



ECONOMIC ANNALS-XXI
ISSN 1728-6239 (Online)
ISSN 1728-6220 (Print)
<https://doi.org/10.21003/ea>
<http://soskin.info/ea/>

Volume 178 Issue (7-8) 2019

Citation information:
Shyian, D., Sakhno, I., & Kramarenko, K. (2019). Impact of expectations on grain futures price formation. *Economic Annals-XXI*, 178(7-8), 123-133. doi: <https://doi.org/10.21003/ea.V178-11>

UDC 338.517.2



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Impact of expectations on grain futures price formation

Abstract.

Introduction. The problems of estimating and forecasting the price of grain futures in the US market are discussed in the paper. It is emphasized that the expectation factor in such markets plays one of the leading roles. It is noted that it is the grain market that is significantly influenced by expectations due to the forecast of future harvests in different parts of the world.

The purpose of the study is to analyze the process of shaping the dynamics of future prices for wheat and corn (maize) under the influence of the expectations factor in the United States in 2009-2019.

Methods. The authors' own technique to analyze the dynamics of future price changes through the transformation of primary data, using the cumulative sliding expectations method, is proposed.

Results. Analysing the data on changes in the prices of futures for grain, the periods of their sharpest increase in wheat and the most significant fall in corn have been identified. Comparison of the absolute data of the dynamic series and the values of the total sliding expectations made it possible to state that the maximum and minimum values of the total sliding expectations are related to the maximum values of future prices. Analysing the fastest rise in prices of wheat futures and the values of total sliding expectations, the latent fluctuations in expectations change of economic agents have been revealed.

Conclusion. It is concluded that the proposed transformation method of the primary data on the dynamic series of changes in grain futures prices reveals hidden patterns, which in turn improves forecasting of future events in the market.

Keywords: Time Series; Total Sliding Expectations; Commodity Markets; Futures; Price of Goods; Grain Futures; Corn Futures; USA

JEL Classification: G13; G14; Q11

Acknowledgements and Funding: The authors received no direct funding for this research.

Contribution: The authors contributed equally to this work.

DOI: <https://doi.org/10.21003/ea.V178-11>

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Вплив очікувань на формування ціни ф'ючерсів зернових культур

Анотація. Авторами розглядаються проблеми оцінки та прогнозування ціни ф'ючерсів на зернові культури на прикладі ринку США. Метою дослідження є аналіз процесу формування динаміки ціни ф'ючерсів на пшеницю та кукурудзу під впливом фактору очікувань в США у 2009-2019 рр.

На підставі аналізу даних зміни цін ф'ючерсів на зернові культури встановлено, що максимальні й мінімальні значення сумарних ковзних очікувань пов'язані з максимальними значеннями цін ф'ючерсів.

У статті зроблено висновок, що запропонована методика трансформації первинних даних динамічних рядів зміни цін ф'ючерсів зернових культур дає можливість виявити приховані закономірності, що в свою чергу підвищує рівень прогнозування майбутніх подій на ринку.

Ключові слова: динамічні ряди; сумарні ковзні очікування; товарні ринки; ф'ючерс; ціна товару; зерно; кукурудза; США.

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Влияние ожиданий на формирование цены фьючерсов зерновых культур

Аннотация. Авторами рассматриваются проблемы оценки и прогнозирования цены фьючерсов на зерновые культуры на примере рынка США. Целью исследования является анализ процесса формирования динамики цены фьючерсов на пшеницу и кукурузу под влиянием фактора ожиданий в США в 2009-2019 гг.

На основании анализа данных изменения цен фьючерсов на зерновые культуры установлено, что максимальные и минимальные значения суммарных скользящих ожиданий связаны с максимальными значениями цен фьючерсов.

В статье делается вывод, что предложенная методика трансформации первичных данных динамических рядов изменения цен фьючерсов зерновых культур дает возможность выявить скрытые закономерности, что в свою очередь повышает уровень прогнозирования будущих событий на рынке.

Ключевые слова: динамические ряды; суммарные скользящие ожидания; товарные рынки; фьючерс; цена товара; зерно; кукуруза; США.

1. Introduction

Changing situations in market prices have always attracted the attention of economists since the physiocrats and the first classics. Prices dynamics, their volatility, cyclicity and unpredictability fascinate and prompt the answer to the question: what underlies the factors determining the movement of goods value in the market environment? Besides, there is always a wide range of interested consumers in obtaining forecast data both in the short term and in the medium and long term. Although the latest task today, despite the significant achievements of econometrics and mathematics, looks as ill-fated as it did a hundred years ago.

2. Brief Literature Review

There is no doubt today about the ability of markets to determine the real price of goods, despite the constant criticism of the pricing mechanism by various economists and politicians. Another question is how markets do this and what underlies the price of the product. In fact, the answer to this question is the basic one for economic science. Discussions on the concept of the value of goods and the factors determining it have been going on since the advent of economics as a science. We do not analyse these issues in great detail, otherwise, we will go far beyond the scope of the purpose of the article. Simultaneously, the situation will be briefly characterized.

