Manifestations of Influence of Solar Activity and Cosmic Ray Intensity on the Wheat Price in the Medieval England (1259–1703 Years)

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Abstract

The database of Professor Rogers, with wheat prices in England in the Middle Ages (1249–1703) was used to search for possible manifestations of solar activity and cosmic ray variations. The main object of the statistical analysis is investigation of bursts of prices. We present a conceptual model of possible modes for sensitivity of wheat prices to weather conditions, caused by solar cycle variations in cosmic rays, and compare the expected price fluctuations with wheat price variations recorded in the Medieval England.

We compared statistical properties of the intervals between price bursts with statistical properties of the intervals between extremes (minimums) of solar cycles during the years 1700–2000. Statistical properties of these two samples are similar both in averaged/median values of intervals and in standard deviation of this values. We show that histogram of intervals distribution for price bursts and solar minimums are coincidence with high confidence level.

We analyzed direct links between wheat prices and solar activity in the 17^{th} Century, for which wheat prices and solar activity data as well as cosmic ray intensity (from ^{10}Be isotope) are available. We show that for all seven solar activity minimums the observed prices were higher than prices for the nine intervals of maximal solar activity proceed preceding to the minimums. This result, combined with the conclusion on similarity of statistical properties of the price bursts and solar activity extremes we consider as direct evidence of a causal connection between wheat prices bursts and solar activity.

1. INTRODUCTION

We base our approach on the several known facts:

1. Existence direct correlation between cosmic ray flux, entered into atmosphere of the Earth and cloudiness of the atmosphere (Svensmark, H. et al., 1997) (we take into account that amplitude of the correlation and even its

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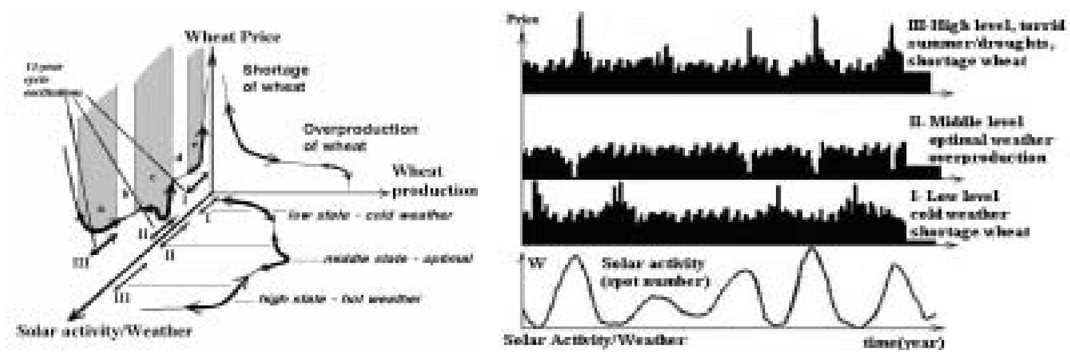

Fig. 1. Left — 3_D diagram of possible influence of solar cycle/weather on wheat prices. System state is defined by its position in the 3-D space "Solar activity/Weather"-"Wheat Production"-"Price." Amplitude and sign of the influence depend on the state of the system on a weather-production plane (Low, Middle, High) and on a range of weather variability caused by solar cycle (size of arrows); Right — Possible dependences of the prices bursts on solar cycle variability depend on the state of the system in the left 3-D space: I — "Low Level" state sensitive to cold/cloud increase and leading to shortage in wheat supply, II — prices for the "Middle Level" state with regular generation of optimal conditions for wheat production, leading to price fall down caused by "overproduction", III — prices for the "High Level" state sensitive to "hot" weather — cloud decrease leading to shortage in wheat supply.

sign change from one region on the Earth to another drastically)

2. From the other side cosmic ray intensity in the solar system change with solar activity with negative correlation between cosmic ray flux solar spots number
3. Weather condition as factor of influence on the wheat production has specific nonlinear dependence with threshold region in weather state, when relative small variations, like to a few days of early frosts or week of drought in vegetation period may decrease a crop catastrophically
4. From the other side wheat market with a limited supply (as in medieval England) has nonlinear sensitivity to variations of wheat production with threshold state where small change in the wheat supply may lead to price of burst (case of the wheat shortage) or to prices falling down (case of the wheat overproduction).

