarily interested in constructing a short-term exchange rate model based on the reasons explained in introduction. Besides, the use of the daily and monthly data for earlier period was also not possible due to lack of some data. For example, we failed to find prices for some commodities during 1990s and 2000's, which would be required for a quarterly basis modeling to avoid a problem related to the small number of observations.

In the table 1 below, one can see the main export items of Kazakhstan considered as major factors influencing the exchange rate and selected proxy price variables for them [22] to be used in corresponding calculations later. For some export items we couldn't select the proxy price variables due to insufficient level of the necessary detailed data. Trade balance over the 2015M9-2018M07 period is positive and ranges approximately from 0.3 billion dollars to 2.5 billion US dollar in a month, which allow consider export as main driver of the exchange rate. Otherwise, we should have included the import items, which would have complicated our exchange rate model.

In the table 2 below, one can see correlations of the exchange rates of the Kazakh tenge, Russian ruble and oil price with prices of other export items and their significance levels (*p-value)* from the Pearson test. These calculations and others shown later are made on the R program. All provided variables in the table 2 (hereafter – factors), except for the Kazakh tenge, are accepted by as exogenous ones influencing the exchange rate of the local currency.

The Kazakh tenge significantly correlates with the exchange rate of the Russian ruble to the US dollar (hereafter – the Russian ruble) and prices of all export items, except for those of aluminum and zinc (p – value > 0.05) both on the daily and monthly bases. It is interesting to note that the Russian ruble impacts stronger on the local currency than oil does, which supports the observation from [6]. On the contrary, aluminum and zinc appear to be insignificant factors for the Kazakh tenge.

Table 1 – Main export items of Kazakhstan and their proxy price variables

#	Export items	Volume, in billions of USD	Share in total export, in %	Selected price variable
1	2	3	4	
1	Mineral fuels, oils, distillation products	30,68	69,6%	Brent Oil Futures (LCOU8)
2	Iron and steel	4,19	9,5%	Iron ore fines 62% Fe CFR Futures - (TIOc1)
3	Copper	2,53	5,7%	Copper Futures (MCUc1)
4	Inorganic chemicals, precious metal compound, isotope	2,17	4,9%	Uranium Futures (UXXc1)
5	Ores slag and ash	2,10	4,8%	-
6	Zinc	0,84	1,9%	Zinc Futures (MZNc1)
7	Cereals	0,83	1,9%	US Wheat futures (ZWU8)
8	Pearls, precious stones, metals, coins	0,59	1,3%	Gold Futures - (GCQ8)
9	Aluminum	0,53	1,2%	Aluminum Futures (MALc1)
10	Milling products, malt, starches, inlin, wheat gluten	0,49	1,1%	-
Note: compiled by the author [17, 18]				

The Russian ruble is significantly correlated with all major export items of Kazakhstan due to fact, probably, that both the Russian and Kazakh economies are commodity export oriented and have many similar natural resources. On its turn, oil is significantly correlated with all shown export items including with wheat. It provides the partial evidence made in [13], although the correlation coefficient between oil and wheat is not strong. Also, oil is negatively correlated with its energy substitute – uranium.

Additionally, in the table 3 below, again similar to the above made statement, one can say that the Kazakh tenge significantly correlates with the lagged Russian ruble and all export items, except for aluminum and zinc ($p-values>0{,}05$), but only on a daily basis. On a monthly basis, the Kazakh tenge is significantly correlated only with the lagged Russian ruble and iron.

