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## UKRAINIAN FINANCIAL MARKET STABILITY INVESTIGATION

**Abstract.** In the paper, stability of the Ukrainian financial market segments development has been analyzed. The stability theory and non-linear analysis are the mathematical tools of the investigation. In the article, we used three types of stability, namely: Lagrange stability, Poisson stability and Lyapunov stability. The stability indexes show unstable trajectories for the trend of stock and credit segments by Lagrange. Poisson stability recognizes stable cyclic components in the dynamic of credit market. Ukrainian financial market was analyzed as a single system by the Lyapunov stability that shows sustainable trajectories of both segments.

**Keywords:** stability; financial market; index; trajectory; dynamics.

**JEL Classification:** C22, G10

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### ДОСЛІДЖЕННЯ СТІЙКОСТІ ФІНАНСОВОГО РИНКУ УКРАЇНИ

**Анотація.** У статті досліджено стійкість розвитку фондового і кредитного сегментів фінансового ринку України. Для цього використовувалися як математичний інструментарій методи теорії стійкості та нелінійної динаміки. Розглянуто три типи стабільності – Лагранжа, Пуассона і Ляпунова. Індекси стійкості, проаналізовані автором за підходом Лагранжа, показали турбулентність трендових траєкторій як для фондового, так і для кредитного сегментів фінансового ринку, за підходом Пуассона – стабільність циклічних траєкторій для кредитного ринку і нестабільність – для фондового, за підходом Ляпунова – стійкість фінансового ринку України як єдиної системи. За результатами дослідження зроблено загальний висновок про стійкість фінансового ринку в цілому. Однак наявність нестійких проявів у розвитку окремих сегментів фінансового ринку в часткових компонентах порушує загальну стійкість фінансового ринку України.

**Ключові слова:** стійкість; фінансовий ринок; індекс; траєкторія; динаміка.

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### ИССЛЕДОВАНИЕ УСТОЙЧИВОСТИ ФИНАНСОВОГО РЫНКА УКРАИНЫ

**Аннотация.** В статье проанализирована устойчивость развития фондового и кредитного сегментов финансового рынка Украины. В качестве математического инструментария использовались методы теории устойчивости и нелинейной динамики. Индексы устойчивости, проанализированные автором на основе подхода Лагранжа, показали турбулентность трендовых траекторий как для фондового, так и для кредитного сегментов финансового рынка, на основе подхода Пуассона – стабильность циклических траекторий для кредитного рынка и нестабильность – для фондового, на основе подхода Ляпунова – устойчивость финансового рынка Украины как единой системы. По результатам исследования сделан общий вывод об устойчивости финансового рынка в целом. Однако наличие неустойчивых проявлений в развитии отдельных сегментов финансового рынка в частных компонентах нарушает общую устойчивость финансового рынка Украины.

**Ключевые слова:** устойчивость; финансовый рынок; индекс; траектория; динамика.

### Introduction

The financial market is characterized by globalization and integration processes. These processes increase random effects that lead to the crisis on the market. Last financial crisis demonstrated the weakest sides of the financial market regulation. Neoclassical paradigm is based on the conditions that are not related to the modern economical situation [1; 2; 3; 4; 5; 6].

Thus, developing markets (like Ukrainian financial market) have only strategic investors in majority cases and a lot of entrance barriers into the market. Free and immediately accessible information is the second condition of neoclassical paradigm in financial market. But, in modern economy high quality information is costly object of the company's safety. Also, only a lot of people could influence onto the tendency of financial market in the old paradigm. But, as we can see, there are odiously powerful persons in the World. Their words can greatly change the world financial tendencies.

Deeg (1999) [7] considers that the global crises are not possible in the neoclassical paradigm and the local crises could only be for certain financial institutions. Greenspun (2008) [5] declared failure of neoclassical paradigm in the summer of 2007 after the collapse of the «Lehman Brothers» company. Thus, the core of neoclassical stability and efficiency of markets have allo-

cated the wrong channel of policies in the financial markets and led to the emergence of a global devastating crisis.

