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Possible influence of heliosphere Dynamics on Prices from medieval England to modern USA

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In this work we continue to search for possible evidence of the influence of solar activity on agricultural and consumables prices through heliosphere dynamics and the Earth weather. We consider possible connections between solar activity and studied prices as a process that includes nonlinear transition elements with threshold type of sensitivity. Burst-like reactions of prices are expected responses for this approach. As we showed earlier in the first part of this research (Pustilnik and Yom Din, 2004: PY 2004), two types of manifestation of causal connection between the price level and the state of solar activity can be observed: 1) Statistical parameters of the distributions of time intervals (interval distribution) for price bursts and for correspondent phases of sunspot cycle are the same; 2) Max/Min price asymmetry with systematic differences between prices in Maximum and Minimum states of solar activity can be detected. The previous part of our work was based on a 450-years sample of wheat prices in England. It was shown that the two types of manifestations had place indeed. In the present study we test the discovered connection on another 700-years database of prices of consumables in England. We show that statistical parameters of the interval distributions for bursts of the consumables prices and for sunspot minimum states are very close one to another. In the second part of the presented work we search for possible manifestation of the discovered connection under conditions of the modern agricultural markets. For this purpose, we analyze wheat price dynamics in USA in the 20-th century and show that reliable Max/Min price asymmetry consistent with the sunspot cycle exists. We discuss possible explanations of the observed effects

1. Introduction

In the first part of our research (PY 2004) we reconsidered possible causal connection between solar activity and wheat price level. We included into consideration two new elements of this possible connection:
Connection between cloudiness state in the earth atmosphere and high energy cosmic ray flux, entered into the atmosphere from Heliosphere. We noted that sensitivity of atmosphere to cosmic ray effects is very inhomogeneous on the earth surface and corresponding regions of high sensitivity are localized in a few specific regions (presumably, caused by critical state of atmospheric vapor condensation).
We formulated a possible causal chain of connection between solar activity and price level: "sunspot cycle variation" >"solar coronal activity with solar wind enhancing" > "suppressing of penetration of high energy Galaxy Cosmic Rays into active Heliosphere with decreasing of cosmic ray flux into the Earth atmosphere" > "suppression of cloudiness formation caused by deficit of ion and radical created by entered cosmic rays" > "weather abnormalities caused by correspondent variation in cloudiness state" > "nonlinear reaction of agriculture output, caused by unfavorable weather state" > "nonlinear and threshold type reaction of the market of agricultural commodities on decreased supply with the following price burst for the corresponding commodity". According to this scheme, one can expect a burst- like price reaction that will have a place mainly in the corresponding phase of solar activity (minimum or maximum of sunspot cycle).

This approach enables to expect the following two types of changes in prices of agricultural commodities as the result of the solar activity:
Burst-like disturbances of prices when statistical parameters of the interval distribution of price bursts are similar to those for the interval distribution of phases of solar activity, favorable for price burst generation.

Price asymmetry between sunspot Maximum and Minimum states (max/min asymmetry), when prices of the agricultural commodities in a favorable state of solar activity will be systematically lower then those for the next unfavorable state.

Clearly, these effects can be expected only for the agricultural production with high and nonlinear sensitivity to weather conditions in the considered region. This was true for the case of wheat in Medieval England, which was identified as a risk region for this agricultural crop (Rogers, J. E. Thorold, 1887).

When we applied this scheme to the observed bursts of wheat prices in Medieval England a very good agreement between expected and observed effects was obtained: a) very good coincidence between statistical parameters of the interval distributions for price bursts and sunspot maximum-minimum states; b) 100% sign asymmetry between wheat prices in a maximum and the next minimum states of solar activity for the 1600-1700 period of the overlapped databases (of prices and solar activity).

In the presented work our research tasks were:

a) to test the previous conclusion about the Medieval England market on the basis of another, essentially different sample of consumables prices;

b) to test efficacy of the proposed causal chain of solar activity influence on the price level under conditions of the Modern Time economics characterized by a high role of technological innovations (selection, genetics, control of plant diseases) and market globalization what suppress prices sensitivity to variations in external conditions.

2. Data

For our aims, we used the following two databases of prices:

- Prices of composite unit of consumables (CUC) in England for seven centuries, 1264-1954 (Brown and Hopkins 1956). In this database, the article of "Farinaceous" included wheat, rye, barley, peas, and in the 20th century – wheat and potatoes. The weight of the price-index of this article in the cost of the whole unit was 20% when the quantity of wheat in the total quantity of farinaceous products changed from 37 to 49%. Since, the direct contribution of wheat in CUC is less then 10% and wheat price and CUC samples can be considered as independent for the following analysis. The main sources of data were the works of Rogers (1987) and Beveridge (1939), and from the beginning of the 19th century – quotations of the wholesale prices from the organized markets. The prices of CUC are measured as indexes (1451-75 = 100).
- Wheat Prices in USA in 20-th Century (1908-1993)

The second database contained year average prices in $ per bushel received by American farmers for their wheat (durum, spring, winter and other kinds of wheat, total) collected in USDA - US Department of Agriculture (USDA, 2004).

