

Analysis of a Japan government intervention on the domestic agriculture market

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Abstract

We investigate an economic system in which one large agent—the Japan government changes the environment of numerous smaller agents—the Japan agriculture producers by indirect regulation of prices of agriculture goods. The reason for this intervention was that before the oil crisis in 1974 Japan agriculture production prices exhibited irregular and large amplitude changes. By means of analysis of correlations and a combination of singular spectrum analysis (SSA), principal component analysis (PCA), and time delay phase space construction (TDPSC) we study the influence of the government measures on the domestic piglet prices and production in Japan. We show that the government regulation politics was successful and lead: (i) to a decrease of the nonstationarities and to increase of predictability of the piglet price; (ii) to a coupling of the price and production cycles; and (iii) to increase of determinism of the dynamics of the fluctuations of piglet price around the year average price. The investigated case is an example confirming the thesis that a large agent can change in a significant way the environment of the small agents in complex (economic or financial) systems which can be crucial for their survival or extinction.

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1. Market complexity and government regulation

The growing complexity of the human society increases the difficulties in ensuring its steady economic development. This leads to increasing importance of large social agents such as state central bank or the national government which can influence in a significant way the financial and economic subsystems of the society. Changes of the interest rates, intervention on the exchange markets and subsidies for selected economic branches improve or worsen the environment for the small-size economics and social agents. Below

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we discuss an especially critical issue for the sustainable development of the society namely the development of the large network of economic, ecological and social components called national agricultural system. A sudden decrease of the agriculture production can lead to social tensions. The requirement for steady increase of the food quality and quantity presses entire branches of the agriculture system to move from the natural (due to the climate) regimes of cyclic output to more uncontrollable regimes of chaotic output. Because of the above two reasons the governments try to regulate the market for agriculture goods especially after large crises such as wars or oil shocks [1–3]. Here we shall analyze the results of a such intervention by the methods of the time series analysis (see Ref. [4] and for applications Refs. [5–7]). Together with the methods of the nonlinear dynamics and stochastic analysis the above-mentioned methods are much applied for understanding, description and evaluation of the dynamics of complex economic and social systems [8–11] and in particular in studies of different aspects of the agriculture production such as analysis of the dairy production in the USA [12] or the analysis of the meat production in Japan [13].

With its about 130 million citizens and highly developed economy, Japan is a large consumer of meat but up to about 45 years ago no specialized piglet production farms existed. As the consumption increased in the 1960s this production became lucrative source of money for the farmers and specialized farms for production of piglets and meat arose. Until 1974 there was no massive intervention of the Japanese government on the agriculture market, i.e., less than $\frac{1}{10}$ from the farmers received subsidies from the state. After the oil crisis in 1974 the situation changed significantly and almost all agricultural producers have been included in the subsidies schemes and other farm programs intending to fix the instability of the agriculture markets.

2. Was the Japan government intervention successful?

In order to investigate the consequences of the actions of the large agents often we do not need to analyze the large amount of data normally required by econophysicists for analysis of systems containing many almost identical small-size agents. Here we study the monthly time series for the piglet production and prices in Japan from 1965 to 1992 (i.e., before the recession events in the last decade of previous century). The time series are too short and too nonstationary in order to be investigated by means of the conventional methods of the nonlinear time series analysis such as Lyapunov exponents or generalized dimensions but we can apply another methodology based on singular spectrum analysis (SSA) and principal component analysis (PCA) (see for example Refs. [14–18]). The time series are shown in Fig. 1. The oil crisis from 1974 is located just before the maximum of the price time series. In the period before the crisis the price time series are very nonstationary with a sharp upward trend. The government intervention after the crisis stabilized the price and the seasonal periodicity became more important in comparison to the period before the oil crisis. Such drastic changes are not observed in the time series for the production which shows a trend of increase up to the beginning of 1990s. The autocorrelation function supplies us with additional information. For an example if the time series