Table 2 – Correlations of the exchange rates of the Kazakh tenge and the Russian ruble with prices of export items and their significance levels (*p*-value)

	Tenge		Ruble		Oil	
	correlation	*p-value*	correlation	*p-value*	correlation	*p-value*
On a daily basis						
Tenge	1	-	0,35	0,00	-0,12	0,00
Ruble	0,35	0,00	1	-	-0,63	0,00
Oil	-0,12	0,00	-0,63	0,00	1	-
Aliminium	0,01	0,79	-0,70	0,00	0,85	0,00
Copper	-0,08	0,04	-0,70	0,00	0,83	0,00
Zinc	0,06	0,12	-0,79	0,00	0,78	0,00
Wheat	-0,26	0,00	0,23	0,00	0,13	0,00
Gold	0,25	0,00	-0,49	0,00	0,48	0,00
Iron	-0,11	0,00	-0,73	0,00	0,54	0,00
Uranium	-0,28	0,00	0,68	0,00	-0,53	0,00
On a monthly basis						
Tenge	1	-	0,36	0,00	-0,10	0,00
Ruble	0,36	0,00	1,00	-	-0,59	0,00
Oil	-0,10	0,00	-0,59	0,00	1,00	-
Aliminium	0,03	0,79	-0,72	0,00	0,84	0,00
Copper	-0,08	0,04	-0,74	0,00	0,83	0,00
Zinc	0,03	0,12	-0,82	0,00	0,76	0,00
Wheat	-0,27	0,00	0,17	0,00	0,27	0,00
Gold	0,23	0,00	-0,54	0,00	0,43	0,00
Iron	-0,19	0,00	-0,78	0,00	0,53	0,00
Uranium	-0,23	0,00	0,71	0,00	-0,51	0,00

Table 3 – Correlations of the exchange rate of the Kazakh tenge with the lagged exchange rate of the Russian ruble and prices of export items at t – 1

	Tenge			
	correlation	*p-value*	correlation	*p-value*
	A daily basis		A monthly basis	
Tenge	1,00	-	1,00	-
Ruble	0,37	0,00	0,47	0,00
Oil	-0,14	0,00	-0,18	0,32
Aliminium	0,00	0,97	-0,12	0,49
Copper	-0,09	0,02	-0,22	0,21
Zinc	0,05	0,21	-0,17	0,34
Wheat	-0,25	0,00	-0,08	0,65
Gold	0,24	0,00	0,03	0,85

Iron	-0,12	0,00	-0,48	0,00
Uranium	-0,27	0,00	-0,01	0,95

In the figure 1 the exchange rate of the Kazakh tenge over the above specified period is presented on the both daily and monthly bases. It can be seen that the exchange rate is more volatile in the earlier time interval due to its stabilization process in the second half of 2015 when it was suddenly shifted from the fixed regime to the floating one.

To construct an ARIMA model, we used the auto.arima() function in R from the {forecast} package. It automatically runs the Hyndman-Khandakar algorithm, which combines unit root tests (KPSS and/or Dickey-Fuller tests) for checking the stationary regime and proposing the appropriate differencing order of time series, decomposition of it into effects (season, trend and cycle) and minimization process of the AIC and/or BIC to obtain "the best" ARIMA model for the fixed number of variables. We also developed own program to receive different "the best" ARIMA models with various combinations of our exogenous variables (factors), including the Russian ruble.