Adam Smith wrote in his classic work «The Study on the Nature and Causes of the Wealth of Nations», that the price of bread could remain stable, like the price of silver, for half a century or even a century in the absence of significant changes in society. However, during the year the price could vary from 25 to 50 shillings per quartet (1776) [1]. Addition to changes in the society has proven to be very relevant, because today the real value of wheat is much less than it was in Adam Smith's time. In those days wheat acted as the all-round equivalent of money as gold is today.

Considering the problem of prices, one cannot but mention the famous saying of Alfred Marshall (1890) [2] about the blades of scissors regarding the price of goods' determination. Thus, the problem of the price of goods was figuratively formulated due to the demand caused by the greatest marginal utility or marginal cost. After that, this comparison became classic. Analyzing the change in the price of wheat, A. Marshall noted that this product had a very low elasticity. In his opinion, changing the price of bread from 6 to 4 pence was unlikely to increase its consumption.

J. Keynes (1936) devoted a separate section in his classic work, «General Theory of Employment, Interest, and Money» to the issue of pricing [3]. Analyzing the impact on interest rates and changes in the amount of money in circulation, the author addressed the macroeconomic problems as a whole. However, in his view, price stability over the long term will depend on the intensity of the rising cost trend compared to the rate of increase in production efficiency. In agriculture, this finding is supported by a significant increase in yield over the past hundred years. Thus, wheat yields in the USA increased about four times from 1867 to 2008, and yields in Ukraine - 4.5 times during 1940-2018. This is the evidence of efficiency growth in crop production, which in turn, can lead to a reduction in its real price.

Contemporary researchers pay attention to different aspects of pricing in the markets. Sam Peltzman, (2000) [4] while analysing the change in prices for 77 consumer goods and 165 commodity producers, concluded that shock positive factors had twice as much influence on commodity price formation as negative factors. According to the author, this fact goes beyond the existing economic theory of pricing.

According to David Lobell, Kenneth Cassman and Christopher Field (2009) [5], one of the key factors that will drive global food prices in the long term is population growth and, hence, demand. In 2030, food demand is projected to increase by 50%. According to the authors, the solution to this problem will be related to the future profitability of production in new conditions.

The authors also draw attention to the problems of climate change impact on crop yields, in particular, D. B. Lobell and Ch. B. Field (2007) [6]. According to their data, due to climate change, gross losses of wheat, corn (maize) and barley will be up to 40 million tonnes per year. These losses may have a corresponding impact on price increases. However, the authors themselves note that technological changes have made it possible to compensate for them.

It is emphasized that one of the reasons for the rise in prices in the food market in the early 21st century was the growth of petroleum products' prices and, accordingly, the demand for biofuels [8]. However, it should be noted that this paper was published in 2008 when oil prices were the highest in the last decade. In 2019, oil prices were twice as low as in 2007-2008. Moreover, instead of the biofuel market development, the development of the electric car market began.

K. Anderson and S. Nelgen (2010) [8] point out that fluctuations of the world prices on the food market are affecting domestic markets in one way or another. According to them, this impact has a lag of one year. This makes governments impose internal barriers to keep prices at an appropriate level.

Various aspects of pricing and volatility were studied by L. McPhail, X. Du, and A. Muhammad (2015) [9], Y. Xu, F. Pan, Ch. Wang, and J. Li (2019) [10], Ch. Boyer, J. Larson, R. Roberts, M. McClure, D. Tyler, and S. Smith (2015) [11], J. Luckstead and S. Devadoss (2019) [12], El M. Amrouk, Th. Heckelei, and S.-C. Grosche (2019) [13], S.-C. Grosche and Th. Heckelei (2016) [14].

The problem of pricing on the agricultural market does not bind researchers to the factor of expectation, which is its essential element. Although it is on the agricultural market, where the factor of expectations plays a significant role. All market participants are affected by crop forecasts in different countries of the world. These expectations force market participants to make specific decisions regarding future contracts, the size of possible investments and insurance payments [7].

The theory of expectations includes two directions: the theory of adaptive and rational expectations. L. Koyck (1954) [15] and A. Cagan (1956) are considered to be the founders of the adaptive expectations theory. The basic principle of this theory is the assumption that past events, with varying likelihood, affect our future actions. This is quite logical because, as we know, there is no future without the past which can be exemplified by [16]. However, simple life experience of each person indicates that past events are never completely repeated.

Each economic cycle is unique with its peculiar features, both in terms of the events that have led to its inception and the nature of the duration and amplitude of the oscillation. Why, then, do past events play such an important role in shaping the expectations of economic agents? The answer to this question is also closely related to the history of past events. In particular, we can

recall a rapid rise in oil price futures from September 2006 to May 2008, when it increased from about USD 60 to USD 128. Such a course of events has generated a large number of forecasts regarding possible prices in the future. Some analysts have estimated the price of oil at USD 200 and even USD 250, justifying their position by oil shortage due to, firstly, rapid development of Asian countries, and secondly, the need to develop hard-to-reach oil fields with a high cost. All of this gave rise to the corresponding expectations of the market participants, first of all, investors. However, the economic crisis of 2008-2009 and the development of shale technology in the US have significantly changed the situation, generating new expectations in the market. Unforeseen events can significantly distort the importance of previous events. At the same time, it should be noted that extraordinary or shocking events occur very rarely in the vast majority of economic development periods.