3. Results and discussion

3.1. Effects of sunspot activity on prices of composite unit of consumables (CUC) in England

The dynamics of CUC for about 700 years is shown in the upper part of Fig. 1. It includes several historical periods of global changes in socio-economic conditions (Coulomb discovery of America, Continental Wars, First and Second World Wars) with corresponding price transitions to a higher level and the following stabilization in the quieter period. For our aims, only a part of the available sample of CUC prices was analyzed (Fig 1, bottom part), namely, for the period 1260-1720 that was a basis for the first part of this research which included the analysis of wheat prices (PY 2004).

At the next step we repeated data analysis as it was made in the first part of our research for wheat prices: restoration of slow trend-transition component with the following normalization of CUC prices by this slow component, what gave us relative variations of CUC prices; filtration of the noise component from the burst component by the amplitude discrimination (the level of 27.5% was used); identification of the largest CUC price bursts in each 11-grid intervals; calculation of inter-burst time intervals and analysis of statistical parameters of the generated sample of burst-burst time intervals. In the first row of Table 1 we show the results of the statistical analysis (median of intervals, average interval, and standard deviation of intervals) for burst-burst intervals of CUC prices.

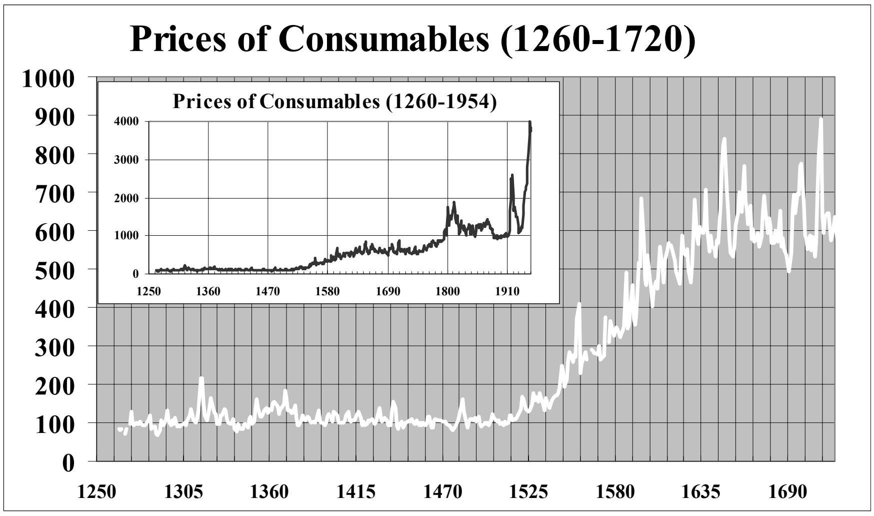

Fig1. Upper part: price dynamics of composite unit of consumables (CUC) during 700 years (1260-1954) and the selected period of analysis (1260 - 1710); bottom part: a chart of the CUC prices for the selected period consistent with the Rogers' data of wheat prices in Medieval England.

In the second and third rows of Table 1 we show similar statistical parameters estimated in the first part of our research for burst-burst intervals of wheat price sample for the same period (1259-1710) and for minimum-minimum intervals of sunspot cycle for 1700-2000 years. As it can be clearly seen from the Table 1, statistical parameters of these 3 interval distributions are very close one to another and the zero hypothesis that all 3 samples have the same nature (are taken from the same statistical population) can not be rejected on 99.9% level of confidence. Another indication on the common nature of CUC price bursts, wheat prices bursts and sunspot minimum states is illustrated in Fig.2 where three histograms of these interval distributions are shown. Comparison of the histograms with $\chi 2$-criterion enables accepting of the hypothesis that they are taken from the same statistical population, on significance level >90-95%.

In this statistical test we related to the samples of prices of CUC and of wheat prices as independent samples, for the purpose of comparison. The sources of these two samples are essentially different, because the weight of wheat prices in prices of CUC is less than 10% (Section Data). However, in reality of Medieval England wheat prices were an essential part of prices of consumables as directly through the price of food, as indirectly through the workers' salary. In some sense, the role of wheat as a main source of the muscular energy (the main kind of energy in that time) was similar to the role of oil in our time. In any case, a good agreement of interval distributions for price bursts of consumables and for minimum-minimum intervals of sunspot cycle confirm our previous result about influence of solar activity on wheat prices in Medieval England.