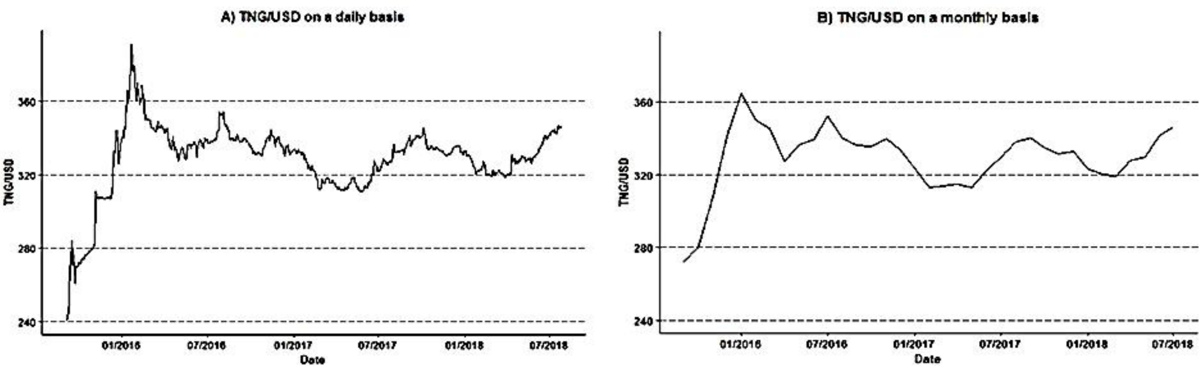

Figure 1 – Exchange rate of the Kazakh tenge to the US dollar
Note: compiled by the authors in R

The following other conventionally accepted criteria were applied to select "the best" ARIMA model:
– The Shapiro-Wilk test to check normality of residuals (shapiro.test(), {stat});
– The t-test to check the equality of expected value of residuals to zero (t.test(), {stat});
– The Ljung-Box test to check zero autocorrelation among residuals (checkresiduals(), {forecast});
– McLeod Li-test to check homoscedasticity of residuals with up to 15 lags (McLeod.Li.test(), {TSA}).

Initially we constructed three samples of data: the first one included the current variables at time t, second one – the lagged variables at l – 1 and third one – the current and lagged variables altogether. The reason behind this action is that the auto.arima() function accepts exogenous variables as input and doesn't automatically consider various combinations of them by creating necessary level of lagging. Consideration of only one lag was reflection of our trade-off between heavy computational load and "good" values of criteria, which would stipulate an inclusion of additional lags in the case if the values were significant. This approach with samples corresponds to the methodology proposed by Rob Hyndman [23].

To simplify an exchange rate model and reduce a computation load, which turned out to be quite weighty given 9 factors with their additional lagged variables, the Variance Inflation Factor (VIF) method was used to determine multicollinearity among them – the vif() function from the {car} package. It appears that aluminum, copper and zinc are highly correlated among independent variables with VIFs more than 10, while the others have less than 5.

The abovementioned approach provided the following results:

– A daily basis: All ARIMA models with the first several minimum possible values of AIC in all three samples $N = 697$ have the heteroskedastic residuals ($p - value < 0{,}05$). Some models also have a significant residual autocorrelation. According to other criteria, all models were acceptable. The possible explanation for this result is the highly volatile period in second half of 2015, when the Kazakh tenge tried to find its equilibrium exchange rate during some time period. So, our decision was not to apply the ARIMA model for a daily basis for the given period. Possible solution in this situation – one should a) think over an appropriate time interval with the relevant economic justification to exclude the mentioned highly volatile period or b) apply other econometric approach such as integrated Generalized Autoregressive Conditional Heteroscedasticity (GARCH), which goes out the scope of the article;

– A monthly basis: there is a range of preferred models. In the table 4 one can see the corresponding result. It appears that the most preferred ARIMA model by AIC, RMSE and R^2 is in the sample 2, where the exchange rate in a current month depends on gold and iron from a previous month, which is, probably, reflection of a long existing relationship between oil and gold [24], keeping in mind that oil is the major export item of Kazakhstan and the gold, in this case, is merely more appropriate from the econometric and statistical calculations. But from the simplicity of structure and existing economic opinion on the market, explained in the introduction, the exchange rate model from the sample 1, describing dependence of the Kazakh tenge from oil price in the same month, is more economically sound, even if its AIC is greater and R^2 is lower. The model from the sample 3, describing dependence of the Kazakh tenge from the Russian ruble and wheat, is also economically acceptable but seriously suffers from heteroskedasticity, which gave us reason not to consider additional lags. The possible reason of this satisfactory result can be the small number of observations ($N = 35$). In the table 5, one can see ARIMA models from samples 1 and 2.

In the table 6, one can see a predicted value of the exchange rate and its 95% confidence intervals for August 2018 from two selected models (samples 1 and 2) on a monthly basis, which represent out-of-sample forecasting. One can observe that there is no big difference between the exchange rates predicted by two models. On the time when this article was submitted, i.e. on 10 August 2018, the current daily exchange rate was at 355.69. Let us see how the selected ARIMA models will have predicted and judge later how effective their predictions will have been in a reality.

