Novel Methods for Observing Economical Circulations

Toshihiro Iwata*

Faculty of Informatics,
Kansai University,
2-1-1 Ryozenji, Takatsuki-City, Osaka, Japan

Most of the time series data about an economy are random. Time series data can be extracted from a moving slope. Source data, or x-y-z plots, rarely show regularity. However, x-z plots show clear regularity. This is exactly the meaning of chaos in the concept of determinism.

1. Introduction

Regression analysis, in which anyone can find similar conclusions, has been used particularly in the field of economics. It is certainly deterministic. It seems that if a determinate coefficient approaches +1, we can be confident in the conclusions of the analysis, but the conclusions of regression analysis are more ambiguous than commonly thought. Indeed, we have faced great difficulties in forecasting business cycles, the price of stocks, and foreign exchange rates.

I would like to begin by describing the meaning of "chaos analysis." In typical chaos research studies, there have been many attempts to show that small changes in initial values or parameters in equations cause the irregular occurrence of unstable or discontinuous phenomena. This study deals with a new type of chaotic analysis in economics. This is a positive approach toward chaotic phenomena, not an abstract approach. The components of complexity and circulations (spectrum and moving slope) coexist.

2. Moving slope as a tool

By taking a moving slope in a stock, we can find the regularity of the stock price fluctuation. The moving slope is a useful tool in cases where it is difficult to find the points of change, such as the peak or bottom in the source data. The moving slope has the nature of substituting differential coefficients, and the next time instant can show in which

*Electronic mail address: yamana@res.kutc.kansai-u.ac.jp.

direction and with how much force a movement occurs.[1] The formula for the moving slope M_t of the term $2P+1$ is

$$M_t = \frac{-PX_{t-p} - \cdots - 2X_{t-2} - 1X_{t-1} + 1X_{t+1} + 2X_{t+2} + \cdots + PX_{t+p}}{\frac{P(P+1)(2P+1)}{3}}.$$

For example, the moving slope M_t of the fifth term here can be expressed as

$$M_t = \frac{-2X_{t-2} - 1X_{t-1} + 1X_{t+1} + 2X_{t+2}}{10}.$$

3. On the complexity and the circulation

All stock prices are random, irregularly occurring, unstable complex curves that have been shown to be sets of simple sine or cosine waves.

The curve in Figure 1 increased and decreased rapidly with time. Most economic time series data are random. Accordingly, the forecasts are apt to depend on the subjectivity of the analyst or economist.[2] When the three-dimensional figure that we will observe in section 4 shows regularities, such as a buy time cycle change in this moving slope, the forecast of the quality near $1/f$ is better than others.[3] Our forecast from these two analyses is completely original. For Fourier analysis, spectrum graphs similar to that in Figure 1 are generated by fast Fourier transformations.

Figure 2 shows the stock price of Sony. The y-axis shows the logarithm of the power spectrum, and the x-axis shows the logarithm of the frequency. The power is the square of the amplitude. Many frequencies are present in the spectrum shown in Figure 3, and there is no specific dominant frequency. This figure plots Sony's stock price after moving slope analysis, which shows the regularity (particularly circulations). Many frequencies make collective circulation. It is a complicated motion but is confined within "circulations." This is the essential point. We can find regularity in the chaos from the same data. Here we can observe two components:

$$\begin{matrix}\text{Complexity} \\ \langle\text{Unpredictable factor}\rangle\end{matrix} \Longleftrightarrow \begin{matrix}\text{Circulation} \\ \langle\text{Limited motion (Predictable factor)}\rangle\end{matrix}$$

[1] We should note that Gregg, Hossell, and Richardson [1] proposed the calculation of the moving slope first. But they and Howard [2] were interested in the trend line on plots of the moving slope only.

[2] Moore [3] showed the random data.

[3] A clear statement of the spectrum analysis, particularly for economic data, is given by Iwata in [4].

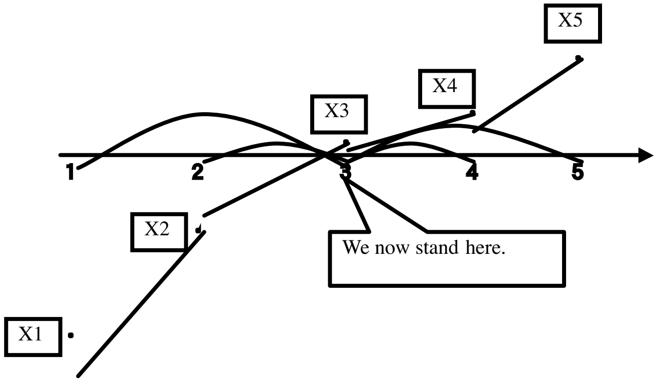


Figure 1. Structure of moving slope • denotes the original data.