As noted by Stiglitz (2010) [8], a paradigm shift is not an easy process because the old paradigm invested a lot of effort. The main advantage in the formation of a new paradigm is no need to immediately specify all key components paradigm. Specification of concepts is in the process of adapting to the new paradigm of economic conditions.

The main conditions for the formation of a new paradigm are globalization and integration processes in the economy and society. However, investigations in this area led to the construction of the 4U concept. This concept reflects the disadvantages of globalization for the global economy and includes four components: unsustainable, unfair, unstable and undemocratic.

At the same time, Schumpeter (1934) [9], Grainer (1972) [10] and others pointed at the inevitable evolution of financial, organizational and social structures. According to the Grainer's theory about evolution and revolution [10], the last phase of the evolution is relation with the crisis of bureaucracy and regulation. The last events in 2006-2010 show lack of coordination and cooperation between structural elements in EU and USA. Therefore, the stability of the financial market is the global aim in the regulation of the world economy.

**The purpose** of this article is investigation of stability of the Ukrainian financial market development in 2008-2013. It decomposes on the following tasks:

- i) investigation tendencies of financial market segments;
- ii) components analysis in dynamics of the financial market segments;
- iii) determination of financial market stability and its measurement.

We constructed methodology to solve these tasks.

**Methodology**

The methodology of investigation consists of two units: preliminary unit and stability unit. The main idea of preliminary unit is investigation of time-series components using stationary tests and decomposition of time series. The stability unit includes three types of stability: Lagrange stability, Poisson stability, and Lyapunov stability.

*1. Preliminary unit.*

The special tests for analysis of the stationarity are: Dickey-Fuller test (DF), Augmented Dickey-Fuller test (ADF) and Philip-Peron test (PP). In this investigation we used the Augmented Dickey-Fuller test. The test is carried out by the estimation of the equation  $y_{t-1}$  with subtracted from both sides of this equation:

$$\Delta y_t = \mu + \gamma y_{t-1} + \varepsilon_t, \tag{1}$$

where  $\mu, \gamma$  are the parameters of the model ( $\gamma = 1 - \rho$ );  $\varepsilon_t$  is assumed to be white noise.

The null and alternative hypotheses are:

$$\begin{aligned} H_0 : \gamma &= 0 \\ H_1 : \gamma &< 0 \end{aligned} \tag{2}$$

While it may appear that the test can be carried out by performing a  $t$ -test on the estimated  $\gamma$ , the  $t$ -statistic under the null hypothesis of a unit root does not have the conventional distribution. Dickey and Fuller (1979) [11] showed that the distribution under the null hypothesis is nonstandard, and simulated the critical values for the selected sample size [11]. More recently, MacKinnon (1991) [12] has implemented a much larger set of simulations than those tabulated by Dickey and Fuller [12]. The null hypothesis of a unit root is rejected against the one-sided alternative if the  $t$ -statistic less than a critical value.

*2. Lagrange stability.*

The trajectory  $x(t)$  that goes from the initial state  $x_0$  and for all time periods is to some closed area of phase space, which is characterized by constant  $R$  is called sustainable trajectory by Lagrange:

$$\|x(t)\| < R, \quad \|x(t)\| = \sqrt{x_1^2 + x_2^2 + \dots + x_N^2}, \tag{3}$$

where  $x(t)$  – investigation trajectory;  $R$  – phase space characteristics;  $x_1, x_2, \dots, x_N$  – points of the  $N$ -dimensional space of trajectory.

Financial market's segments (stock or credit segment) are sustainable by Lagrange in condition that the index of business activity has sustainable trajectory by Lagrange.

