

# Application of Data Mining to Exchange Rate Influence Identification

Oleh Veres<sup>[0000-0001-9149-4752]</sup>, Pavlo Ilchuk<sup>[0000-0003-4636-2309]</sup>, Olha Kots<sup>[0000-0001-7123-3635]</sup>

Lviv Polytechnic National University, Lviv, Ukraine

oleh.m.veres@lpnu.ua, pavlo.g.ilchuk@lpnu.ua,  
olha.o.kots@lpnu.ua

**Abstract.** The growth of data sets requires new approaches to analyzing and processing them. Effective use of Data Mining is the basis for managerial decision making in various fields. Data Mining using potential in the economic sphere has been investigated to identify the impact of the exchange rate on economic development indicators, as well as to generate an array of forecast data and to work with them. The main focus of the research is on analyzing the impact of the National Bank of Ukraine (NBU) international reserves management on macroeconomic indicators using Data Mining. The links between the exchange rate and the international reserves, inflation, the PFTS index were analyzed, as well as the change in the GDP and current account balance of Ukraine in the key periods of the research. The regression method was used to establish appropriate links between the indicators. The results of the study will allow improving the monetary policy of the NBU in terms of achieving strategic goals, in particular economic growth.

**Keywords:** Data Mining, data analysis, information technology, monetary policy, bank, exchange rate, GDP.

## 1 Introduction

Data Mining's multidisciplinary allows applying statistics methods and database theory for the needs of different spheres of public life, in particular economy. Therefore, the results of the Data Mining for exchange rate influence identification research can be used as informational support for such types of Data Mining systems as case-based decision-making systems. Today, Data Mining systems are increasingly used to predict the socio-economic behavior of business entities at the macro and micro levels. Analysis of expediency and effectiveness of the NBU separate monetary and credit policy measures in 2013-2019 and 2019 will allow us to assess the level of the NBU monetary policy efficiency and its impact on the economic development of Ukraine. We will analyze use of international reserves to maintain the UAH / USD exchange rate stability using Data Mining methods.

Copyright © 2020 for this paper by its authors.  
Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

## **2 The Problem of the Relationship with Important Scientific and Practical Tasks**

Data Mining systems are used for both research and modeling of alternative development scenarios. This is important for an economy whose decision-making is based on analyzing big historical data. In modern economic environment, which is characterized by increasing globalization processes, it is becoming increasingly important to implement the best global practices of monetary regulation by central banks, since monetary policy of central banks is one of the most important factors of investment activity and economic growth of national economies. The recent change in the regime of monetary regulation in Ukraine is a consequence of the implementation of the above processes by the NBU. Changes in monetary policy over recent years have inevitably been accompanied by changes in the economy. Thus, it's important to research the peculiarities of the impact of monetary policy instruments on the economy in general and the effectiveness of the application of certain monetary instruments by the NBU in particular using Data Mining methods.

## **3 Recent Research and Publications Analysis**

Data mining is increasingly used to analyze big data sets. The newest information technologies allow the use of Data Mining in various spheres of public life, in particular in the economy. Early researches in Data Mining were about principles, methods, technologies and tools [18-20]. Later, the application of Data Mining in the applied fields of public life has become very relevant. Scientific researchers have extended the scope of interest to the possibility of using Data Mining in the economy. Data Revolution and Economic Analysis is the subject of L. Einav, J. Levin research [3]. Data Mining using for market modeling investigated by V. O. Bilenko [1]. However, Data Mining researches in the IT field are basically traditional [7, 14]. Central bank's monetary policy researches, their impact on the economy as a whole and the NBU in particular were made by a number of economists. Specifically, V. S. Stelmakh [15] explores the current methodology of the NBU monetary policy. The issue of regulation of the NBU on the intensity of use of foreign currency, in particular the US dollar, in the economy of Ukraine, which directly affects the level of its dollarization, has been investigated in [4, p. 362-370]. U. M. Nikonenko and O. I. Kopylyuk focus attention on priorities changes of the NBU monetary policy [11]. V. Korneyev [5, p.30-33] examines the monetary policy instruments as tools of economic development stimulation in the crisis period. O. Shcherbakova [13] examines the NBU new monetary regime theoretical foundations and the use of exchange rate policy in its context. O. Petryk, S. Nikolaychuk [12, p.12-20] explore the possibility to use the transmission mechanism model of Ukraine monetary policy. S. V. Mishchenko [10, p. 12-20] review modern approaches to the GDP implementation in the financial system regulation context. T. V. Melnyk identified weaknesses in monetary regulation and developed a number of recommendations for improving the use of monetary regulation tools [9, p. 113-119].