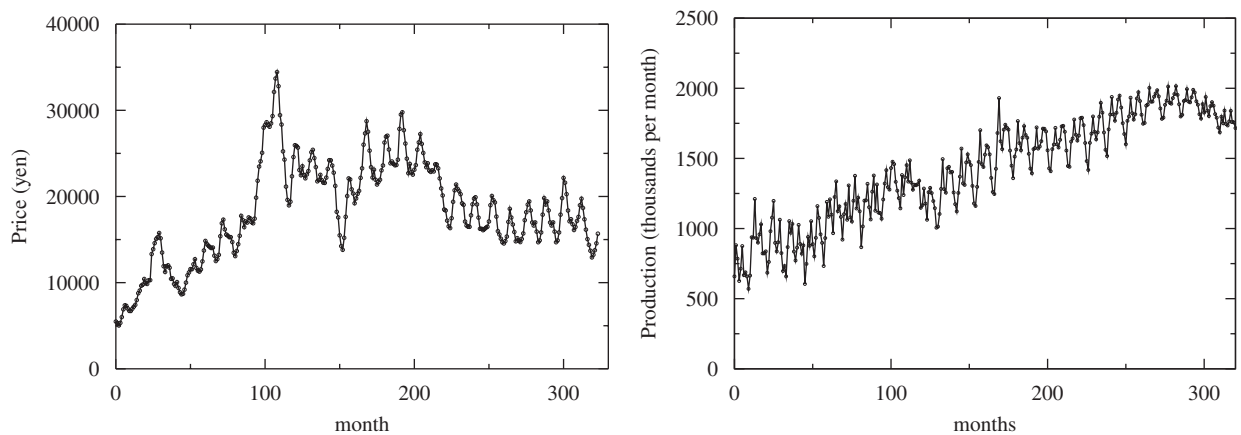


Fig. 1. Piglet prices and production in Japan, 1965–1992.

are correlated and not periodic the autocorrelation function decays slower than exponentially and in presence of long-range correlations we can observe a power-law decay (for more details see for an example Refs. [19–23]). The autocorrelation functions for the production and prices of the piglets in Japan are shown in Figs. 2 and 3. In Fig. 2 we observe slower decay of the autocorrelation function $A(n)$ of the production time series after the oil crisis when compared to the pre-crisis function. Thus after the government intervention the piglets production became more correlated in the time, e.g., more predictable. The government intervention has not influenced significantly the (caused by the specifics of the consumers demand) 6- and 12-month production cycles. Completely different is the situation about the piglet prices. Before the crisis the price correlations decay with increasing n . After the government intervention the strong upward trend is not presented anymore. The dominant process is a 12-month cycle and the minima and maxima of $A(n)$ follow each other in a 6-month tact. Thus the intervention coupled the price and production cycles and the prices became much more predictable.

In combination with the method of delay vector construction [4,24] the SSA can deal successfully with short and nonstationary time series [14–18]. Let us have a time series consisting of N^* values $x(\tau_0), x(2\tau_0), \dots, x(N^*\tau)$ recorded by using fixed time step τ_0 . On the basis of the time series we construct m -dimensional vectors as follows. First we choose the step $\tau = n\tau_0$ and then we construct the vectors $\vec{X}_i = \{x(i\tau_0), x(i\tau_0 + \tau), \dots, x(i\tau_0 + (m-1)\tau)\}$. In such a way by means of the TDPSC (time delay phase space construction) we transform the time series to a set of vectors. We note that the requirements for TDPSC are different from