*3. Poisson stability.*

The trajectory  $x(t)$  that goes from the initial point  $x_0$  is sustainable by Poisson if each point of the trajectory includes into the two sets –  $\Omega x, Ax$  with limited points  $w$  and  $a$ .

$$x(t) \in \{\Omega x \cap Ax\}, \tag{4}$$

where  $w$  – limit points of phase trajectory  $\Omega x$  with following conditions:  $\lim_{t \rightarrow \infty} x(t_k) \rightarrow y$  if  $t_k \rightarrow \infty$ ;  $a$  – limit points of phase trajectory  $Ax$  with following conditions:  $\lim_{t \rightarrow -\infty} x(t_k) \rightarrow z$  if  $t_k \rightarrow -\infty$ .

In other words, the trajectory  $x(t)$  is sustainable by Poisson if it is recurring to the confidential area ( $\varepsilon$ ) of a point  $G$ . This point determines the type of Poisson stability (Poincare recurrence [13]). The various types of Poisson stability depend from Poincare recurrence. There is periodical stability, quasi-periodical stability, chaotic stability (random stability). The interrelation between recurrence and time determine the type of stability (Figure 1).

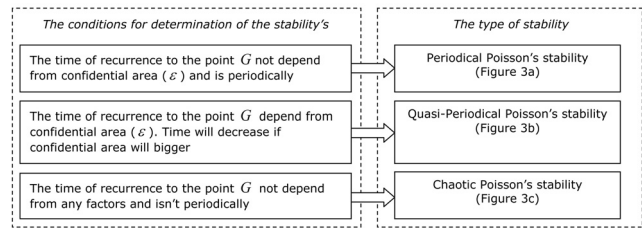


Fig. 1: Determination of Poisson stability type  
Source: [14]

*4. Lyapunov stability.*

The trajectory  $y(t)$  is sustainable by Lyapunov if there is another trajectory that goes from  $y_0$  and close to the trajectory  $x(t)$  at any time (point  $y_0$  is close to point  $x_0$ ).

The stability has two main kinds, there are classical stability and asymptotical stability. Classical stability for the trajectory determined following equation:

$$\|x(t) - y(t)\| < \varepsilon, \text{ if } \|x_0 - y_0\| < \delta \tag{5}$$

Asymptotical stability is

$$\lim_{t \rightarrow \infty} \|x(t) - y(t)\| = 0, \text{ if } \|x_0 - y_0\| < \delta, \tag{6}$$

where  $\delta$  is the first point of stability trajectory.

The main idea of the Lyapunov stability in the financial market investigation is to determine the stability of the interrelation between financial market's segments.

**Results**

*1. Preliminary unit.*

We use two main indexes of the business activity of financial market segments (PFTS Index for the stock market and KievPrime Index for the credit market).

The analysis of date shows us trend and cyclic components in time series of indexes. Trend is used for Lagrange and Lyapunov stability, cyclic component is used for Poisson stability.

This test shows that all series is non-stationary, therefore, need elimination trend from these series.

Decomposition of the time series of financial segments indexes starts from the elimination of trend component. We propose the hypothesis about polynomial trends by the analysis of indexes dynamics.

The polynomial trend is:

$$Y(t) = a_0 + a_1 \cdot t + a_2 \cdot t^2 + \dots + a_n \cdot t^n, \tag{7}$$

where  $a_0, a_1, a_2, \dots, a_n$  – parameters of models.

The results of the trend parameters calculation show statistical significance of all parameters. Next step of the decomposition is analysis of the cyclic component under the Fourier analysis.

MAPE criteria is used for the analysis of adequacy of the cyclic models. Therefore, MAPE for PFTS Index is 0.89, MAPE for KievPrime Index is 0.94. The results of the composition of trend and cyclic components are shown on Figure 2.