## **4 Problems Selection**

The main problem with the using of Data Mining's systems to identify regularities in the economy is the establishment of logical algorithms and if-then-rules, as well as the interpretation of the identified regularities, while the classic problem of sorting options in a reasonable time is less relevant. The results of such algorithms are effective, but the behavioral characteristics of the economy cause additional requirements for interpreting the results. Thus, modern economists fully explore as general the GDP formation theoretical aspects as some practical aspects of monetary policy specific instruments and monetary policy influence models on the economy growth. However, it should be noted that there is a lack of possibilities coverage and consequences of such monetary policy instruments using as the international reserves management in the NBU activities. There is not clearly described the specific and consequences of the NBU use that monetary policy instrument in 2019 in the condition of inflation targeting regime in resent scientific research.

After the literature analyzing, we found there was no researches about the management practical aspects of using Data Mining methods to find link between the NBU international reserves regulation and the national currency exchange rate regulation. And there was nothing about determining the impact of the UAH to USD exchange rate on the main macroeconomic indicators changes using Data Mining methods.

## **5 Goals Formulation**

The goal of the research is to approve the exchange rate influence on macroeconomic indicators by Data Mining methods, including statistical methods. The objectives of this research are revelation of international reserves management theoretical and applied bases as instrument NBU monetary policy realization; revealing the link between the NBU international reserves and UAH / USD exchange rate; definition of influence UAH / USD exchange rate changing on macroeconomic indicators changes using Data Mining.

## **6 Research Results Analysis**

Data Mining is a special approach to data analysis, because the main task is not to obtain facts, but to generate and hypothesize, by looking into the unstructured data of the hidden regularities required for management decisions. In the research there is used the capabilities of Data Mining through the traditional analysis tools such as mathematical statistics (regression, correlation, time series analysis) for exchange rate influence identification.

Monetary policy is a complex of measures in the field of money circulation and credit, aimed at the stability of the Ukraine monetary unit ensuring through certain tools and methods using [16]. The goals of the monetary policy are achievement certain

macroeconomic indicators that are determined by the monetary authorities and are solved by monetary methods.

There are following economic-mathematical Data Mining methods in the research: the least square method, correlation and regression indices, Fisher's ratio test to check model adequacy.

The regression analysis models and methods are central in the econometrics mathematical tool. The regression analysis task is to detect forms of dependence between variables, to evaluate the regression function, to forecast values of the dependent variable.

Least Squares Method is the method of approximate solution surplus-defined system. It is often used in regression analysis. In practice, the linear least squares method is most often used in the case of linear equations system [8].

The function is described by formula:

$$Y = a_0 + a_1X \quad (1)$$

Where:

$$a_0 = \frac{\sum XY - a_1 X^2}{\sum X} \quad (2)$$

$$a_1 = \frac{\sum Y \frac{\sum X}{n} - \sum XY}{\frac{\sum X^2}{n} - \sum X^2} \quad (3)$$

n – number of variable pairs.

Correlation (correlation dependence) is the statistical link between two or more random variables. At the same time, changes in the one or more values of these quantities are accompanied with systematic change in the values of another or other variables. The mathematical measure of two random variables correlation is the correlation link or correlation coefficient.