2. ANALYSIS OF DATA

For our analysis we use three samples of data: 1) Agricultural prices P(t) in England for 1259–1702 from Prof. Rogers (1887); 2) Moments of maximums and

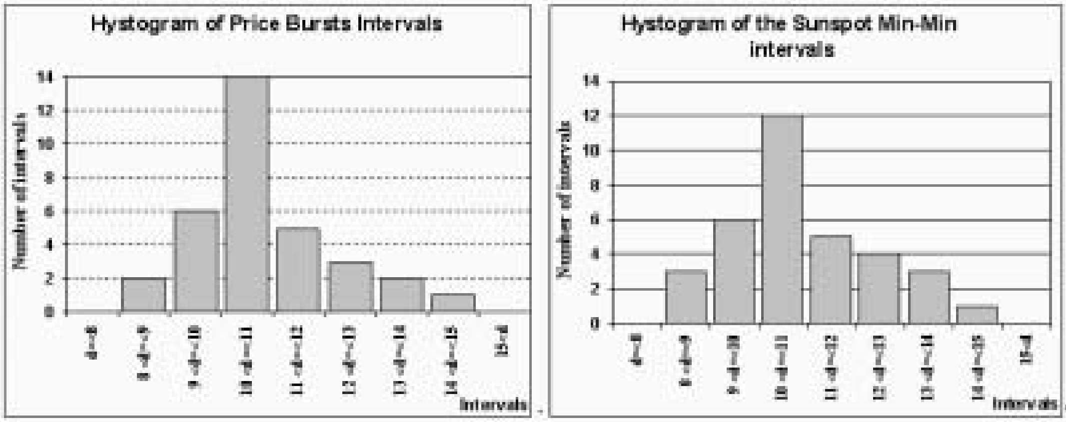

Fig. 2. Interval distributions for price bursts and for min-min intervals of sunspot cycle.

minimums of solar spots $T_{Max}(t)$, $T_{Min}(t)$ for years1610–2000 from NOAO Satellite and Information Center; 3) Data on solar activity maximums from isotope ^{10}Be in Greenland for the years 1600–1700 from Beer et al. (1998). In the first part of analysis we compared the distribution of intervals of price bursts with the distribution of the intervals between extremes (minimum phases) of solar cycles (Fig. 2).

Conclusions from the interval analysis:

1. For sunspot minimum-minimum interval distribution the estimated parameters are: median - 10.7 years; mean - 11.02 years; standard deviation - 1.53 years.

2. For price burst interval distribution the estimated parameters are: median - 11.0 years; mean - 11.14 years; and standard deviation - 1.44 years.

3. The null hypothesis that the frequency distributions are the same for both of the samples (intervals between price bursts and intervals between minimums of sunspots) was not rejected with $\chi 2$-test (significance level $> 95\%$).

We see that statistical properties of the intervals between the price bursts and minimums of the sunspot cycle are very close or coincide.

In the second part we present analysis of the behavior of wheat price during period of Maunder minimum (1600–1700), when data on solar activity are available from ^{10}Be data from Greenland ice. In the Fig.3 we show wheat price variations curve with marked moments of the ^{10}Be minimums and maximums. This 100% sign correlation for 9 cycles of activity of wheat prices and ^{10}Be state can not be explained as random coincidence ($P < 2^{-9} \approx 2^*10^{-3}$).

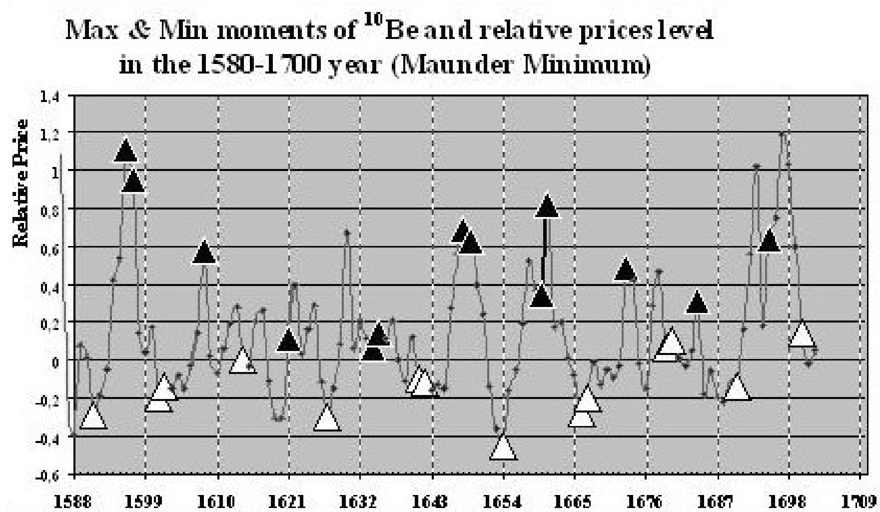

Fig. 3. Systematical difference in prices at moments of maximum and minimum states of solar activity (1600–1700). White triangles are prices on moments of maximum solar activity and minimal ^{10}Be, black triangles in opposite — prices on moments for minimum activity and maximal ^{10}Be. If time moment of the max/min has value between two integers we marked it as 2 triangles nearest to exact value.

We consider these 2 coincidences (distribution of intervals between minimums of sunspot cycle and wheat price bursts for 1250–1700 years and 100% sign coincidence between wheat price and ^{10}Be state minimums and maximums) as direct arguments in support of our causal connection scheme between solar activity and wheat market state in Medieval England.

3. References

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