The theory of rational expectations is a competing theory to the theory of adaptive expectations. Its founders are J. Muth (1961) [17] and H. Simon (1958) [18]. The main tenet of this theory is that people use more sophisticated ways of forming their expectations, especially when it comes to investing significant capital. This means that in the process of shaping their expectations about the future behaviour of economic variables companies and individuals use all the information at their disposal, combining it with their ideas formed on the basis of the established dependencies in economic systems. Thus, if there is some information about a possible easing of monetary policy by the government or the central bank of the country, it can lead to a change in the trend in the price and capital markets. Previous events, however, will no longer have a significant impact on the formation of current situations.

An example is a situation with the formation of inflation expectations. This problem was closely linked to the A. Phillips curve (1958) [19], characterising interdependence of inflation and unemployment. The fact is that economic policy in the United States in the 1970s, relying heavily on this dependence, led to the opposite results, namely, high unemployment and high inflation. E. R. Lucas Jr. (1976) noted in this regard that dependence ignored optimal behaviour of economic agents, including the formation of rational expectations [20]. Since economic entities use their explicitly available information optimally in formulating their expectations, R. Lucas believed that their expectations should be considered as rational. This means that economic agents make predominantly correct forecasts for the future and can anticipate a government's action in their plans. It is inflationary expectations of economic agents that can play a decisive role in shaping inflation in the long term.

3. The purpose of the article is to analyse the process of shaping the dynamics of future prices for wheat and corn (maize) under the influence of the expectations factor in the US in 2009-2019.

4. Research methodology

An approach based on the theory of adaptive expectations is used in our study. From our point of view, the theory of rational expectations has considerable advantages in the long run. In the short term, the theory of adaptive expectations has every reason to dominate. And in this case, it is not that a person cannot objectively evaluate economic reality due to limitations in the information or the ability to interpret it correctly. Very often both professional investors and ordinary people make their decisions largely under the influence of current trends or subject to the pressure of the «crowd». For example, if the price of a product rises rapidly, it is very often tempting to buy it urgently to make a profit in the future when it becomes even more expensive. But the practice may be different. Stock exchanges always have investors who focus on the principles of fundamental or technical analysis. In this case, it can be argued with some degree of a convention that the former has a long position in the acquisition of assets and the latter - a short position. In fact, from our point of view, this reflects the commitment of economic agents to the theory of rational or adaptive expectations.

Our methodological approach is based on the principle that previous events matter. Trends and tendencies on the market matter also. In doing so, we assume that they shape the current expectations of economic agents directly. It should be noted that there is also an opposite point of view regarding the impact of previous events on the formation of future market results. M. Kendall and A. Hill (1953) [21], having analysed the dynamics in price change of British companies' shares, concluded that they were random and therefore could not be predicted. Therefore, there must be some

fundamental factors behind them. In fact, A. Ferrell (2003) also came to this conclusion [22]. Analysing the dynamics of changes in asset prices, he noted their detachment from the effective stock market hypothesis. This gave the author reason to conclude that today economists lack the ability and reliable means to predict changes in asset prices. At the same time, rapidly changing trends are associated with urgent events that do not occur infrequently. Therefore, the role of previous trends in pricing and expectations of economic agents must be recognized as significant.

However, not only expectations are important but their correlation with what has happened in reality is important, too. If the difference between expectations and the actual course of the event is significant, it will force economic agents to draw appropriate conclusions and change their strategy and tactics of market behaviour. Thus, if an investor invests in futures contracts, expecting the commodity price to rise and it declines, he will be forced to either sell his futures or fail. One way or another, such a situation will have actual consequences for economic agents.

To test these principles, a methodological approach to calculating total sliding expectations has been developed [23]. In general, it can be summarized as follows. In the first stage, we determine a segment of the dynamic series according to which the alignment will be performed. However, both the length of the segment and the function may be different for different situations. In the second stage, according to the obtained equation, forecasting of the indicator for one period in advance is made. That is, if the equation of the linear function $y = a_0 + a_1x$ is selected, then the value of x in the period $t + 1$ is taken to be equal to x_{t+1} , and we obtain the predictive value of y' . Thus, we make the assumption that previous events should shape the future expectations of economic agents. These expectations may be linear or otherwise. One might mention, for example, Elliott's theory of waves, which is widely used in technical analysis in predicting future events in the stock and commodity markets. However, in the short term, from our point of view, the vast majority of people make decisions under the influence of recent market developments. In fact, it is about taking into account trends that can be mathematically expressed.

The third step is to compare the predicted value (y') with the actual (y_{t+1}) as the difference between them:

$$\Delta y = y_{t+1} - y' . \quad (1)$$

The purpose of this comparison is to correlate current expectations based on previous trends with the actual situation. If they coincide, the difference will be 0. If the difference between them is significant, this may be the basis for making appropriate decisions. In the fourth stage, the entire described process is shifted one period ahead and is repeated. As a result, the primary dynamic series is converted into a series that represents the deviation of the expected data results from the actual ones.