The correlation coefficient indicates the density of communication between the variables. It ranges from 0 to 1, where "1" is the highest density of communication, and "0" indicates that variables are probably independent.

It is calculated with the formula:

$$R = \frac{\sum(Y_i - \bar{Y})^2}{(Y_f - \bar{Y})^2} \quad (4)$$

$Y_i$  – value of a dependent variable in the "i" period;  $\bar{Y}$  – average arithmetic value of sample  $\frac{\sum Y_i}{n}$ ;  $Y_f$  – calculated (theoretical) value of the dependent variable in the "i" period; n – number sample elements.

The regression coefficient shows a link existence between variables. It ranges from -1 to 1, where "0" means there is no connection; "-1" means reversed functional connection; "1" means functional connection.

It is calculated with the formula:

$$r = \frac{\sum(X_i - \bar{X}) * (Y_i - \bar{Y})}{\sqrt{(\sum(X_i - \bar{X})^2) * (\sum(Y_i - \bar{Y})^2)}} \quad (5)$$

$X_i$  – factor determination value in the “i” period;  $\bar{X}$  – average arithmetic factor determination value.

Fisher’s ratio test is used to check model adequacy; it means whether the analytical model corresponds to reality. The model is considered adequate if Fisher calculated value is higher than Fisher theoretical value (from directories). Fisher calculated value can be gotten with the formula:

$$F = \frac{\frac{Y_f - \bar{Y}}{k_1}}{\frac{Y_i - \bar{Y}}{k_2}} \quad (6)$$

$k_1$  and  $k_2$  - degrees of freedom;  $k_1$  - number of dependent variables;  
 $k_2 = n - k_1 - 1$ .

The exchange rate is a currency price of the country, expressed in the currency of another country. The exchange rate as the price of any ordinary commodity has its basis cost and it varies depending on supply and demand.

The exchange rate has a number of important economic functions:

- overcoming national currency constraints;
- local value of a monetary unit becomes international;
- it is as a tool of monetary relations internationalization;
- promotes the formation of an integrated global money system.

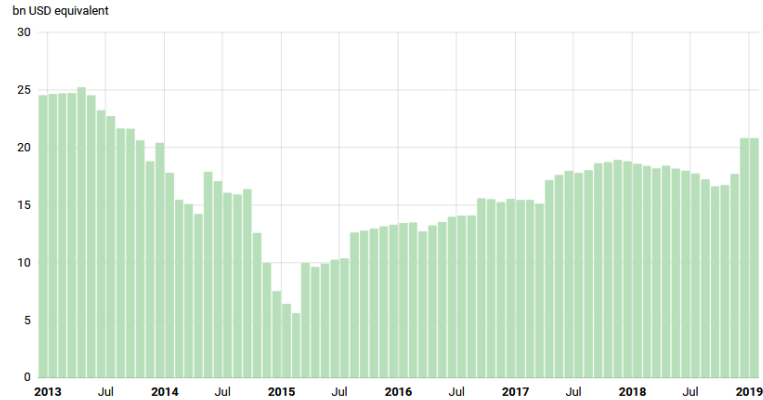
A state influences on exchange rate through operations of central issuing banks with interest policy and currency intervention using.

Interest policy – is a change in the interest rate of the central bank with local regulations for exchange rate effects on short-term capital movement.

Currency intervention – is a direct intervention of the country central bank in the foreign exchange market functioning through a foreign currency purchase and sale in order to influence the national currency rate. Foreign currency demand and supply balance occurs when bank buys and sells foreign currency which also leads to limitation in changing of the national monetary unit currency exchange rate.

In recent years, the NBU has moved to a floating exchange rate, which is set on the basis of supply and demand in the foreign exchange market. There have also been changes in the NBU monetary policy and its approaches to controlling inflation. Therefore, we consider it relevant to carry out a similar research of the impact of the NBU international reserves management in the conditions of free capital movement and floating exchange rate.

