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The mechanism of double-exponential growth in hyper-inflation

T. Mizuno^{a,*}, M. Takayasu^b, H. Takayasu^c

^a*Department of Physics, Faculty of Science and Engineering, Chuo University, Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan*

^b*Department of Complex Systems, Future University-Hakodate, 116-2 Kameda-Nakano-cho, Hakodate, Hokkaido 041-8655, Japan*

^c*Sony Computer Science Laboratories Inc., 3-14-13 Higashigotanda, Shinagawa-ku, Tokyo 141-0022, Japan*

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Abstract

Analyzing historical data of price indices, we find an extraordinary growth phenomenon in several examples of hyper-inflation in which, price changes are approximated nicely by double-exponential functions of time. In order to explain such behavior we introduce the general coarse-graining technique in physics, the Monte Carlo renormalization group method, to the price dynamics. Starting from a microscopic stochastic equation describing dealers' actions in open markets, we obtain a macroscopic noiseless equation of price consistent with the observation. The effect of auto-catalytic shortening of characteristic time caused by mob psychology is shown to be responsible for the double-exponential behavior. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

In ordinary markets prices fluctuate up and down fairly randomly as typically observed in foreign exchange markets or in stock markets. Inflation is the special economic situation in which prices apparently move monotonically upward and the value of money decreases rapidly. There are many examples of inflation not only in the

* Corresponding author.

E-mail address: mizuno@phys.chuo-u.ac.jp (T. Mizuno).

history [1] but even now some countries are facing with the fear of inflation. Especially the so-called hyper-inflation is a kind of breakdown of currency system devastating the whole society. Detection of hyper-inflation in its early stage might contribute to avoid the tragedy; however, no such tool exists at present as the scientific description of inflation has not been established yet.

2. Empirical laws of inflation

The worst inflation in the history occurred in Hungary right after the world war II. The exchange rate of 1 US dollar was about 100 Pengo in the beginning of July 1945. After 1 year, the exchange rate became 6×10^{24} Pengo in the middle of July 1946. Here, the inflation rate estimated by exchange rate difference is of order of 10^{22} per year. This terrible inflation was stopped by the introduction of the present Hungarian currency Forint in July 1946 which was exchangeable with Pengo with the exchange rate 1 Forint = 4×10^{29} Pengo, which exceeds the symbol of large numbers, the Avogadro number, 6×10^{23} .

The time evolution of exchange rate of US dollar during this period is shown in Fig. 1 in semi-log scale. As known from this figure the exchange rate grew exponentially until $t = 220$ days measuring from 1 July 1945, and after that the growth became obviously faster than an exponential function. At that time, government of Hungary introduced a new unit of currency called the Adopengo. During the hyper-inflation, these two currencies, Pengo and Adopengo, coexisted in the market. The utility value of the Pengo was decreased by the appearance of the new currency. We guess that the state of two currencies enhanced the decline of Pengo. In Fig. 2 the exchange rates for $t > 220$ are re-plotted in double-logarithmic scale. The points are clearly on a straight line, demonstrating that the rapid growth is nicely approximated by a double-exponential function.

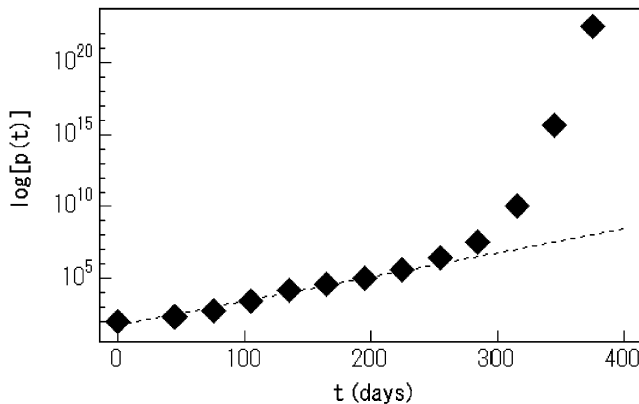


Fig. 1. Semi-log plot of exchange rates of Pengo for 1 US dollar. The origin of the time axis is July 1 1945. The straight line shows an exponential growth fitted for $t < 220$.

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