In the fifth stage, the summation of the value over a certain period of time is done (it can be equal to 5-10 periods or some other value):

$$\sum \Delta y = \Delta y_1 + \Delta y_2 + \dots \Delta y_n . \quad (2)$$

As a result, the received value can be both positive and negative. If the value is positive, it indicates that the actual values outweighed the predicted ones for the selected period. If the value is negative, the conclusion will be the opposite. This figure is the value of the total sliding expectations.

The magnitude of total sliding expectations is an important indicator of assessing the stability of markets. If this value is significantly different from 0 or, at least, its average level, it will evidence the variability in the markets and, consequently, increased risk of investing in assets.

5. Results

Daily data on the prices dynamics of wheat and corn futures in the US market for the period 2009-2019 were chosen as an object of analysis. The performance of this market is largely influenced by different expectations of both the forecast yields in different countries and the corresponding supply and demand in the US market. Figures 1 and 2 show the dynamics of future prices for selected crops.

Analyzing the above data, we should, first of all, note considerable volatility of prices for both wheat and corn. There are several periods of rapid rise and fall in price. In particular, wheat can be distinguished by several periods of rapid price growth (Table 1).

The highest rate of increase in the price of wheat futures was observed from 29.06.2010 to 05.08.2010 when it increased from USD 456.6 / bu. up to USD 815.6 / bu., or by 78.6%. In this case, we do not consider the reasons for this fact but only note it. Besides, the price increased significantly from June 15 to July 20, 2012 (by 53.8%).

The dynamic range of the futures price for corn indicates that the nature of this market was somewhat different (Figure 2). Thus, we noted that a period of the rapid growth of wheat futures prices in 2010 also occurred in corn, but in a different time frame and with a different characteristic

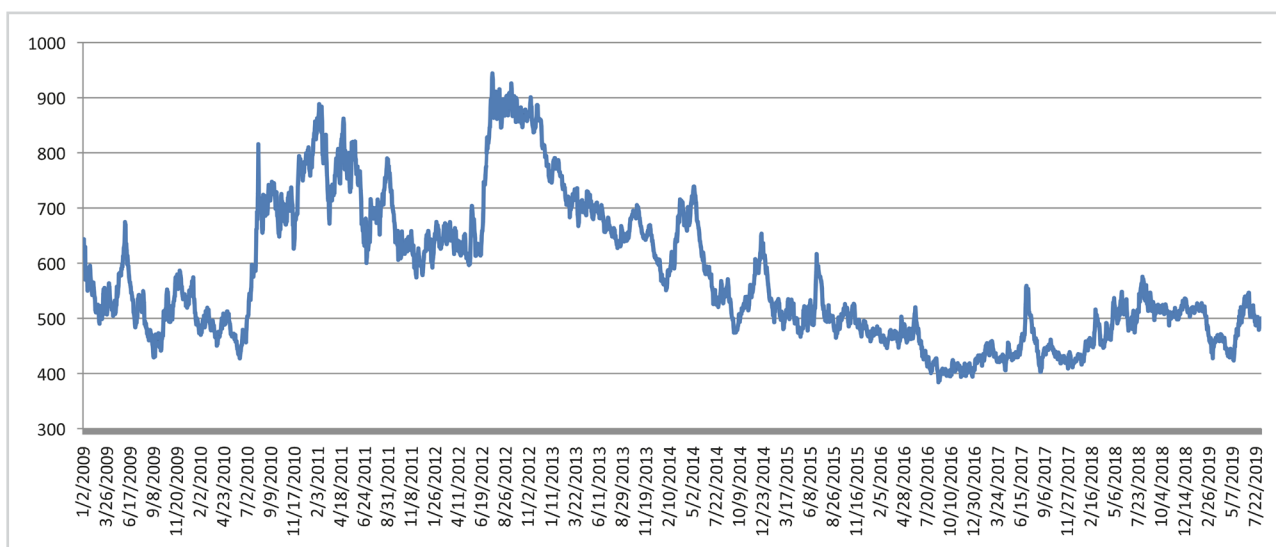


Figure 1:
Dynamics of changes in the price of wheat futures in the US for 2009-2019, USD / bu.
Source: Designed by the authors based on data of [24]