It is necessary to analyze the reliance between the international reserves and the UAH / USD exchange rate in 2013-2019 (Fig. 1, Fig. 2) [10].



**Fig. 1.** The NBU international reserves in 2013-2019



**Fig. 2.** UAH / USD exchange rate in 2013-2019

Thus, we can calculate indicators:  $r = -0.2350$ . As we see, there is a very weak link between the indicators. And we will get resulting model with main parametric variable  $a_0 = 2636.5$ ,  $a_1 = -37.907$ :

$$Y = 2636.5 - 37.907X \quad (7)$$

This model is proved to be inadequate because the correlation coefficient between the calculated values and the actual  $R = 0.0552$  indicates weak density of communication; calculated Fisher's criterion is equal to 0,292 what is less than theoretical Fisher's criterion (0.95) [2] (for  $k_1 = 1$ ,  $k_2 = 5$ ) is equal 6.61.

The link between international reserves and UAH / USD exchange rate was missed during the investigated period.

However, the NBU made significant efforts to support the exchange rate stability at the cost of international reserves in 2019. To check that we will analyze the link between international reserves and the UAH / USD exchange rate. The basic data are represented in the Table 1 [10].

**Table 1.** The dynamics of the NBU international reserves, the UAH / USD exchange rate, consumer price index and the PFTS index in January – October 2019

Date	International reserves, billions USD	Exchange rate, UAH / 100 USD	Consumer price index, % to December 2018	PFTS index
January	20.82043	2768.826	101.0	556.7
February	20.81971	2774.096	101.5	553.0
March	20.22046	2685.917	102.4	555.4
April	20.63287	2720.910	103.4	563.0
May	20.52472	2661.933	104.2	559.4
June	19.40208	2687.257	103.6	564.7
July	20.63897	2617.794	103.0	549.5
August	21.84017	2502.076	102.7	540.6
September	22.01518	2523.230	102.6	528.5
October	21.43771	2419.747	103.1	524.9

We got the following results:  $r = -0.6378$ . We can summarize of the estimated data presented above that there is significant link between international reserves and UAH/USD exchange rate in 2019. Regression coefficient confirms the existence of reversed connection. It confirms to us that the NBU used its reserves for course support. So we got resulting model with main parametric variable  $a_0 = 4682.931$ ,  $a_1 = -98.235$ :

$$Y = 4682.931 - 98.235X \quad (8)$$

This model is adequate because the correlation coefficient between the theoretical and actual values of the variable  $R = 0.4068$ ; calculated Fisher's criterion is equal to 5.49 what is more than theoretical Fisher's criterion (0.95) (for  $k_1 = 1$ ,  $k_2 = 8$ ) is equal 5.32 [2]. So, in 2019 the NBU used significant accumulated reserves to ensure the financial stability.

Also we can use basic data to confirm the link between UAH / USD exchange rate and consumer price index. We got the following results:  $r = -0.3352$ . So, the link between the UAH / USD exchange rate and the consumer price index is close to reverse functional connection. We got resulting model with main parametric variable  $a_0 = 109.839$ ,  $a_1 = -0.003$ :

$$Y = 109.839 - 0.003X \quad (9)$$

This model is not adequate because the correlation coefficient  $R = 0.1123$  doesn't show significant density between the theoretical and actual values of the variable and calculated Fisher's criterion is equal to 1.01 what is less than theoretical Fisher's criterion (0.95) (for  $k_1 = 1$ ,  $k_2 = 8$ ) is equal 5.32 [2].

Thus, we see that the NBU doesn't use foreign exchange intervention to keep the exchange rate. Today, the NBU's monetary instruments are aimed at achieving the inflation target rather than regulating the hryvnia exchange rate. This is proved by the

results of the research. The link between the UAH / USD exchange rate and the PFTS index is calculated according to the data in Table 1.