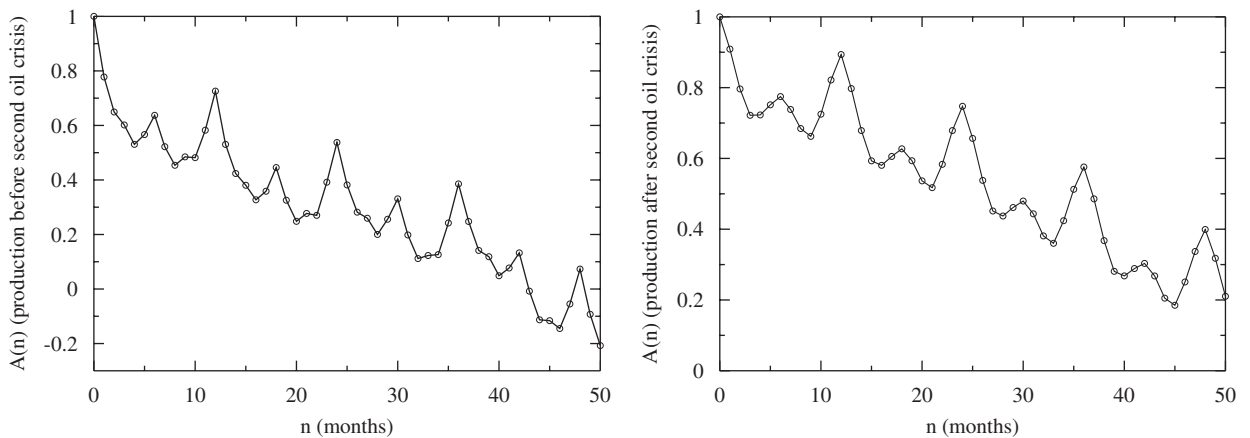


Fig. 2. Autocorrelation functions for the piglet production before (left-hand side) and after (right-hand side) the oil crisis in 1974.

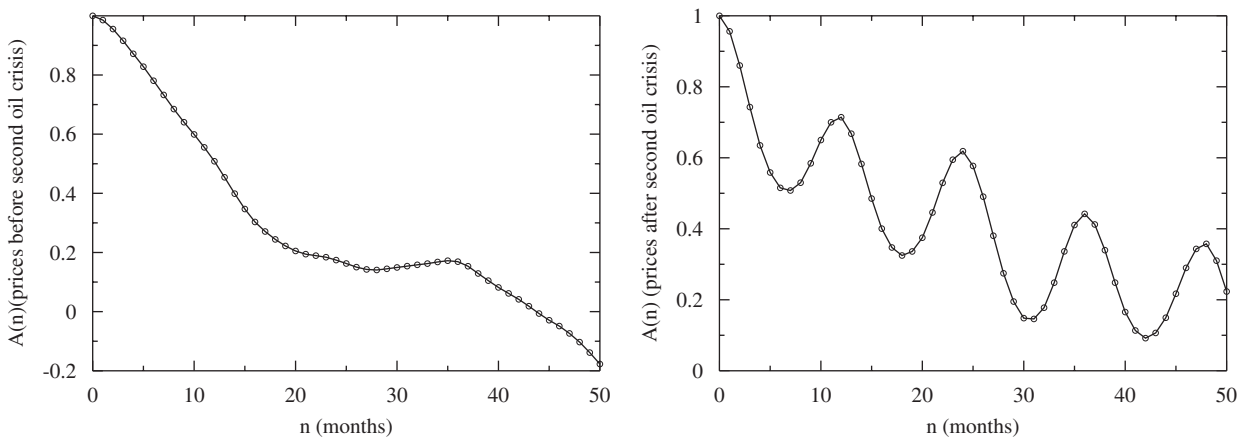


Fig. 3. Autocorrelation functions for the piglet prices before (left-hand side panel) and after (right-hand side panel) the oil crisis in 1974.