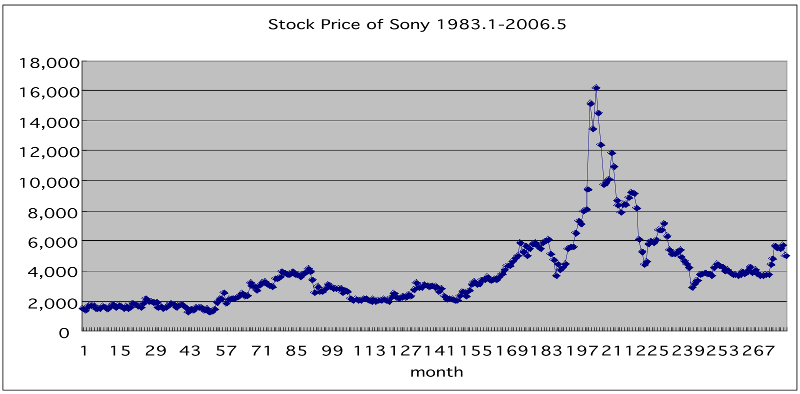


Figure 2. Time series of stock price.

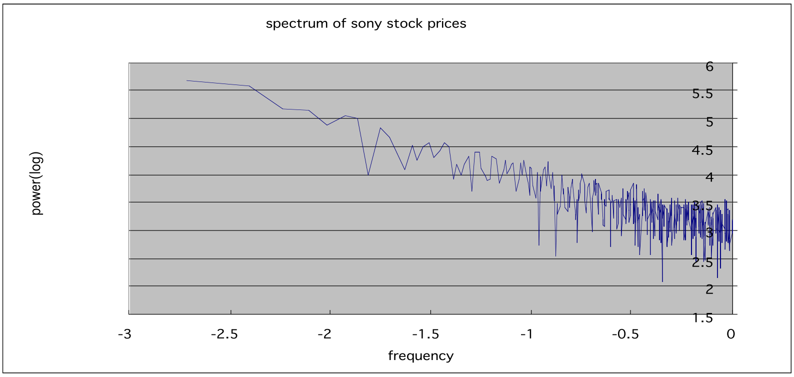


Figure 3. Spectrum graphs of stock price.

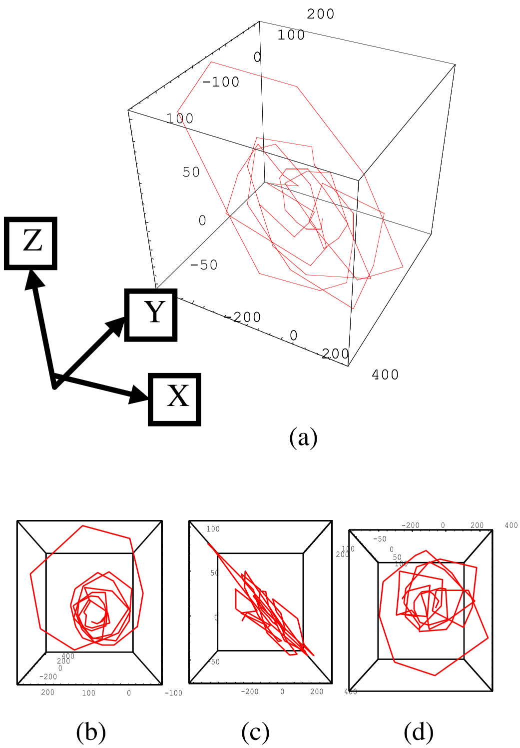


Figure 4. Plots of the DJIA, (a) x-y-z, (b) x-y, (c) x-z, (d) y-z.

4. The impacts of three-dimensional figures

The Dow Jones Industrial Average (DJIA) shows a turn to a peak and a bottom every four to six months. In Figures 4 through 6, the x-axis is the moving slope obtained the first time, the y-axis is that obtained the second time (square), the z-axis is obtained the third time (cube). These three slopes are projected to make the three-dimensional plot. We can recognize the feature of fluctuation in this figure, especially in the x-z plots where we are able to observe thin slant-shaped plots.

From the model solution and x-y, y-z, and x-z plots, we can find a thin film structure for the x-z plots. On the source data, or the x-y-z plots, negligible regularity is observed. However, on the x-z plots we are able to observe the regularity clearly.