Table 4 – Exchange rate models on a monthly base and their characteristics

	Sample 1	Sample 2	Sample 3
ARIMA model	ARIMA(1,0,2)	ARIMA(3,0,2)	ARIMA(0,1,0)
Exogenous variable	Oil_t	$Gold_{t-1}$ and $Iron_{t-1}$	$Wheat_t$, $Ruble_t$, $Ruble_{t-1}$
AIC	259.64	246.66	241.02
Autocorrelation, p value	> 0,05	> 0,05	> 0,05
Heteroskedasticity, p value	> 0,05	> 0,05	> 0,05
Normality, p value	> 0,05	> 0,05	> 0,05
t-test, p value	> 0,05	> 0,05	> 0,05
R^2	0.81	0.83	0.77
Own observation			All first several models with minimum possible values of AIC suffer from heteroskedasticity

Table 5 – Output in R for exchange rate models with their characteristics

Sample 1	Coefficients: ar1 ma1 ma2 intercept OIL 0.73 0.64 0.60 358.98 -0.59 s.e. 0.18 0.17 0.29 25.73 0.45 sigma^2 estimated as 74.2: log likelihood=-123.82 AIC=259.64 AICc=262.64 BIC=268.97 Error measures: RMSE MAPE ACF1 7.97 1.97 -0.10 Formula: $T_t = 358.98 - 0.59 O_t + \eta_t$, $\eta_t = 0.73\eta_{t-1} + 0.64\varepsilon_{t-1} + 0.60\varepsilon_{t-2}$, where T_t – a predicted value of the exchange rate at t, O_t – an oil price at t, η_t – ARIMA error at t, $\varepsilon_{t-1} \sim N(0{,}74.2)$ – an error term (noise) at $t-1$, $\varepsilon_{t-2} \sim N(0{,}74.2)$ – an error term (noise) at $t-2$
Sample 2	Coefficients: ar1 ar2 ar3 ma1 ma2 intercept -0.02 0.28 -0.60 1.61 0.85 272.10 s.e. 0.18 0.20 0.18 0.24 0.27 27.40 GOLD IRON 0.06 -0.16 s.e. 0.02 0.29 sigma^2 estimated as 53.1: log likelihood=-114.33 AIC=246.66 AICc=254.16 BIC=260.4 Error measures: RMSE MAPE ACF1 6.37 1.59 -0.20 Formula: $T_t = 272.10 + 0.06 G_{t-1} - 0.16 I_{t-1} + \eta_t$, $\eta_t = -0.02\eta_{t-1} + 0.28\eta_{t-2} - 0.60\eta_{t-2} + 1.61\varepsilon_{t-1} + 0.85\varepsilon_{t-2}$ where T_t – a predicted value of the exchange rate at t, G_{t-1} – an gold price at $t-1$, I_{t-1} – an gold price at $t-1$ η_t – ARIMA error at t, $\varepsilon_{t-1} \sim N(0{,}53.1)$ – an error term (noise) at $t-1$, $\varepsilon_{t-2} \sim N(0{,}53.1)$ – an error term (noise) at $t-2$

Table 6 – The forecasted exchange rate of the Kazakh tenge for August 2018 on a monthly basis (on average)

#	Forecast	Confidence interval	
		Low 95%	High 95%
Sample 1	345.6	331.325	359.91
Sample 2	341.4	324.78	358.08

CONCLUSION

In this paper authors tried to examine the applicability of ARIMA models to forecast exchange rates of the local currency in the short-term period, when the Kazakh tenge was completely under a floating regime.

We explored the export structure of Kazakhstan. The major 10 export items of Kazakhstan were identified as factors influencing the exchange rate of the local currency. Pearson test revealed that all factors, except for aluminum and zinc, are significantly correlated with the Kazakh tenge. Also, one of evidence has been confirmed that the Kazakh tenge is stronger correlated with the Russian ruble than it is with oil.