the requirements for the time-delay embedding. In TDpsc we have to choose n as small as possible and m must be as large as possible (here $n = 1, m = 30$). By means of the TDpsc vectors we build the trajectory matrix $\mathbf{X} = (1/N^{1/2})[\vec{X}_1^T, \vec{X}_2^T, \dots, \vec{X}_N^T]^T$ as well as the covariance matrix of the trajectory $\mathbf{K} = \mathbf{X}^T \mathbf{X}$. Let \vec{k}_p be the eigenvectors of the last matrix and σ_p are the eigenvalues corresponding to these vectors. The vectors \vec{k}_p form an orthonormal basis in the m -dimensional space of the vectors \vec{X}_i . The matrix \mathbf{X} can be decomposed in the following way: $\mathbf{X} = \mathbf{S}\mathbf{\Sigma}\mathbf{C}^T$ where \mathbf{S} is an $N \times m$ matrix consisting of the eigenvectors of the trajectory matrix [14]. $\mathbf{C} = [\vec{k}_1, \vec{k}_2, \dots, \vec{k}_m]$ is the $m \times m$ orthogonal matrix and $\mathbf{\Sigma} = \text{diag}[\sigma_1, \sigma_2, \dots, \sigma_m]$ is the diagonal matrix constructed by the eigenvalues σ_i called also singular values. These values are nonnegative and the common rule is to number them with respect to their values as follows: $\sigma_1 \geq \sigma_2 \geq \dots \geq \sigma_m \geq 0$. In addition we can decompose the time series $\{x_i\}$ using the eigenvectors \vec{k}_q of the Toeplitz matrix of the time series $x_{i+j} = \sum_{l=1}^m a_l^i k_j^l, 1 \leq j \leq m$. The principal components a_l^i of the time series can be obtained by a projection of the time series on the basis vectors $a_l^i = \sum_{j=1}^m x_{i+j} k_j^l$.

Below we shall extract additional information about the behavior of the piglet prices by application of SSA and PCA to the piglet price time series from which the moving average year trend is subtracted. What remains are the oscillations around the trend and we shall investigate if the dimension of the phase space dynamics of these oscillations decreased as a result of the discussed Japan government intervention. Strong evidence for

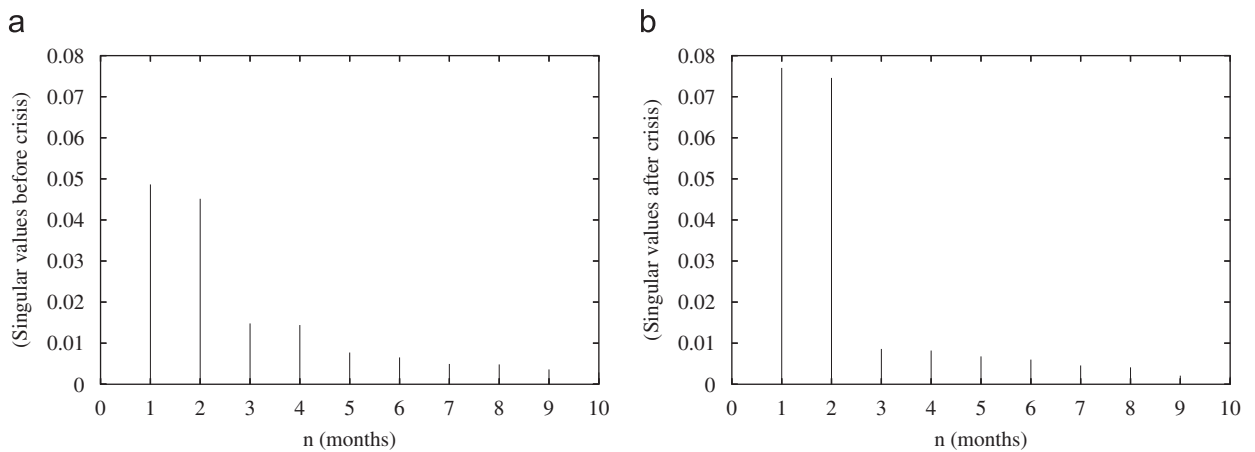


Fig. 4. Singular values for the detrended price time series before (left-hand side panel) and after (right-hand side panel) the crisis.

