

# Agricultural Markets' Analysis and Forecasting on the Base of Fractal Price Cycles Modelling

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## Abstract

The article is devoted to the agricultural markets' analysis (grains and sunflower) as an integral system having its peculiarities which make it different from other markets. These specific features are connected with heterogeneity of participants following various aims and working in different investment horizons, as well as seasonal functioning of this market. The calculations have been given proving the E. Peters' hypothesis on the presence of fractal agricultural markets. The research adjusts the use of the fractal markets' analysis results in creating agrarian markets models and the possibility of forecasting its participants' and prices behavior taking into consideration models' data simplification.

**Keywords:** Agricultural markets, Specific features, Fractal models, Forecasting

## 1. Introduction

In the modern world in the conditions of a huge number of information flows in various markets, it is necessary to understand the situation – whether the real behavior of agents of the market and the price helps to predict a large number of data or it is necessary, according to E. Toffler, "to simplify the world", that is, to simplify the predicted market models, to find the most important factors of influence on the prices and the behavior of agents, minimizing the so-called casual noise, analyzing only useful information on the market. All this, undoubtedly, will allow approaching the task of improvement of agrarian markets' behavior forecasting, among them - finding the dependence of the prices of future periods of production in agro-industrial complex taking into account available uncertainty.

## 2. Literature Review

The classic theory of the market (or efficient market hypothesis) has found its ideal embodiment in 2011, by the award of the Nobel prize to American scientists T.Sargent and Ch.Sims. They recognize that all macroeconomic agents are rational in their behavior if they get "ideal information". Then the economy won't be unstable. The rational behavior means that the same mistake won't be repeated twice. All agents will unmistakably predict what may occur in economy. The only difficulty is the presence/absence of reliable information.

But the quantity of collected information does not guarantee the correct decision. «Every time information grows quicker than our understanding of how exactly to process the obtained data, we are waited by danger<sup>[1]</sup>. From the point of view of the efficiency of the decisions taken one can mark out two controversies. Accord-

ing to Paul Krugman, 1970-s were «the hour of triumph of a number of theories created around incredibly small volumes of data». At that time people started to widely use computers for the creation of the models of the world, society, economy. Many ideas had been suggested.

Classic methods of processing known at that time have created a static market model. This approach had the advantage of offering a set of instruments for the research and processing and was based on the following key concepts:

- Rational participants who prefer the assets giving the highest expected profit at the set risk level;
- The effective market in which the prices reflect all public information.

Owing to the two above mentioned conceptions the prices follow random wandering. And if it is not so, then data are subjected to smoothing or rationalization to keep the critical assumption of their random wandering. The hypothesis of the effective market (EMH)<sup>[2]</sup> has stepped out a little further, drawing a conclusion that, for example, current prices reflect all public information: all last prices, the reports and economic news published. The current prices correctly reflect this information because all the sellers and consumers have got equal access to it, and, being, "rational", in their "collective wisdom" they will appropriately estimate production. The final conclusion is: each action causes proportional reaction

The theory which is the cornerstone of EMN in the process of increasing in number of data often conflicted with their observed behavior. Great data have to lead to progress if a person manages to find regularities in them and quickly to react to changes. But the developed human instincts force us to see regularities both in the places where they are and where they are absent. Having saved up a large number of data – we accumulate thereby casual noise as well. Information volume daily increases by 2,5 quintillion bytes, but the situation is quite different as for the volume of useful in-

formation. The bulk of a gain represents the usual noise growing quicker than a useful signal, but the volume of useful information practically remains invariable. According to E. Toffler, the best protective mechanism is simplifying the world according to somebody's prejudices though the world itself becomes more and more various and complex [3].

The theory of chaos is applicable concerning the systems having properties of dynamism and nonlinearity. The system is dynamic if its behavior at one period of time influences its behavior in the future. The system isn't linear if exponential rather, than additive communication is supported inside it. Many scientists and analysts agree that the markets react non-linearly to various events. However, advantages of the linear models constituting in their simplicity often outweigh dangers of the mistakes arising at the cancelling (exclusion) of non-linearity.