We identified and applied a wide range of econometrical and statistical tests as conventionally accepted criteria in the frame of the solid model construction process such as: VIF, normality test, t-test, autocorrelation test, homoskedasticity test.

The main result is that for the given time-period ARIMA models in a daily basis suffer from the heteroskedasticity problem due to high volatility in the second half of 2015 when it was suddenly shifted from the fixed regime to the floating one. Probably, GARCH models will fit the given data better, which requires a further exploration. To apply ARIMA models one can also think over an appropriate time-period, which will not include second half of 2015 and such action should be well justified from the economic position.

For a monthly basis it is possible to construct a solid ARIMA model from the econometric and statistical position. As results show, the factors influencing the exchange rate are gold, iron and oil. Economic reasoning can also be applied to select an appropriate model. Unfortunately, the major drawback in this case is the small number of observations.

The main conclusion is that it is possible to construct a solid and sound ARIMA model for the exchange rate of the local currency in a short period for some data and at some conditions, but such approach should be well justified from the economic, econometric and statistical positions.

REFERENCES

1. WTO Statistics Database (2016), “Trade Profile. Kazakhstan”, available at: http://stat.wto.org/CountryProfile/WSDBCountryPFView.aspx?Language=S&Country=KZ (Accessed July 2018).

2. Hasanov, F., Mikayilov, J., Bulut, C., Suleymanov E., Aliyev, F. (2017), “The Role of Oil Prices in Exchange Rate Movements: The CIS Oil Exporters”, *Economies*, Vol. 5 No 13, pp. 1-18.

3. Frankel, J.A. (2017), “The Currency-Plus-Commodity Basket: A Proposal for Exchange Rates in Oil-Exporting Countries to Accommodate Trade Shocks Automatically”, HKS Working Paper No. RWP17-034, Harvard University, available at: https://ssrn.com/abstract=3024910 (Accessed April 2018)

4. OECD (2016), “Puti razvitiya OESR. Kompleksnyy stranovoy obzor Kazakhstana. Chast’ II. Uglublennyy analiz i rekomendatsii”, available at: https://www.oecd.org/dev/MDCR_Kazakhstan_Vol_2_web.pdf (Accessed July 2018) (In Russian)

5. Zakon.kz (2018), “Pochemu v posledneye vremya tenge to rastet, to padayet”, available at: https://www.zakon.kz/4925549-pochemu-v-poslednee-vremya-tenge-to.html (Accessed July, 25, 2018) (In Russian)

6. Tengrynews (2017), “Ekspert proanaliziroval, chto sil'neye vliyayet na kurs tenge - neft' ili rubl'”, available at: https://tengrinews.kz/private_finance/ekspert-proanaliziroval-silnee-vliyaet-kurs-tenge-neft-rubl-324106/ (Accessed July, 25, 2018) (In Russian)

7. Ahmad, A.H., R. Moran Hernandez, M.R. (2013), “Asymmetric Adjustment Between Oil Prices and Exchange Rates: Empirical Evidence from Major Oil Producers and Consumers”, *Journal of International Financial Markets*, *Institutions and Money*, Vol. 27, pp. 306-317. DOI.org/10.1016/j.intfin.2013.10.002

8. Cashin, P., F., R. Céspedes, L.F., Sahay, R. (2004), “Commodity currencies and the real exchange rate”, *Journal of Development Economics*, Vol. 75, Issue 1, pp. 239-268.

9. Egert, B., Leonard, C., S. (2007), “The Dutch Disease in Kazakhstan: An Empirical Investigation”, *Focus on European Economic Integration,* Vol. 2, pp. 85-108.