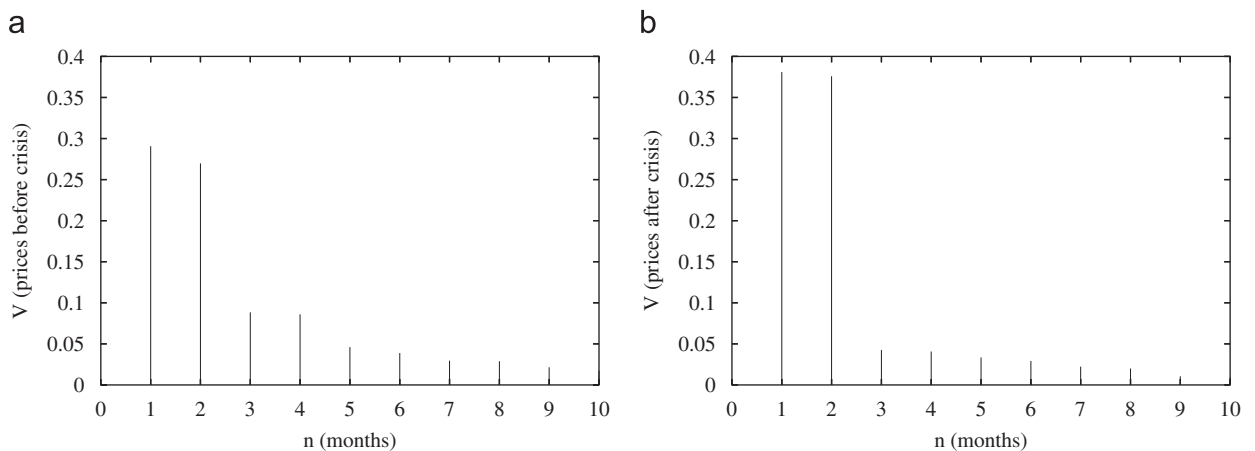


Fig. 5. Variance in the principal components for the detrended time series of the piglet prices before and after the crisis.

such a conclusion is obtained by comparing the singular spectra of the time series as well as the part of total variance of time series contained in the corresponding principal components. These two quantities for the detrended time series before and after the crisis are shown in Figs. 4 and 5. The largest singular values in the singular spectra shown in Fig. 4 are connected to the deterministic part of the time series and the number of the significant components in the singular spectrum (which values are significantly larger than the other singular values) gives us the value of the statistical dimension S which is an upper bound of significant degrees of freedom of the investigated system. The concentration of fluctuation dynamics can be observed in Fig. 4 where we can see the increase of the significance of the first two principal components after the crisis at the expense of the significance of the second two principal components. Additional light on the concentration of the dynamics is given by Fig. 5 where we observe increasing of the percentage of total variance of time series concentrated in the first two principal components after the crisis. We can conclude that the dynamics of the fluctuations is (a) low-dimensional even before the crisis and (b) its dimensionality decreases further after the crisis and the essential part of the dynamics can be captured by an appropriate model containing small number of equations. In order to test the last assumption we plot in Fig. 6 the full detrended time series after the crisis (panel (a)) as well as the time series projected in the subspace of first two principal components (panel (b)) or on the first five principal components (panel (c)). As we can see essential features of the dynamics such as its periodicity are captured already in two-dimensional phase space, whereas the details of the dynamics of the fluctuation can be very well described when the $S = 5$. On the basis of this conclusion in future we shall try to model the fluctuation price dynamics by means of a low-dimensional nonlinear dynamics model.