In the average stock price of Japan's stock market, dark clouds have hung low these past ten years. However, we can recognize characteristics similar to those of the DJIA. By repeatedly taking the moving slope, we can see a slight change in x-z plots which implies a large change in source data.

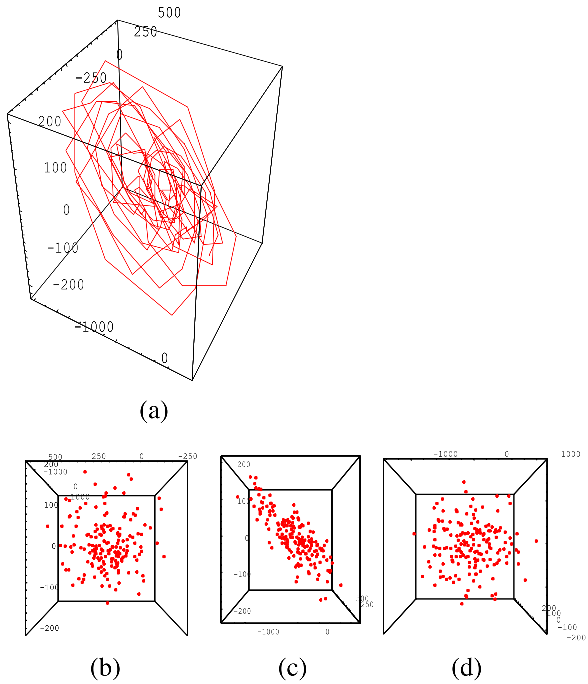


Figure 5. Plots of Japan's stock market average, (a) x-y-z, (b) x-y, (c) x-z, (d) y-z.

The data structure is ordered to a high dimension, and we are able to observe the same basic slopes in Figures 4 through 6.

In calculating the moving slope repeatedly, the value of the slope becomes smaller (step by step $\ldots M_1 \cdot M_2 \cdot M_3 \cdot M_4 \ldots$), and this simple shaped curve is elliptical (Figure 7). In complexity, the simple moving slope furthers possible applications. Eventually, every time series data point can be extracted from the moving slope. If we can observe regularity, it is exactly the chaos in the concept of determinism.

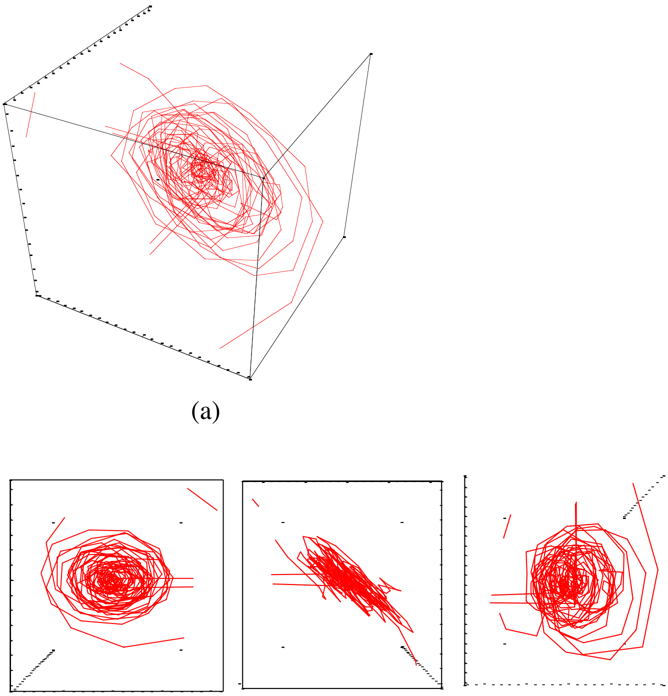
5. Model solution and *x-y*, *y-z*, and *x-z* plots

There are rules for the thin slant-shaped plots. Let us consider the functions

$$f(x) = A \sin k_x f'(x) = A_k \cos k_x$$
$$f''(x) = -Ak^2 \sin k_x$$
$$f'''(x) = -A_k 3 \cos k_x$$

for $0 < k < 1$, where k is a fixed number and A is the amplitude.