3.2. Possible manifestation of the solar activity in modern USA wheat market

As it was discussed in the first part of our work [1], manifestation of the solar activity effects in the modern time has to be suppressed significantly by three new effects, negligible before:

Technological innovations in agriculture (selection, genetics, control of plant diseases) what increase resistance of agriculture to unfavorable external condition including weather abnormalities.

Globalization of the world market what increases resistance of local markets to unfavorable conditions, caused by local crop failure.

Interference of the government (in developed countries) aimed at suppression of price bursts by premium for decrease in crops area and stimulation of crop insurance.

Table 1. Comparison of the statistical parameters (median, average, standard deviation) for 3 studied samples: burst-burst intervals for prices of Composite Unit of Consumables, burst-burst sample for Wheat Prices, Minimum-Minimim intervals for Sunspot Cycle

SAMPLE	Median (years)	Average (years)	St.Dev (years)
Burst-Burst intervals – Prices of Composite Unit of Consumables	10.0	10.65	1.57
Burst-Burst intervals – Wheat Prices	11.0	11.14	1.44
Min-Min intervals - Sunspot Cycle	10.7	11.02	1.53

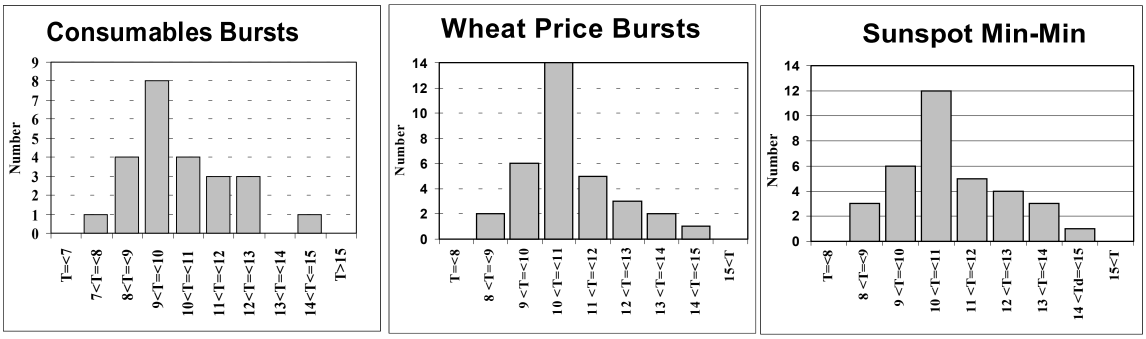

Fig. 2. Comparison of histograms of interval distributions for prices of consumables bursts, Wheat Prices bursts and Sunspot Min-Min intervals.

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From the other side, we noted that in certain situations these compensation mechanisms may be ineffective. It can have place, for example, in developing countries, placed in zones of high risk agriculture. Another feature of these regions is a lack of necessary financial resources in most of these countries for using global market opportunities.

As a possible test of applicability of our approach in modern time, we investigated data of wheat prices in the USA during 20-th century (USDA 2004). Clearly, a small volume of the sample that included only 8 sunspot cycles does not enable to investigate statistical properties of inter-bursts intervals. In this situation, we can only use a criterion of Max-Min Price Asymmetry, like that discovered in (PY 2004) for wheat prices in Medieval England during Maunder Minimum century (1600-1700 years). In that period, all wheat prices in the Maximum state of solar activity were systematically lower than prices in the next Minimal state of sunspot number, as it was expected from our approach for England condition.

To test the Max-Min Price Asymmetry criterion, we examined wheat price variations in the USA in 1908-1993 and marked the moments of sunspot minimum and maximum (Fig. 3).

In the upper chart in Fig. 3 the differences between prices Δ(Price) observed in maximum and succeeding minimum states of solar activity are shown, for every sunspot cycle. The sample mean was estimated as mean(Δ(Price))=0.29 and the mean's standard deviation – as st.dev (Δ(Price))=0.12. This allowed rejecting the one-tailed zero hypothesis about the non-positive mean value of the price difference on a significance level better than 95%.