The aim of the research

To investigate and forecast the market of agricultural production, to define market model type by the leading price positions of grain and sunflower on the base of sales statistics by traders and processing enterprises of the Saratov region, Russia.

### 3. Methods

The nonparametric probability theory making no preliminary assumptions of the form of foodstuffs prices distribution was used. Required nonparametric method was developed by H.E. Hurst in 1951, it was subsequently developed and improved by E. Peters [2, 4]. It allows distinguishing between random and non-random systems. The methodology received the name of a method of rated scope, or the *R/S*-analysis. A. Einstein's work (1908) on Brownian motion of particles is its cornerstone - the distance which there passes the casual particle weighed in liquid increases in proportion to a square root from the time of observation of this particle:

$$R = T^{0,5} \quad (1)$$

where  $R$  is the distance passed,  $T$  is the indicator of time.

H.E. Hurst generalized such cases and got the equation (2):

$$\left(\frac{R}{S}\right)_n = c * n^H \quad (2)$$

The *R/S* value is called rated scope because it has a zero average and is expressed in terms of a standard deviation. Generally, this value changes the scale in the process of increase in an increment of "time"  $n$  according to the value of sedate dependence of  $H$  which is called Hurst exponent. Value  $c$  is a constant, and  $n$  is the number of observations (hours,

Hurst exponent can be brought closer by means of drawing of  $\log(R/S_n)$  against  $\log(n)$  and calculating of an inclination through simple linear regression (3) by the method of the smallest squares. It is possible to use at the same time the mechanism of charts trends creation or the superstructure "Regression" from the Package of the analysis of the Microsoft Office spreadsheets.

$$\log\left(\frac{R}{S_n}\right) = \log(c) + H * \log(n) \quad (3)$$

The *R/S* analysis does not demand the main process to be submitted to the normal law of distribution: the main thing is independence here. This requirement relates not only to Gaussian process, but also to any other. Therefore, the *R/S* analysis is nonparametric, i.e. does not contain requirements to the form of the distribution base.

### 4. Results

We have applied the given approach to change the week prices of agricultural production of grain trading and grain processing enterprises in the Saratov region, Russia. The data on sunflower, rye and wheat processing and sales for the period of 2008 - 2014 published on the website [5] were used. In the analysis we will use the logarithmic prices determined as follows:

$$C_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \quad (4)$$

where  $C_t$  is logarithmic price at the moment of time  $t$ ,  $P_t$  is the price at the moment of time  $t$ .

The research conducted [6], showed that these prices are not random fluctuations around average value and have the fractal nature. We conclude that the grain prices market players react to information influencing decision-making, not right after its receiving, but after some of its confirmation, makes impact on the fractal nature of the prices. They undertake nothing until the trend becomes obviously settled [7].

**Table 1.** The data of fractal *R/S* analysis of rye price for 2008-2014 (calculated by the authors).

n	r/s	log(n)	log(r/s)
2	0,84269	0,301	-0,0743
4	1,70337	0,602	0,2313
5	1,92673	0,6989	0,2848
10	3,1537	1	0,4988
13	3,7895	1,1139	0,5785
20	4,8952	1,301	0,6897
26	5,9643	1,4149	0,7755
52	9,2875	1,716	0,9679
65	11,3077	1,8129	1,0643
130	17,3077	2,1139	1,2382

According to the initial theory at  $H=0,5$  independent process would be meant. At  $0,5 < H < 1,00$  the persistent time row characterized by the effect of long-term memory would be. The range  $0 < H < 0,5$  means anti-persistence of the row. Antipersistent system passes a smaller distance than casual system. To pass a smaller distance, the system has to change itself more often than probabilistic process. Such system always tends to average value.

As in our research  $H$  is more than 0,5 on all the range of the change of Hurst exponent (figure 1), the time row of prices gives smoother, less jagged line. than random fluctuation and has a long-term memory.

E. Peters [4] states that at the presence of autoregression process there can be a shift of Hurst exponent towards its increase. Autoregression process is the process where the change in price at some point of a time interval is linearly- correlated with the previous change.