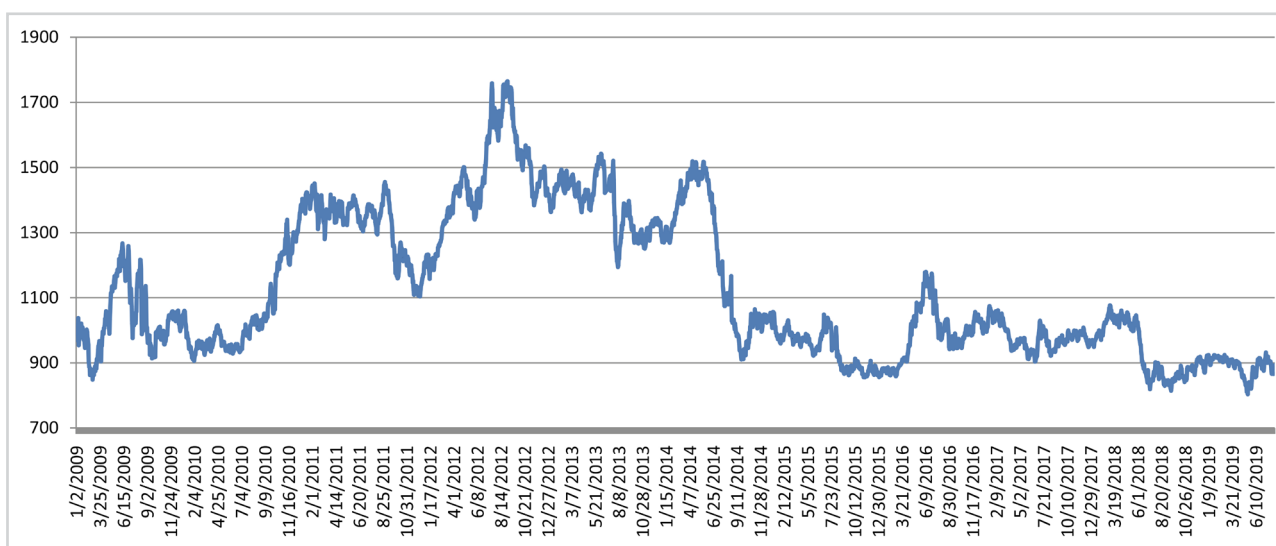


Figure 2:
Dynamics of changes in the price of corn (maize) futures in the US for 2009-2019, USD / bu.
Source: Designed by the authors based on data of [24]

Table 1:
Periods of the highest price of wheat futures, USD / bu.

Periods	Price at the beginning of the period	Price at the end of the period	Growth rate, %
From 29.06.2010 to 05.08.2010	456.6	815.6	78.6
From 15.06.2012 to 20.07.2012	613.9	943.9	53.8
From 29.01.2014 to 24.03.2014	550.9	713.4	29.5
From 29.05.2015 to 30.06.2015	477.9	616.6	29.0
From 14.06.2017 to 05.07.2017	429.3	558.8	30.2

Source: Designed by the authors based on data of [24]

of growth rates. The rise in wheat futures prices continued from 9.06.2010 to 02.02.2011 and was characterized by an increase from USD 945.6 / bu. to USD 1451 / bu., or 53.5%. Moreover, this dynamic range is also characterized by periods of the rapid fall in prices. That is why it was decided to focus on dynamic series analysis in terms of falling futures prices (Table 2). Firstly, the period of the biggest price drop - from June 3 to September 26, 2014, should be highlighted. During this time, the futures price dropped from USD 1481.2 / bu. to USD 910.6 / bu., or 38.5%. In other selected periods the drop was slightly more than 20%.

After a brief description of the dynamic series, we analyse the results of the proposed methodology use. Firstly, it was decided to use 20 days as the width of the window to predict the outcome on day 21. A linear function was used. Then, we proceeded from the fact that this result should form the corresponding expectations, which were subsequently compared with the actual data per our methodology. Concerning the summation of the deviations obtained as a result of this comparison, it was decided to take a window width of five days. What was the reason for that? This period corresponds to the length of the workweek when the stock is traded. In fact, investors have time before the start of next week to assess the situation and make a decision based on how their expectations have come true this week. The results obtained on the dynamics of the total sliding expectation of futures prices are shown in Figures 3 and 4.

Analyzing the results, it should be emphasized firstly that the nature of the dynamic series has changed significantly. It is approaching the stationary one. This is confirmed by the results of the dynamic series data autocorrelation, which tended to significant decrease and gradual transition to negative values at the seventh level (Figure 5).

The last result is evidence of cyclicity in the studied time series. The Fourier analysis made it possible to state the existence of cycles of different duration, but none of them was clearly expressed. Thus, we have a situation where the obtained dynamic series of total sliding expectations

Table 2:
Periods of the greatest fall in the price of wheat futures, USD / bu.

Period	Price at the beginning of the period	Price at the end of the period	Rate of fall, %
From 11.08.2009 to 29.09.2009	1216.5	917	-24.6
From 06.09.2011 to 13.12.2011	1423.75	1118.13	-21.5
From 31.08.2012 to 16.11.2012	1754.37	1383.63	-21.9
From 22.07.2013 to 06.08.2013	1520.6	1194.13	--21.5
From 03.06.2014 to 26.09.2014	1481.25	910.63	-38.5
From 23.05.2018 to 13.07.2018	1039.25	819	-21.2

Source: Designed by the authors based on data of [24]