We got the following results:  $r = 0.8601$ . Therefore, the link between the UAH / USD exchange rate and the PFTS index is close to direct functional interconnections, because  $r > 0.85$ .

In addition, we got the model with parameters  $a_0 = 284.620$ ,  $a_1 = 0.101$ :

$$Y = 284.620 + 0.101X \quad (10)$$

The model is adequate, because correlation coefficient between the calculated and actual values of the PFTS index  $R = 0.7398$  means a significant density, and calculated Fisher's criterion is equal to 22.75 and it is more than theoretical Fisher's criterion (0.95) (for  $k_1 = 1$ ,  $k_2 = 8$ ) is equal 5.32 [2].

Consequently, the NBU stimulated Ukrainian stock markets activities thru keeping up the hryvnia exchange rate. The existence of inverse interconnections between these indicators, the more UAH exchange rate goes down against the USD, the worse the stock markets situation is. This is the case, in particular, of foreign investors for whom it is not profitable to invest when currency fluctuates.

The NBU actions are aimed at stimulating the stock market today. First of all, this is reflected in the fact that the main instrument of monetary policy is the interest rate.

Dynamics of the UAH to USD exchange rate, the NBU international reserves and current account balance in 2019 are in Table 2.

**Table 2.** Dynamics of the UAH / USD exchange rate, the NBU international reserves and current account balance in 2019

Period	International reserves, billions USD	Exchange rate, UAH / 100 USD	Current account balance, million dollars of USA
1 quarter	20.63287	2720.9	-153
2 quarter	20.63897	2617.8	-514
3 quarter	21.43771	2419.7	No data

In 2019, there was the simultaneous increase in international reserves and the negative current account balance in Ukraine. At the same time, the UAH / USD exchange rate decreased. Therefore, it can be argued that the NBU does not use the international reserves management neither to repay the negative current account balance nor to maintain the Exchange rate.

Dynamics of the UAH / USD exchange rate, the NBU international reserves and the GDP of Ukraine in 2019 are in Table 3.

As we can see, in 2019, the NBU replenished its international reserves, which occurred in the context of a decline in the exchange rate, GDP growth and moderate inflation. Under the new monetary regime, the NBU does not use the international reserves management to stimulate the economy or to regulate the exchange rate. In fact, the NBU is a price-taker in the foreign exchange market and helps to smooth the exchange rate volatility, but does not define it.



**Table 3.** Dynamics of the UAH / USD exchange rate, the NBU international reserves and the GDP of Ukraine in 2019

Period	International reserves, billions USD	Exchange rate, UAH / 100 USD	Nominal GDP, million UAH	Price index at the end of quarter, %	Change in real GDP (% to the corresponding period of the previous year)
1 quarter	20.63287	2720.9	807755	103.4	-5.6%
2 quarter	20.63897	2617.8	927773	103.0	-5.8%
3 quarter	21.43771	2419.7	-	103.1	-

## 7 Conclusion

One of the conditions for the effective development of the modern economy is the ability to form, analyze big data sets, as well as interpret the identified regularities, which is possible by the use of Data Mining.

Thus, there is analyzed the interconnection between the international reserves dynamics and UAH to USD exchange rate in this research. The effect of the hryvnia exchange rate changes on the country economic development main macroeconomic indicators (consumer price index, PFTS indices, balance of payments and GDP) was also analyzed.

While there has been no interconnection between UAH to USD exchange rate and international reserves dynamics in years (2013-2019), there is a clear link between these indicators in 2019.

In particular, the links between the consumer price indices and the PFTS index show us the viability and effectiveness of such the NBU actions. Thus, we can make conclusions about the extremely negative consequences for Ukraine economic development in case if the NBU will continue to use international reserves managing tool as the only one factor of influence on the UAH exchange rate with decreasing the reserves amount. Therefore, the necessary influence measures is application of all monetary policy use and the maximum convergence of goals and tools as monetary as fiscal state policy to stimulate country economic growth and to ensure UAH exchange rate stabilization.