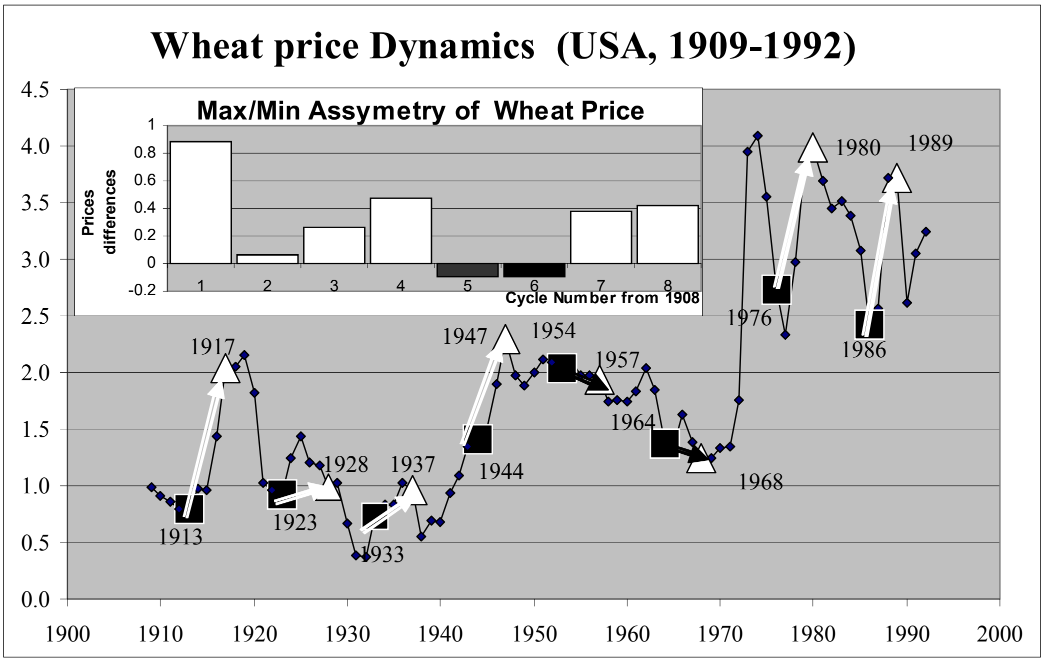

Fig.3. Max-Min Price Asymmetry for the USA wheat prices, 1909 - 1992. X-Axes - years, Y-axis – prices in $US/bushel. White triangles are prices in sunspot maximum states; black squares are prices in sunspot minimum states. Arrows show price transition from state of sunspot minimum to the next sunspot maximum when color of arrow is white for a positive transition (price increases) and black for a negative transition (price falls down).

Thus, it can be accepted that the Max-Min Price Asymmetry for the studied sample does exists. We wish to note that the amplitude and significance of this Asymmetry effect are lower than obtained for the case of the Medieval England wheat prices.

We would like to emphasize here that during the studied period the wheat market was influenced by strong external disturbances caused by political and economic cataclysms: two world wars (1914-1921, 1939-1945) and the Great Depression (1929-1941). The existence of the significant Max-Min Price Asymmetry, in spite of these disturbances and the abovementioned suppression effects of the modern market, could not be expected in advance.

This result can be explained by a relatively compact localization of the wheat production in USA (specifically, durum and other spring wheat) near the risk agriculture zone. For example, about 70% of durum production is placed in the state of North Dakota whose area is less than 2% of the USA territory. Clearly, a high concentration of the crop area in a small region increases sensitivity of wheat production to possible weather abnormalities and among them, to abnormalities caused by space weather.

3. Conclusions

1) The test of the interval distribution of the prices of consumables for Medieval England shows a good consistence with the interval distribution of sunspot Minimum-Minimum. It confirms our conclusion from the previous part of our study (PY 2004) about the manifestation of the influence of solar activity on wheat prices in that period and in this region.

2) The test of the Maximum/Minimum Price Asymmetry for wheat prices in the USA in the 20-th century shows that this effect of the influence of solar activity has place but it is weaker and its significance level is lower than that for Medieval England.

One can place a very sensitive upper limit on the flux of diffuse γrays using the GRAPES-3 experiment. The far-infrared radiation may also have a big impact on the observed γ-ray flux and its energy may come down by about two to three orders of magnitude to (≤0.1 TeV). Thus as a result the diffused γ-ray flux produced by extragalactic cosmic rays would be drastically affected.

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References

L.A.Pustilnik, G.Yom Din, Solar Physics 223: 335–356 (2004)

E.H.P. Brown and S.V. Hopkins, Economica, v. XXIII (89-92): 296-314, (1956)

Rogers, J. E. Thorold, “Agriculture and Prices in England”, Volume I-VIII, Oxford, Clarendon Press, (1887), Reprinted by Kraus Reprint Ltd, 1963, Vaduz

Beveridge W. H. B., Prices and wages in England from the twelfth to the nineteenth century. London ; New York : Longmans, Green (1939)

USDA, 2004, National Agricultural Statistics Service. Prices Received by Farmers: Historic Prices & Indexes 1908-1992 (92152): http://usda.mannlib.cornell.edu/ ,, available 23 July 2004.