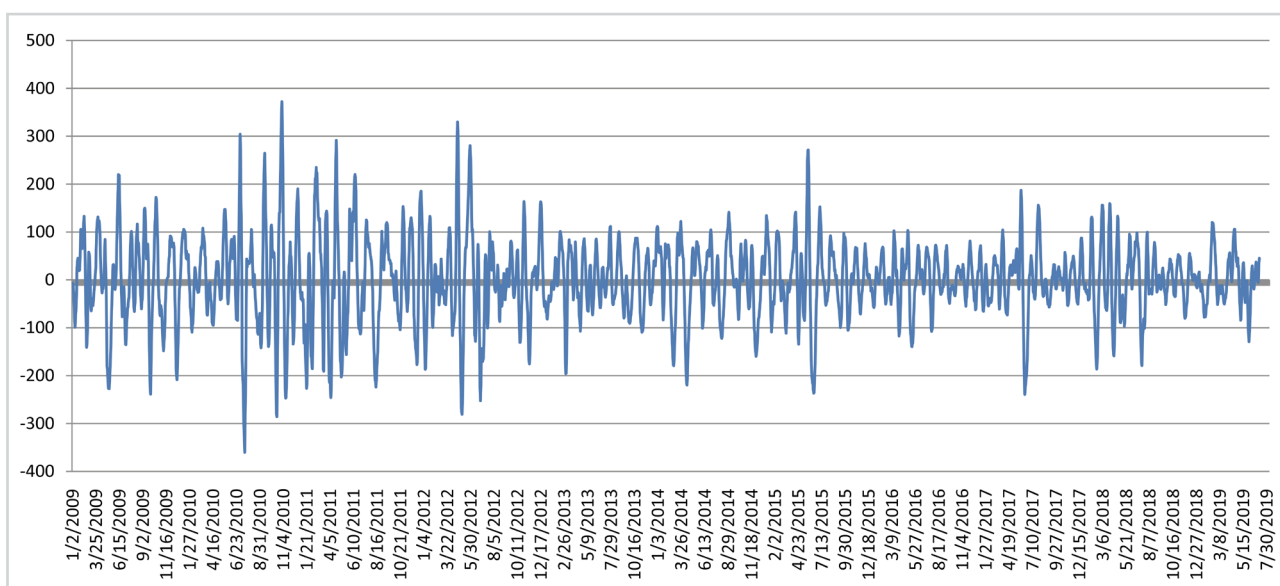


Figure 3:

Dynamics of the total sliding expectation of wheat futures in the United States for 2009-2019, USD / bu.

Source: Calculated by the authors based on data of [24]

is characterized by stationarity, available frequency oscillations and cycles of different duration. The question is: How do these characteristics relate to the phases of rapid trend change identified above? To answer this question, let us first turn to Table 3.

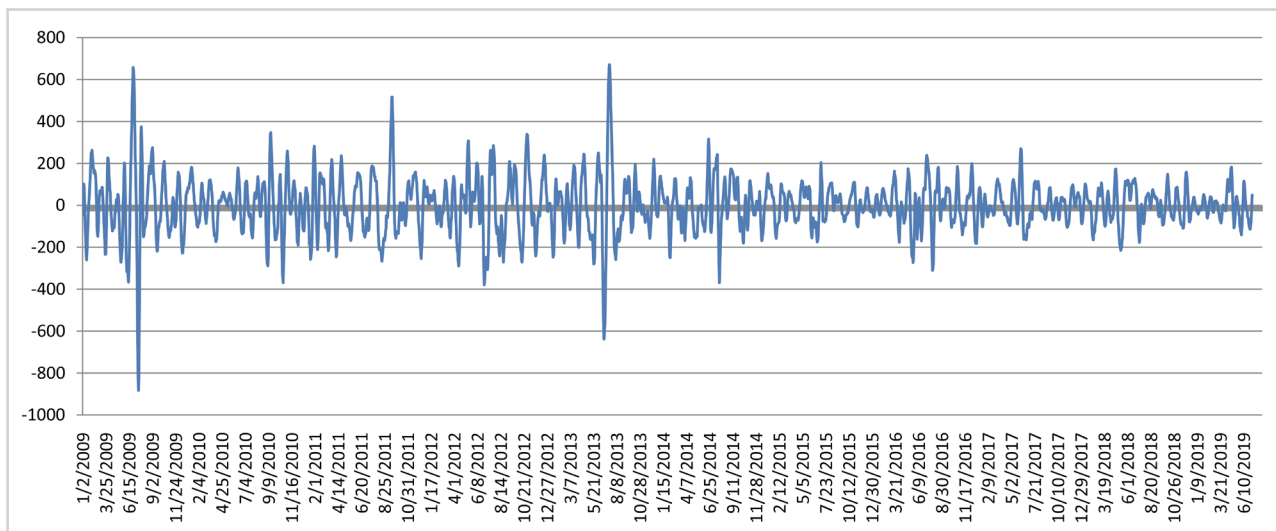


Figure 4:

Dynamics of the cumulative sliding expectation of corn (maize) futures price, USD / bu. in 2009-2019

Source: Calculated by the authors based on data of [24]

