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Procedia Computer Science 122 (2017) 1182–1188

Procedia Computer Science

www.elsevier.com/locate/procedia

Information Technology and Quantitative Management (ITQM 2017)

Hawkes processes for forecasting currency crashes: Evidence from Russia

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Abstract

We consider models for predicting shocks in a foreign exchange market that take into account the endogenous nature of such crashes on the basis of the Hawkes processes. The intensity of the Hawkes processes depends on previous events that allow modeling the clustering effect and self-exciting behavior of returns after the crash. The models were tested on the USD/RUB currency pair.

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Peer-review under responsibility of the scientific committee of the 5th International Conference on Information Technology and Quantitative Management, ITQM 2017.

Keywords: Currency crash risk ; foreign exchange market; Hawkes processes

1. Introduction

A drastic change (usually a decline) in a short time of nominal exchange rate is a currency crash. These crashes can be caused by exogenous and endogenous events. The foreign exchange market is sensitive to financial, political, social changes in the country and in the world, so the currency crash can be caused by exogenous (non-economic) reasons such as wars, natural disasters, political actions, for example, embargo, etc. Usually such exogenous events are not predictable, but they can have a strong impact on the foreign exchange market.

Also foreign exchange market is endogenously unstable due to:

- the great complexity of the system as foreign exchange market is a complex socio-economic system with large number of participants and their heterogeneity (by characteristics, goals, opportunities, information, etc.) and high speed of interaction between traders,
- the possible irrationality of some traders as decision making persons are not always rational, often make decisions under the influence of emotions, etc. It is known that many traders do not have the ability of

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1877-0509 © 2017 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the scientific committee of the 5th International Conference on Information Technology and Quantitative Management, ITQM 2017.
10.1016/j.procs.2017.11.490

correctly predicting the direction of price movements on the stock exchange [1; 2], and the proportion of correct forecasts often does not reach 50% even among financial analysts [3; 4],

- herding behavior that create a speculative bubble, when traders realize that prices are deviating too much from reasonable values and still continue to trade following others' behavior [5; 6].

Although a currency crash may be caused by an exogenous factor, the instability of the foreign exchange market is much more determined by endogenous reasons. Therefore it is necessary to model self-exciting investors' behavior when the actions of some participants induce other market participants to act. This type of self-excitation is naturally observed in the seismic region when a sequence of weak tremors can cause a stronger earthquake, which in turn can generate new shocks, and so on. Analogously herding behavior in the stock market and in the foreign exchange market leads to the self-exciting nature of crashes.

In this paper we use the Epidemic-type Aftershock Sequence model to describe and model the currency crashes of both exogenous and endogenous nature on the currency pair USD/RUB. The ETAS model was developed in 1988 to predict earthquakes in Japan [7] and was successfully applied to financial data, for example, for modeling the duration between trades [8], several stock indices [9], as well as to assess the level of crime [10] and the spread of red banana plants [11]. We analyze the efficiency of the model using the Hanssen-Kuiper Skill Score [12]. It seems that our model based on self-excited behavior of currency rate returns is able to predict some currency crashes in the medium term.

Structure of the paper. Section 2 is devoted to the description of ETAS model, Section 3 contains estimation results of the model of USD/RUB currency rate and Section 4 concludes.

2. ETAS model description

We consider a point process that represents a time series of occurrences of certain events, i.e. the decline of currency rate returns below the certain threshold. Let us denote a point process describing the history of events occurrence as a sequence $H_t = \{(t_i, m_i)\}_{i\in N^*}, N^* = N \cup \{0\}$, in which t_i defines the time and m_i defines the depth of decline, and a point process $N(t) = N_t = \sum_{i\in N^*} 1_{\{t_i<t\}}$ as a counting process with intensity

$$\lambda(t \mid H_t) = \lim_{\Delta t\to 0} E\left[\frac{N(t+\Delta t) - N(t)}{\Delta t} \mid H_t\right]. \tag{1}$$

The intensity of the Hawkes process increases when the new event occurs and then the intensity decreases to the base level, so intensity can be expressed as

$$\lambda(t) = \lambda_0(t) + \sum_{t_i<t} v(t - t_i), \tag{2}$$

where a function $\lambda_0 : R \to R_+$ is the base intensity, a function $v : R_+ \to R_+$ reflects the impact of past events t_i on the current intensity $\lambda(t)$. A function $\lambda_0(t)$ corresponds to the intensity of external events and a kernel function $v(t)$ gives a clustering effect of endogenously generated events.

Such processes were firstly developed in [13] for one-dimensional case $H_t = \{(t_i)\}_{i\in N^*}$ and an exponential kernel function $v(t) = \sum_{i=1}^{P} \alpha_i e^{-\beta_i t}$. In the simplest case with constant base intensity $\lambda_0(t) = \lambda_0$ the intensity of the Hawkes process is given by

$$\lambda(t) = \lambda_0 + \int_{-\infty}^{t} \alpha e^{-\beta(t-s)} dN_s = \ddot{\lambda}_0 + \sum_{t_i<t} \alpha e^{-\beta(t-t_i)}. \tag{3}$$

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