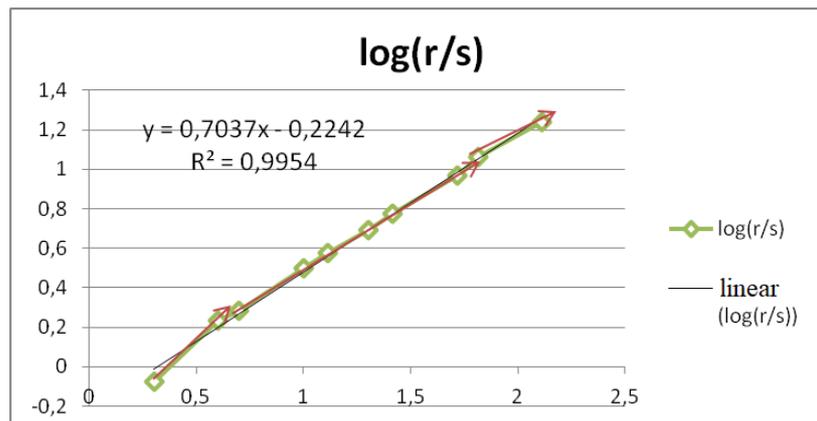


Figure 1: The graph of R/S analysis of the rye week prices and calculation of a linear trend:  $H = 0,7037$

The check shows that significant contribution to the general correlation is made by correlation of the week prices in a year of crop production. The check of autocorrelation of the prices in a year and between years confirms this conclusion. In this table high degree of autocorrelation between the prices in a year is observed, but the correlation between separate years has no stable character. For all rows of prices autoregression process is insignificant.

The question arises: why the correlation of the prices between years of production is so inconsistent and unstable, up to inverse relation. The analysis shows that the prices of each year significantly depend on the prices of the previous year and the amount of the grain produced in the current year. In other words, in Russia the price level in many respects is defined by climatic factors. Conventionally they can be divided into three classes: adverse year (ADY), average year (AY), favorable year (FY). The analysis of data shows that the correlation coefficient between the prices by the years of production for different crops can differ in certain cases. To specify the year of production additional information on gross grain production or average yield of grain crops is necessary. According to these data in the interval of 2008-2014 it is possible to characterize: 2008, 2014 as FY; 2009, 2011, 2013 – as AY; 2010, 2012 – as ADY.

We will define geometrical dimension of a temporary row. Hurst exponent can be transformed into fractal dimension of  $D$  on a ratio:

$$D = 2 - H \quad (5)$$

The size  $H > 0,5$  will correspond to the fractal dimension closer to the curve. Analyzing the alternation of sites of a temporary row with various fractal dimensions and how it is affected by various factors, it is possible to predict its future behavior. Size  $D$  can serve as the indicator of a number of factors influencing the system. At  $D < 1,4$  a row is influenced by one or several unidirectional factors. If the dimension is close to 1,5, then operating forces are multidirectional and more or less compensate each other. The behavior in this case will be stochastic and well-defined by classical statistical methods. If the fractal dimension much more exceeds 1.6, then it shows its instability and readiness to pass into a new state. These features of the fractal analysis make it possible to approach forecasting problems in a new way.

The fractal dimension of the prices of sunflower is given in [6] and is equal:

$$D_n = 2 - 0,71 = 1,29$$

The fractal dimension of the rye prices received in this research has the following value:

$$D_p = 2 - 0,704 = 1,296$$

Close in value Hurst exponents are received also for the other grain production prices. It is possible to state that the prices on agricultural production have fractal persistent character and the form of a steady trend. It means that the obtained information continues to be considered by the market players later. It is not

just linear correlation when the influence of information quickly falls. It is the function of long-term memory that defines information influence during the long periods of time and affects in relation to any temporary scale. The analysis showed that all two-month periods influence all subsequent two-month, all six-months periods influence all the subsequent six-months periods, all twelve-month periods influence all the subsequent twelve-month periods. This influence weakens over the time, however, more slowly than short-term dependences.

Cycle length is a measure of this period's longevity which influences decreases up to the smallest size. In other words, it is the row decorrelation period. The end of a cycle of influence is determined by logarithmic dependence of the size  $r/s$  in accordance with time interval (week). The point of the end of one cycle and the beginning of another is characterized by change of a trend (its direction). For the types of agricultural production observed such points are:

1. For two-months cycle–  $\log(n) = 0,65-0,75$ ;  $n = 5-8$  weeks;
2. For six-months cycle–  $\log(n) = 1,4 - 1,45$ ;  $n = 26-29$  weeks;
3. For twelve-months cycle –  $\log(n) = 1,7 - 1,75$ ;  $n = 52-56$  weeks.

