Available online at www.sciencedirect.com
ScienceDirect
Information Sciences 178 (2008) 1923–1934
INFORMATION SCIENCES
AN INTERNATIONAL JOURNAL
www.elsevier.com/locate/ins

A currency crisis and its perception with fuzzy *C*-means

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Received 19 October 2005; received in revised form 13 December 2007; accepted 15 December 2007

Abstract

In this paper, we attempt to analyze currency crises within the decision theory framework. In this regard, we employ fuzzy system modeling with fuzzy *C*-means (FCM) clustering to develop perception based decision matrix. We try to build a prescriptive model in order to determine the best approximate reasoning schemas. We use the underlying behavior of the market participants during the crisis. With this analysis, we form the dictionary catalogs to construct a perception based payoff matrix. As an illustrative example, we used data from Turkish economy that covers two currency crises. The results show that market participants' dictionary catalogs based on perception knowledge extracted from the first crisis help participants to perceive the rise in market uncertainty. When the expectations are revised accordingly a speculative attack becomes inevitable.

Keywords: Currency crises; Fuzzy system modeling; Perception based decision making

1. Introduction

Since the early 1970s, the world economy witnessed an increase in frequency and severity of currency crises originated from industrial as well as from developing countries. Each passing crisis increased the variety and the frequency of currency crises and hence generated a plethora of theoretical models. In spite of their many insightful contributions, these theoretical models of currency crises cannot be considered fully successful in determining the causes and the timing of currency crises.[1] In historical perspective, the dynamics of currency crises appears to be elusive due to the evolutionary nature of the market participants.

While it is already difficult to understand and predict daily fluctuations in foreign exchange markets, currency crises understandably present additional difficulties. The difficulties lie in the very nature of the crises. By

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[1] For seminal contributions, see: [25,28], for the evaluation and classification of the currency crises see [12,22].

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doi:10.1016/j.ins.2007.12.007

definition, crises' periods are "times of turbulence and excessive volatility". Hence the models developed to explain market behavior under ordinary periods may not serve well during those chaotic times.

One may choose to refine the existing models and gather more data to increase the explanatory and predictive power of the current theoretical and empirical models of currency crisis. On the other hand, one may choose to develop newer models with the help of emerging data analysis techniques. This paper in conjunction with our previous work [30] can be considered examples of such attempts. Also, an application of support vector machines to determine the most significant factors in explaining the consequences of currency crises on the economy [32] can be considered as similar example of the usage of new data analysis technique.

A particularly important aspect of FSM is its power to capture underlying behavior of historical data with proper analysis and without excessive ad hoc axioms. There are at least two advantages of FSM that attracts researchers: (i) its power of linguistic explanation with resulting ease of understanding, and (ii) its tolerance to imprecise data which provides flexibility and stability for prediction. Because of these features, FSM has been increasingly applied to problems in various areas such as computer science, system analysis, electronic engineering, pharmacology, finance and more recently social sciences (some related examples are [41,39,34,33]). To our knowledge this paper represents the first attempt to analyze currency crisis within a decision theory with an application of FSM framework. To be more precise, in our analysis of currency crises, we adopt Zadeh's perception based decision approach [45] with an application of the rule based fuzzy system modeling. Accordingly, we attempt to capture the underlying behavior of market participants during the crisis as part of perceptions. Then we analyze how a payoff matrix can be constructed by integrating these perceptions.

The rest of the paper is organized in four sections. In Section 2 we explain why we choose to use FSM to investigate currency crises. In Section 3, we obtained dictionary catalogs (fuzzy clusters) by using FSM with FCM using Turkish data from 1990 to 2002 which covers two currency crises. This section also includes the results of the model and payoff matrix construction. In Section 4 we present our conclusions.

2. Perception based decision making

In modeling human decision process, one may distinguish the descriptive and prescriptive type approaches. In these approaches, descriptive modeling attempts to identify system structure that capture the behavior characteristics as best as it can, where as the prescriptive modeling attempts to determine the best approximate reasoning schemas that produce the best prediction of system behavior for a given descriptive model.[2] In the first phase of this work, we developed a Type 1 fuzzy system model to predict the currency crisis [30,29]. In order to predict the currency crisis, publicly available data are used. A brief review that includes only the fuzzy system modeling part of this modeling is given in the next section. As a next step, we analyze the currency crisis within the decision theory as explained in this paper.

Human decision processes depend on the perceived world. At any instance of a decision process, a decision maker faces uncertainties. For instance, since the return on financial assets cannot be known with certainty investment decisions are taken under uncertainty, because it is difficult to assign objective probability values for possible outcomes.

Observed values of economic indicators may provide insights to investors and help them to form their expectations. According to mainstream theoretical economics, rational individuals use all available information during the expectation formation process and they optimize the expected value of a well defined objective function under the assumptions of von Neumann and Morgenstern's expected utility theory [27]. Then a decision becomes a mechanical action without emotions. Basic assumptions of von Neumann and Morgenstern's theory may not be fulfilled since most real world probabilities are not precise and measurable. Even if it is the measurable case, when there is a tolerance for imprecision which can be exploited through granulation to achieve tractability, interpretability, robustness and economy of communication, there is a rationale which underlie granulation of attributes and use of linguistic variables [17,47]. Furthermore, uncertainty may appear

[2] See [2, Chapter 2] for a clear exposition of descriptive and prescriptive modeling in decision making.