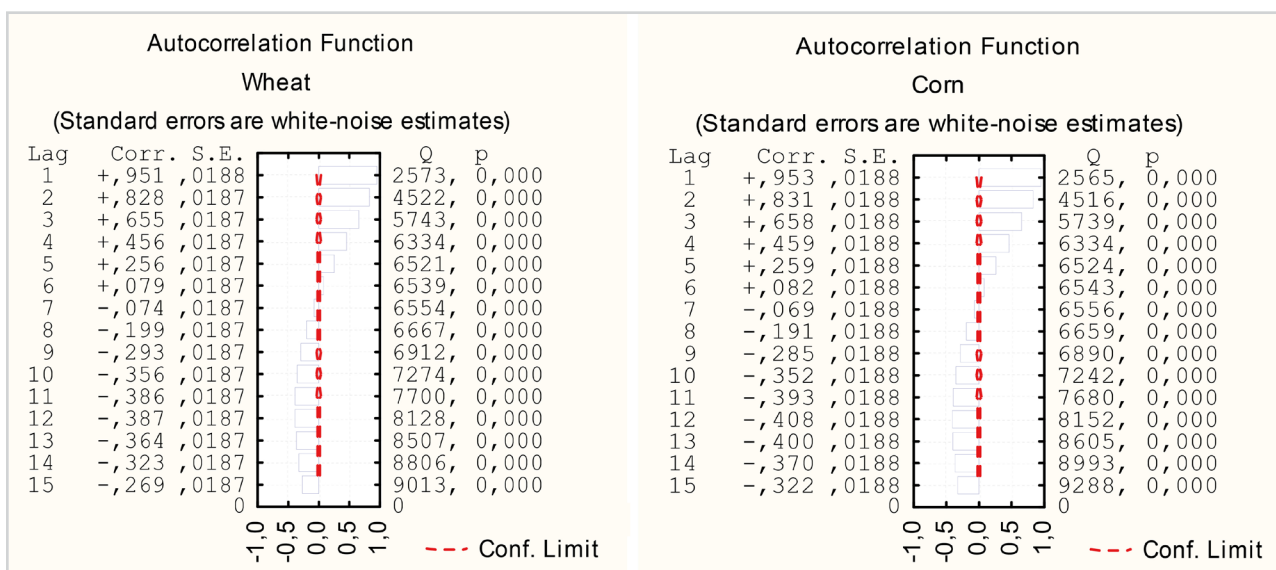


Figure 5:

Selective autocorrelations in the dynamic range of total sliding expectations of futures for wheat and corn in the United States for 2009-2019

Source: Calculated by the authors based on data of [24]

Table 3:

Relation between the total sliding expectations and the futures price, USD / bu.

Total sliding expectations	Wheat		Corn	
	Price	Data	Price	Data
To -250	671.8	12	1244.3	64
From -250 to -150.1	655.3	126	1238.5	203
From -150 to -50.1	586.7	522	1125.8	640
From -50.0 to 0	553.9	740	1072.8	505
From 0.1 50	548.4	718	1078.4	499
From 50.1 to 150	589.8	632	1114.8	651
From 15 to 250	669.7	70	1224.3	196
More than 250.1	732.0	18	1257.5	64

Source: Calculated by the authors based on data of [24]

In this case, it was decided to assess the relationship between the total sliding expectations and the futures price.

All data were divided into eight groups with a total sliding expectation of USD -250 / bu. up to + USD 250 / bu.

The first conclusion that can be drawn from the above is the fact that the highest values of total sliding expectations for both wheat and corn coincide with the highest futures price. This applies to both positive values of the total sliding expectations and negative values. Thus, it is precisely during the period when prices reach their maximum that the expected deviations of the futures price from the actual ones occur.

For wheat, the total deviation less than USD 250 / bu. was noted 12 times at an average futures price of USD 671.8 / bu., and a total deviation of more than + USD 250 / bu. - 18 cases at an average futures price of USD 732 / bu. A similar trend was found for corn.

These facts, in turn, indicate that during the high price period positive and negative expectations almost coincide. Investors are waiting for the moment when the price is maximized. Some of them are already convinced that the price has reached a maximum, and in the future, it will fall, while others expect a further increase in the price. The result reflects the struggle against these expectations.

To better understand how expectations tend to change during a period of rapid price growth, let us refer to Figure 6. In this case, the data are given for the periods of the fastest growth in wheat futures prices (dynamics of changes in futures prices and total sliding expectations for selected periods for wheat, USD / bu.).

The figures above show a clear and unambiguous upward trend in the price of futures, which is quite logical.

At the same time, the dynamic series of sliding expectations tend to rise first and then decline with further increase. What does it mean?

From our point of view, the answer to this question is that at the beginning of the period the upward trend in prices is dominated by more restrained expectations. In future, the trend changes with a gradual transition to a new growth stage of total sliding expectations. The latter result is also logical and shows that cautious expectations begin to prevail during the period of upward trends in price.

Thus, in the original dynamic series, which is usually characterized by a fairly clear tendency, cyclical processes of change in total sliding expectations are revealed. Their dynamics should largely determine the dynamics of the primary time series. The result gives an opportunity to identify trends more clearly and, accordingly, to predict them.

5. Conclusions

In recent decades, the expectations theory has made a significant progress in explaining many macroeconomic phenomena. At the same time, its practical application in assessing dynamic processes in the stock markets, while pricing commodities, remains unsatisfactory.