However, the impact of monetary instruments on macroeconomic indicators is different, which requires its obligatory Data Mining analysis and consideration when making strategic decisions on economic regulation.

## References

1. Bilenko, V. O.: Modeling of the real estate market reflection with the using of data mining. In: Bulletin of Odessa National University. Ser.: Economy, 7, 137-144. (2017)
2. Bobik, O. I., Beregova, G. I., Kopitko, B. I.: Probability theory and mathematical statistics. In: Professional, Kiev, Ukraine. (2007)
3. Einav L., Levin J.: The Data Revolution and Economic Analysis. In: NBER Working Paper, 19035. Available at: <http://www.nber.org/chapters/c12942.pdf>. (2013)

4. Ilchuk, P. H., Kots, O. O., Manzirokha, A. S.: Research of economy dollarization level in Ukraine. In: Financial-credit activity: problems of theory and practice, 93, 362-370. (2017)
5. Korneyev, V.: Monetary instruments of post-crisis recovery: new incentives of the central banks. In: Bulletin of the National Bank of Ukraine, 4, 30-33. (2011)
6. Kosova, T. D., Papaika, O. O.: Central Bank and Monetary Policy. In: Center for Educational Literature, Kiev, Ukraine. (2011)
7. Krytska, Y. O., Bilobrodova, T. O., Skarga-Bandurova, I. S.: Data mining techniques for iot analytics. In: Bulletin of Volodymyr Dahl East Ukrainian National University, 5, 53-62. (2019)
8. Lytvyn, V., Vysotska, V., Veres, O.: Ontology of big data analytics. MEST Journal 6(1), pp. 41-60 (2018)
9. Melnyk, T. V.: Monetary policy instruments and practice of their application by the National Bank of Ukraine. In: Scientific Bulletin of Uzhgorod National University. Series: International Economic Relations and the World Economy, Vol-22, 113-119. (2018)
10. Mishchenko, S. V.: Modern approaches to the implementation of monetary policy and regulation of financial systems. In: Proceedings of the St. Petersburg State University of Economics and Finance, 3(69), 12-20. (2011)
11. Nikonenko, V. M., Kopylyuk, O. I.: Evolution of monetary policy of Ukraine in the conditions of market transformation of economy. In: Ukr. Acad. Printing, Lviv, Ukraine. (2012)
12. Petyrk, O., Nikolaychuk, S.: Structural model of the transmission mechanism of monetary policy in Ukraine. In: Bulletin of the National Bank of Ukraine, 3, 12-20. (2006)
13. Shcherbakova, O.: Prospects of monetary policy at the stage of post-crisis economic recovery of Ukraine. In: Bulletin of the National Bank of Ukraine, 8, 4-8. (2011)
14. Shibaeva, N. O., Vychuzhanin, V. V., Shibaev, D. S.: The concept of data mining building search queries for a large number of criteria. In: Development of transport, 1, 116-122. (2017)
15. Stelmakh, V.: Monetary policy of the National Bank of Ukraine: current state and prospects for change. In: Research center of the National Bank of Ukraine, UB NBU, Kyiv, Ukraine. (2009)
16. The Law of Ukraine "On the National Bank of Ukraine" No. 679-XIV dated 20.05.1999.
17. The official site of the NBU, <https://bank.gov.ua/> (2019)
18. Veres, O., Shakhovska, N.: Elements of the formal model big date. In: Perspective Technologies and Methods in MEMS Design (MEMSTECH'2015), pp. 81-83 (2015)
19. Veres, O., Rishnyak, I., Rishniak, H.: Application of methods of machine learning for the recognition of mathematical expressions. In: CEUR Workshop Proceedings. vol. 2362, Proc. of the Int. Conf. COLINS, vol. 1, pp. 378-389 (2019)
20. Witten, I., Frank, E., Hall, M.: Data Mining: Practical Machine Learning Tools and Techniques. In: Morgan Kaufmann. (2011)