*2. Lagrange stability.*

The first step of the disquisition of Lagrange stability is determining constant  $R$  that shows confidence interval of trend variance. Usually, researchers use three confidence levels (1%, 5% and 10% significance levels). In this paper, we use verbal triangular space. In this case we determine three verbal levels of stability, there are high stability level ( $R = 0,01 \cdot \bar{x}$ ), average stability level ( $R = 0,05 \cdot \bar{x}$ ) and low stability level ( $R = 0,1 \cdot \bar{x}$ ). Time series of PFTS and KievPrime Indexes have the following confidence constants:  $R_{pfts} = 58,8, R_{kp2m} = 1,35$ . The confidence intervals for these time series are shown on Figure 3.

We use stability indicator for the investigation of stability level. This indicator is similar as correlation coefficient and shows the observations that relate to the confidence interval (Table 1).

Therefore, credit market is more unsustainable then stock market by all stability indicators.

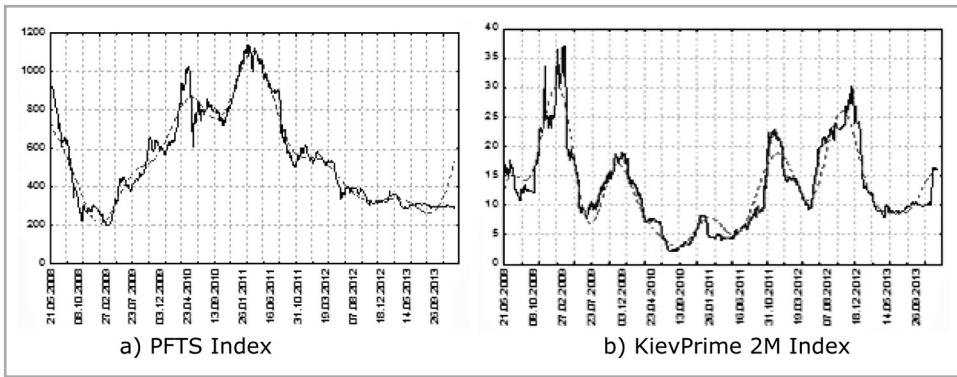


Fig. 2: Composition of the trend and cyclic components  
Source: Own research

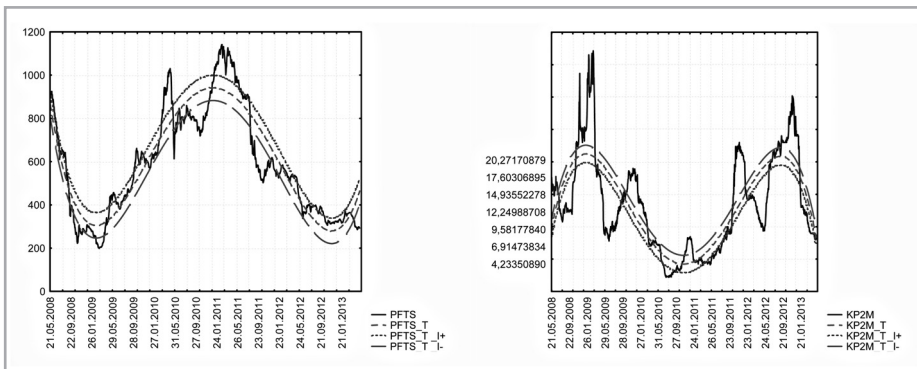


Fig. 3: The confidence intervals with trend  
Source: Own research

Tab. 1: Stability indicator and stability level

Financial segments	Stability indicator			Verbal stability
	High level	Average level	Low level	
Stock market	0,04	0,2	0,36	Unsustainable
Credit market	0,03	0,09	0,16	Unsustainable

Source: Own research

3. Poisson stability.

The analysis of Poisson stability requests time series without trend. Each time series consist of trend, cyclic and irregular components. Therefore, cyclic component is main component for the analysis of Poisson stability. Each cyclic component could be decomposed on local harmonics (Fourier spectral analysis). Cyclic components will have Poisson stability if each harmonic will have Poisson stability.