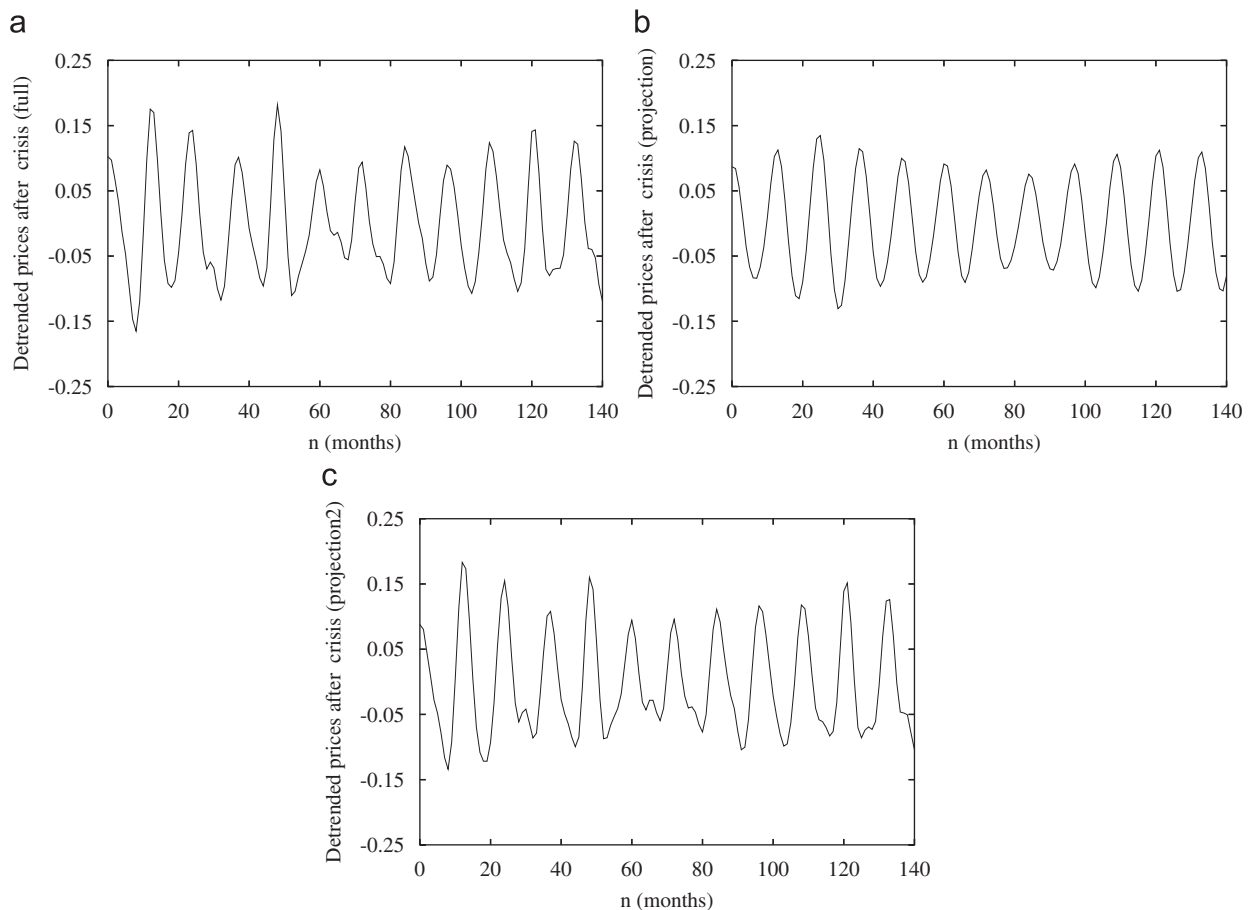


Fig. 6. Time series for the detrended prices after crisis. Panel (a): full time series. Panel (b): projection of the time series on the first two principal components. Panel (c): projection of the time series on the first five principal components.

As a concluding remark we note that in this paper we concentrated our attention on a problem not much investigated up to now by the econophysics which is focused much more on the statistical properties of economic and financial systems containing many similar- (small) size interacting agents. Here we show that the presence of a large agent(s) in such systems can lead to significant changes of the environment of action and interaction of the smaller agents. We have shown that as a result of the Japan government intervention on the agriculture markets after the oil crisis in 1974: (i) the large pre-crisis nonstationarity of the piglet prices was reduced; (ii) the price behavior became cyclic and was coupled to the consumer-driven production cycle and (iii) in addition the dimension of the phase space of the dynamics of price fluctuations around the yearly moving average became smaller as a result of the intervention. The government intervention has made the prices more predictable for the suppliers and for the buyers. Thus we can conclude that with respect to this sub-sector of the Japan agriculture the government intervention was successful.

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