On the one hand, all prices, to varying degrees, are predicted by economic agents, based on their own experience and methods. However, the issue which mechanisms might be best in this case is still open.

The authors' methodical approach to assessing the impact of expectations on the trend of changes in the price of futures for wheat and corn has made it possible to identify hidden patterns and can be used to predict them accordingly.

Besides, the findings raise new questions.

The first is whether expectations are actually shaped by the way we defined them?

This applies, in particular, to the linear function in the process of forecasting future prices. It may be preferable to use nonlinear functions in certain periods, especially of large price fluctuations. The length of the summation period is also debated as to the forecast and actual data. The five-day period we choose, requires other data to be verified. The assumptions must as well be verified against other data.

In addition, the question remains about the extent to which economic agents' expectations are shaped by market prices. Our studies confirm that their impact is actual in the short term. At the same time, the impact of supply and demand in the long run remains prevalent.

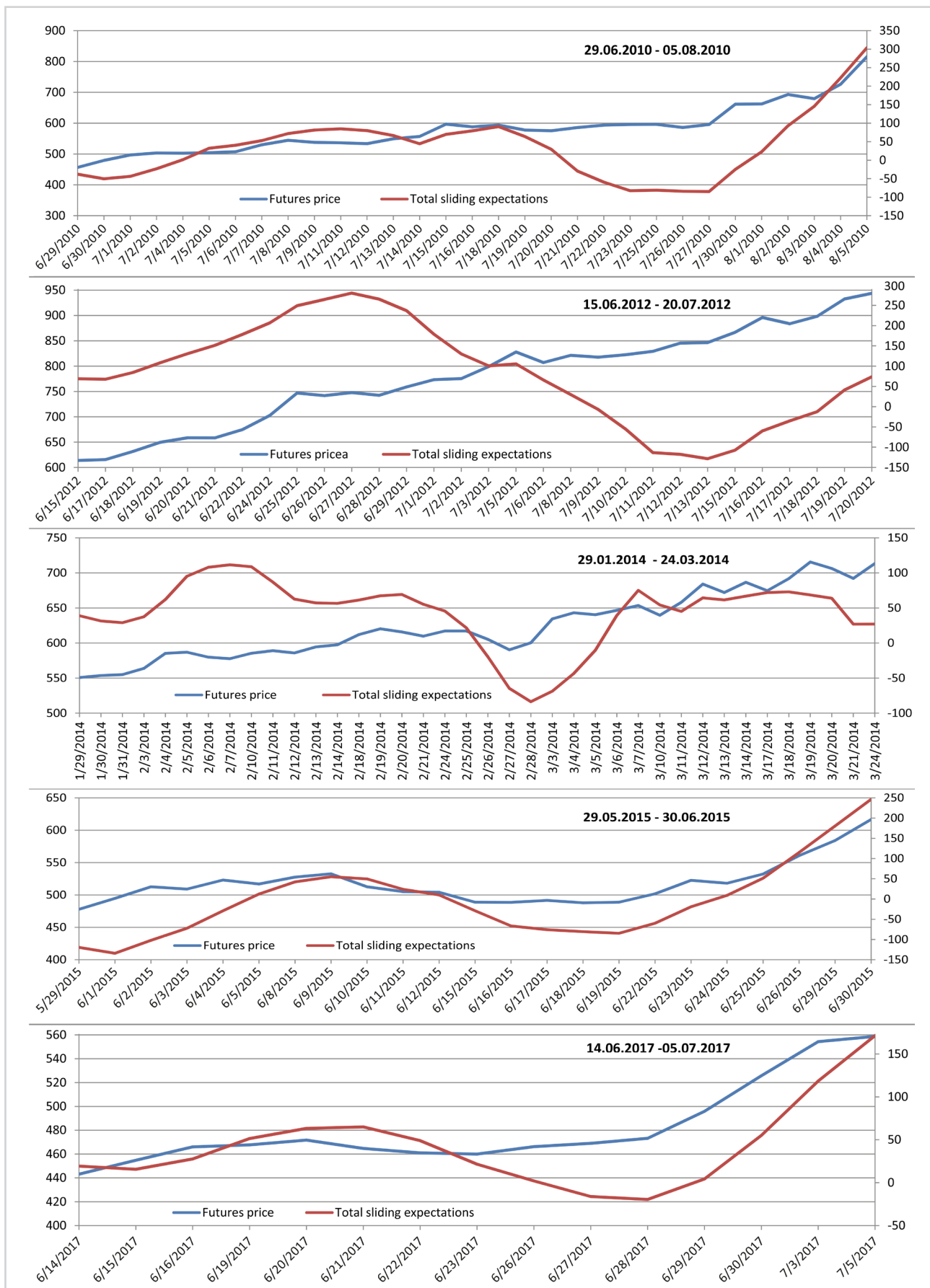


Figure 6:

Dynamics of changes in futures prices and total sliding expectations for selected periods for wheat, USD / bu.

Source: Calculated by the authors based on data of [24]

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Received 29.07.2019

Received in revised form 27.08.2019

Accepted 29.08.2019

Available online 30.09.2019