10. Habib, M., Kalamova, M. (2007), “Are There Oil Currencies? The Real Exchange Rate of Oil Exporting Countries”, Working Paper Series No 839, European Central Bank, Frankfurt, 17 Dec 2007, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1032834 (Accessed July, 18, 2018)

11. Mohammad, J., R., Mohammadi, H. (2008), "Oil Prices and Real Exchange Rates in Oil-Exporting Countries: A Bounds Testing Approach", *The Journal of Developing Areas,* Vol. 45, pp. 313-322.

12. Ferraro, D., Rogoff, K., Rossi, B. (2011), "Can Oil Prices Forecast Exchange Rates?", Working Paper, Federal Reserve Bank of Philadelphia, pp. 11-34.

13. Hudson, D., Harri, A., Nalley, L. (2009), "The Relationship between Oil, Exchange Rates, and Commodity Prices", *Journal of Agricultural & Applied Economics,* Vol. 41 No. 2, pp. 501-510.

14. Cayen, J.P., Coletti, D., Lalonde, R., and Maier, P. (2010), "What Drives Exchange Rates? New Evidence from a Panel of U.S. Dollar Exchange Rates", Working Paper, Bank of Canada.

15. Engel, C., Mark, N., West, K.D. (2007), "Exchange Rate Models Are Not as Bad as You Think", *NBER Macroeconomics Annual*, Vol. 22, pp. 381-441.

16. Chen, Y., Rogoff, K.S. (2003), "Commodity Currencies", *Journal of International Economics*, Vol. 60, pp. 133-169.

17. Akincilar, A., Temiz, İ., Şahin, E. (2011), "An Application of Exchange Rate Forecasting in Turkey", *Gazi University Journal of Science*, Vol. 24 No. 4, pp. 817-828.

18. Ayekple, Y.E., Harris, E., Frempong, N.K., Amevialor, J. (2015), "Time Series Analysis of the Exchange Rate of the Ghanaian Cedi to the American Dollar", *Journal of Mathematics Research*, Vol. 7 No. 3, pp. 46-53.

19. Nwankwo, S. C. (2014) "Autoregressive Integrated Moving Average (ARIMA) Model for Exchange Rate (Naira to Dollar)", *Academic Journal of Interdisciplinary Studies*, Vol. 3 No. 4, pp. 429-433.

20. National Bank of Kazakhstan (2018), "Statistics. Exchange Rates. Official Foreign Exchange Rates on average for the period", available at: http://www.nationalbank.kz/?docid=364&switch=english (Accessed July, 25, 2018)

21. Investing.com (2018), "Real Time Commodity Futures Price", available at: https://www.investing.com (accessed July, 27, 2018)

22. Trade Economics (2018), "Kazakhstan Exports 1998-2018", available at: https://tradingeconomics.com/kazakhstan/exports-by-category (accessed July, 25, 2018)

23. Hyndman, R., J., George Athanasopoulos, G. (2018) "Lagged Predictors", *Forecasting: Principles and Practice*, OTexts, available at: https://otexts.org/fpp2/lagged-predictors.html (Accessed June, 23, 2018)

24. Bessmertnyy M. (2017), "Neft' i zoloto. Kakaya mezhdu nimi svyaz'?", Blog uspeshnogo treydera, available at: http://newbie-forex-trader.blogspot.com/2017/03/blog-post_15.html (Accessed June 2018) (In Russian)

РЕЗЮМЕ

Научная статья посвящена исследованию по выявлению факторов, влияющих на обменный курс национальной валюты в Казахстане с использованием программы R, а также изучению применимости авторегрессионной интегрированной скользящей средней (ARIMA) моделей для построения его прогнозов в краткосрочной перспективе.

ТҮЙІН

Ғылыми мақалада R бағдарламасының көмегімен Қазақстандағы ұлттық валютаның айырбастау бағамына әсер ететін факторларды анықтауға, сондай-ақ қысқа мерзімде оның болжамдарын құрастыру үшін авторегрессиялық интеграцияланған жылжымалы орташа (ARIMA) модельдерін қолданудың зерттелуіне арналған.