The first inflection point of a trend is connected with the fact that the first prices of the first two months of the New Year have high degree of correlation with the last two months of the previous year. Research shows that such correlation is observed, but its cycle isn't periodic. It is an important conclusion which we will use further at justification of the prices forecast method.

The second inflection point has been connected with the period of farm produce harvesting. It is June-July of every production year. To be more accurate it is connected not with concrete time of harvesting, but the time when it is already possible to predict crops productivity (yield). During this period steady price reduction on all types of farm production and its rise after harvesting is being observed (figure 2, figure 3).

The third point of change in the trend's line is connected with the end of one and the beginning of the next fiscal year. Despite the fact that next year prices are continuation of the previous year, their dynamics and price level can differ considerably from each other. In our opinion it is connected with four operating factors: 1) the difference in the starting price of the year; 2) the difference in production's climatic conditions; 3) the level of economic, political tension in the region, country, the whole world; 4) the country's inflation level.

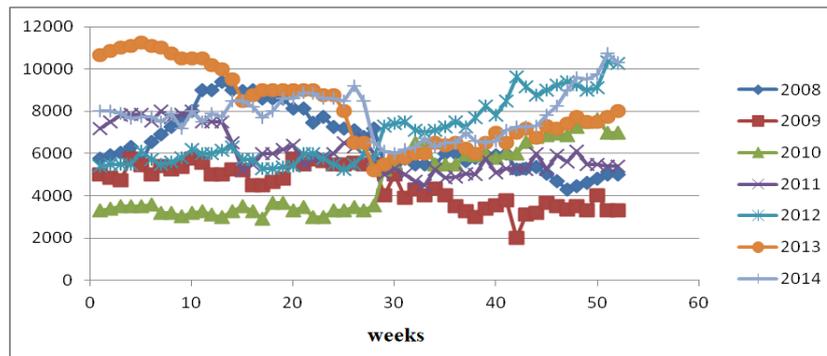


Figure 2. Third class wheat prices' dynamics in the Saratov region in 2008 – 2014.

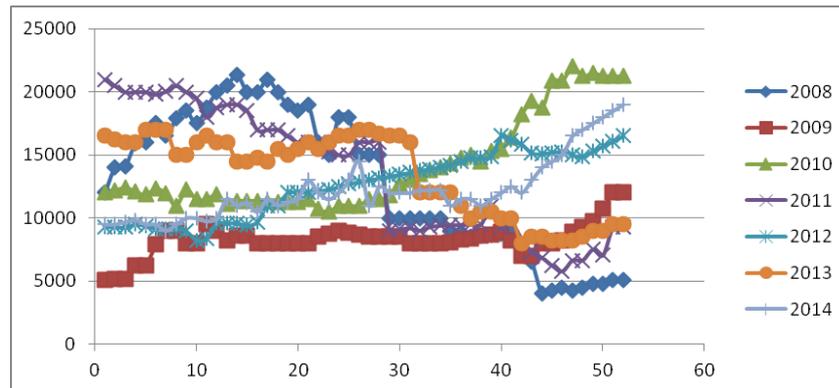


Figure 3. Sunflower prices' dynamics in the Saratov region in 2008 – 2014.

## 5. Conclusion

Thus, the authors sum up that these reasons are factors of non-frequency revealed at R/S-analysis of cycles of the change in prices for agricultural production. These prices have fractal persistent character. At the same time the function of long-term memory defining information influence during the long periods of time takes place.

It is impossible to find the uniform equation of regression connecting prices for products during all the time of supervision because of imposing on the change in prices of their casual, seasonal, climatic and economic-political fluctuations. Therefore, it is necessary to simplify the model: to consider the change in prices for every year separately and find the best determined dependence of the price on a time scale, to analyze their behavior and, on the basis of such analysis, to find the dependence of the future period of production price taking into account real uncertainties.

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