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Currency crises and the evolution of foreign exchange market: Evidence from minimum spanning tree

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ABSTRACT

We examined the time series properties of the foreign exchange market for 1990–2008 in relation to the history of the currency crises using the minimum spanning tree (MST) approach and made several meaningful observations about the MST of currencies. First, around currency crises, the mean correlation coefficient between currencies decreased whereas the normalized tree length increased. The mean correlation coefficient dropped dramatically passing through the Asian crisis and remained at the lowered level after that. Second, the Euro and the US dollar showed a strong negative correlation after 1997, implying that the prices of the two currencies moved in opposite directions. Third, we observed that Asian countries and Latin American countries moved away from the cluster center (USA) passing through the Asian crisis and Argentine crisis, respectively.

1. Introduction

During the past decade, the application of statistical physics and complexity to financial market data has attracted much interest. Network analysis, in particular, has been playing a leading role among the related techniques because the representation of a financial market as a network topology provides efficient ways of understanding its structural properties [1–4]. In the stock exchange market, stock networks generated by trading activity represent the similarities between stocks and have significant implications for portfolio optimization [5,6].

Several attempts have also been made to apply network theory to the analysis of the foreign exchange market. Mizuno et al. [7] analyzed foreign exchange market data and derived a hierarchical taxonomy of currencies constructing a minimum spanning tree (MST). The identified currency clusters matched nicely with the corresponding countries' geographical regions around the world. McDonald et al. [8] developed a network analysis of currency correlations in the foreign exchange market using the MST approach, and showed that global foreign exchange dynamics such as dominant and dependent currency structures can be found in MSTs.

However, previous research into the foreign exchange market has shed little light on the time series properties of currency networks for currency crises. It is important to examine the time series properties of currency networks because network shapes vary as time goes on. Whether the time series have typical properties in response to currency crises is also a serious question.

In this paper, our particular interest lies in the application of network theory to the analysis of the foreign exchange market. We examine the network properties of the market and interpret the network topology in financial terms. Analysis of the time series properties of currency networks in relation to the history of currency crises is the goal of this paper.

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Table 1
Countries and respective symbols.

Continent	Country	Symbol	Continent	Country	Symbol
Africa	Egypt	EGY	Europe	Poland	POL
	Nigeria	NGR		Portugal	POR
	South Africa	RSA		Russia	RUS
Asia	China	CHN		Spain	ESP
	Chinese Taipei	TPE		Sweden	SWE
	Hong Kong	HKG		Switzerland	SUI
	India	IND		Turkey	TUR
	Indonesia	INA		United Kingdom	GBR
	Japan	JPN	Middle East	Bahrain	BRN
	Korea (Rep. of)	KOR		Israel	ISR
	Malaysia	MAS		Jordan	JOR
	Philippines	PHI		Kuwait	KUW
	Singapore	SIN		Lebanon	LIB
	Sri Lanka	LKA		Qatar	QAT
	Thailand	THA		Saudi Arabia	KSA
Europe	Austria	AUT		United Arab Emirates	UAE
	Belgium	BEL	North America	Canada	CAN
	Czech Rep.	CZE		Mexico	MEX
	Denmark	DEN		United States	USA
	Euro	EUR	Pacific Ocean	Australia	AUS
	Finland	FIN		New Zealand	NZL
	France	FRA	South America	Argentina	ARG
	Germany	GER		Bolivia	BOL
	Greece	GRE		Brazil	BRA
	Hungary	HUN		Chile	CHI
	Iceland	ISL		Colombia	COL
	Ireland	IRL		Ecuador	ECU
	Italy	ITA		Peru	PER
	Luxembourg	LUX		Uruguay	URU
	Netherlands	NED		Venezuela	VEN
	Norway	NOR			

The remainder of the paper is organized as follows. In Section 2, we present our data set and discuss some of its specific aspects. In Section 3 we describe the methods that we use to construct the MST derived from the entire sample of data. In Section 4 we present the results obtained from analysis of the data set, and in Section 5 we draw our conclusions.

2. Data

We analyze the foreign exchange rate of 61 countries from January 1990 to December 2008. The data consist of daily closing prices provided by Thomson DataStream. The 61 countries in our study and the respective currency symbols are presented in Table 1.

The foreign exchange rate between two currencies specifies how much one currency is worth in terms of the other and is generally stated in relation to the US dollar. As this feature excludes the US dollar from the currency network, Mizuno et al. [7] suggested that a precious metal such as gold, silver, or platinum should be used as the basis of exchange rate. However, the result could be seriously affected by the variances of the prices of these metals.

To include the US dollar and prevent exogenous factors from affecting the currency network, we base it on Special Drawing Right (SDR), which is a potential claim on the freely usable currencies of International Monetary Fund (IMF) members. The value of the SDR is the combined value of a basket of major currencies used in international trade and finance. At present, the basket consists of the US dollar, the Euro, the Japanese yen, and the pound sterling. For 2006–2010, one SDR was the sum of 0.6320 US Dollars, 0.4100 Euro, 18.4000 Japanese yen and 0.0903 pound sterling. The currency proportions of 1 SDR are 0.44(USD), 0.34(EUR), 0.11(JPY) and 0.11(GBP) approximately. As the relative value of each currency varies, the SDR value continuously fluctuates. The latest value of the SDR in terms of the US dollar is available from the IMF and is updated daily.

The exchange rate of a currency for dollars can be converted into the exchange rate for SDRs by multiplying the exchange rate for SDRs by dollars. The daily exchange rate of each country's currency for SDRs is used as basic data in this study.

We examine changes in the properties of the currency network caused by currency crises. To compile a list of currency crises, we referenced and updated Kaminsky and Reinhart [9] and Didier et al. [10]. These studies used a weighted average of exchange-rate changes as an index of currency market turbulence and reserve changes in the spirit of Eichengreen et al. [11]. The chronology of currency crises after 1990 is summarized in Table 2.

Currency crises became common in the 1990s when the neoliberal ideology shaped the globalized financial capitalism environment. We experienced the European exchange rate mechanism (ERM) crisis in 1992 through 1993, the Mexican peso crisis in 1994, the Asian currency crisis in 1997, and the Russian ruble crisis in 1998, and the Argentine crisis in 2001, to name