In this case, with the repetition of differentiation, a reduction in the number and parity of the x-z plot arises. We consider the next model



(a)

(b) (c) (d)

Figure 6. Plots of foreign exchange rate (Yen/Dollar), (a) x-y-z, (b) x-y, (c) x-z, (d) y-z.

function (at $k_1 < k_2 < \cdots < k_n \cdots < 1$)

$$T(t) = A_1 \sin(k_1 t - j_1) + A_2 \sin(k_2 t - j_2) \ldots + A_n \sin(k_n t - j_n) \ldots$$

so we can propose the next general solution

$$u(t) = A_1 \sin(k_1 t - j_1) + A_2 \sin(k_2 t - j_2) \cdots + A_n \sin(k_n t - j_n) + \ldots,$$

where j_n is fixed. The most essential point is that this solution is based on the fact that the j component does not markedly depend on time. Thus, how can we forecast objectively? In a one-dimensional phase diagram,[4] the ordinate is the original data of the time series X, or its moving average, and the abscissa is its moving slope (Figure 8). The moving slope M_t can take the place of dX/dt. In the cases where the moving slopes are positive, X increases. If M_t is just out on the right and subsequently changes in direction to the left (we can see these points),

[4]Turning points are one of the most important things in the forecast of economic analysis. In Saito [5] moving slopes are used to identify business cycle peaks and bottoms.

these points indicate the chances to buy and sell, respectively.[5] The arrows in Figures 8 indicate the points.

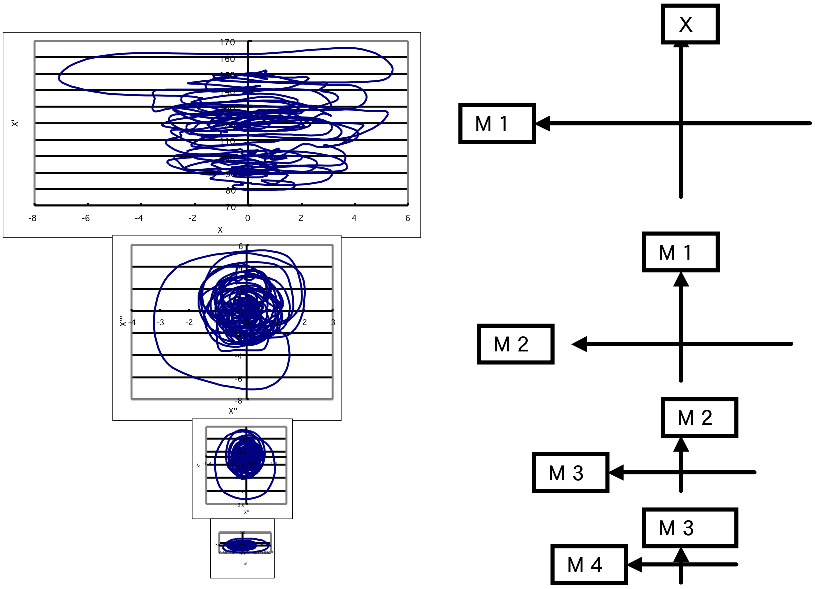


Figure 7. Repeatedly obtained moving slope.

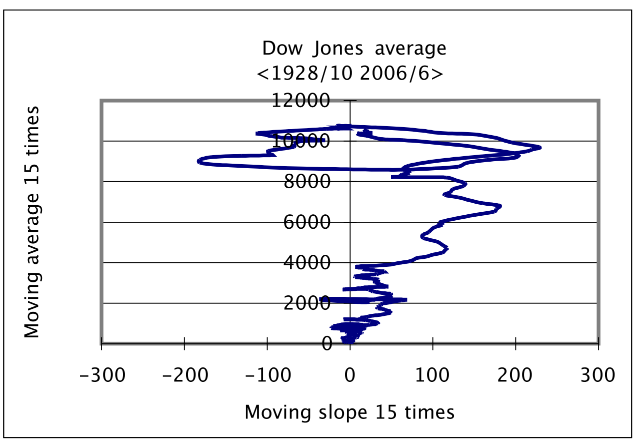


Figure 8. Point of forecast on a one-dimensional phase diagram.

[5]A representative sample of the turning points on the stock market can be found in Iwata [6].

6. Summary and perspective

The complicated evolution of an economic system or stock market appears to be circulating in a limited finite box that appears to have some rules. Our opinion is that such limited circulation and complexity are highly correlated, and we are able to raise the accuracy of the forecast of time series data.

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[4] Toshihiro Iwata, "The Spectrum Analysis of Random Economic Wave Motion," *Kansai University Journal of Informatics*, (2005) 14–20.

[5] Saito Kiyoshi, "A Statistical Technique to Identify Business Cycle Turning Points," *The Economic Review of Kumamotogakuen*, **5**(1) (1998) 23–40.

[6] Toshihiro Iwata, "A New Method of Forecast on the Turning Points," *The Kansai University Business Review*, **47**(5) (2002) 1–21.