By the rule of spectral analysis, optimal quantity of harmonics that compose into the cyclic components is seven. From the other hand, quality of composition must be more than 80%. If this quality is less than 80%, then quantity of harmonics must be increased. The quality analysis shows that composition of seven harmonics gives 72% quality for stock market and 87% quality for credit market.

Therefore, we can conclude that credit market is sustainable, but stock market is unsustainable by Poisson stability.

4. Lyapunov stability.

Lyapunov stability analysis requests one scope (from 0 to 1) for the different trajectories. Normalized trajectories and

module of them is shown on a Figure 4.

As we can see, module trajectory strives to 0, therefore, the system of stock and credit segments is sustainable. Stability analysis results are in Table 2.

Conclusion

Thus, we have main results in this article following:

1) We offered approach for the diagnostic of the three types of the financial market stability, as it is the main purpose of the financial market development. Each stability estimate different components of the time-series. So, Lagrange stability is used for the trend stability analysis. Poisson stability investigates cyclic development of the financial market. Lyapunov stability helps in making decision about global financial market stability.

2) Analysis of the stability of the financial market and its segments in three main areas showed that each of the segments in the general form is unstable. However, the trend in the stock market component is close to stable. Also, cyclic component in the credit market is stable by Poisson stability.

3) The analysis of Ukrainian financial market as a single system by the Lyapunov stability shows that both trajectories of the credit and stock segments are close to each other. Therefore, Ukrainian financial market is sustainable.

The stability of financial market depends from many inside and outside factors. This investigation shows the present stability situation in these economical conditions. At the same time, changing of the conditions could lead to disturbance the stability of financial market (as political and economical crisis 2014 year in Ukraine has shown).

Discussion

The investigation of the fractal dimension that is equal 3 showed one external factor. Therefore, there are two main

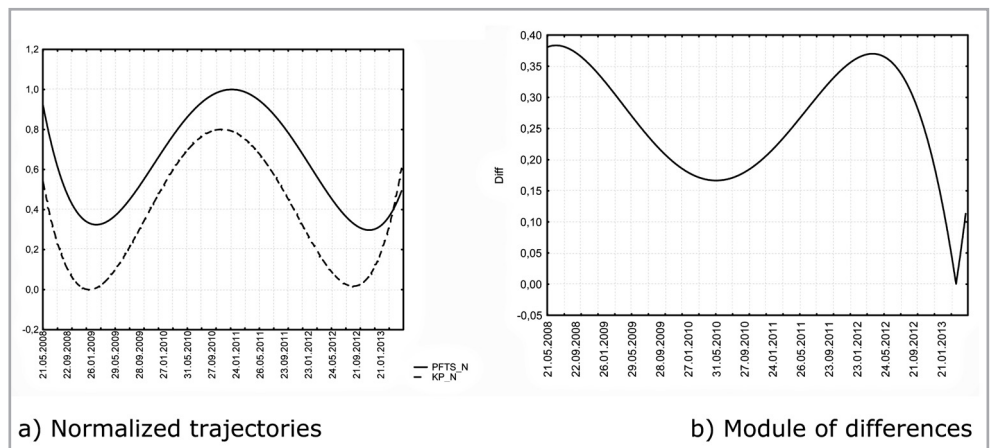


Fig. 4: Lyapunov stability analysis  
Source: Own research

Tab. 2: Stability analysis results

Segment	Stability		
	Lagrange	Poisson	Lyapunov
Stock market	Unsustainable	Unsustainable	Sustainable
Credit market	Unsustainable	Sustainable	

Source: Own research

points for the continuation of the research of this article. Firstly, each financial market has different segments which are in constant interaction with each other. This interaction is recognized into the integration of one component (trend or cyclic components) between the different segments. For the implementation of this idea we plan to use orthogonal function and cross spectral analysis. Secondary, interrelation between different financial segments could be analyzed with the help of vector autoregression models, impulse and variance analyses. This analysis shows the influence of one segment on the others.

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