MATHEMATICAL MODELING OF THE DISSEMINATION PHENOMENON CONCERNING THE CURRENCY CRISIS OF SUOTH-EASY ASIA

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Abstract:
The coincidence of speculative crisis within more devel oping economies has become more and more an emphasizing phenomenon, being analyzed by specialty literature. The way of inflationary tensions taken over the Thailand's baht currency in 1997, which has lead fast to theoretical tensions over some other curren cies, by using a basic mathematical model of the currency's crisis, is analyzed within this paper.

Keywords: mathematical model, inflationary , the currency crisis, probability, inflationary

Jel classification: C02, C20

1. INTRODUCTION

The currency crisis that occurred in Mexico (1994–1995) and expanded towards other countries of Latin America, but considering also the crisis of Thailand (1997 –1998), which extended to neighbor countries (Indonesia, Malaysia, Philippines and even towards countries havi ng strong economies, as Hong Kong, Singapore and Korea) have determined the occurrence of a new concept within specialty literature: the contagion. The models of contagion accomplished during time have based upon certain currency's crisis model, built by M asson (1998). These currency crisis have generated powerful tensions over the exchange rates and prices of assets concerning other developing countries' markets.

The model includes two states in progress of development. The external environment (particularly represented by the rate of interest on industrialized countries r^*) is assumed to be known. Firstly, the model takes into consideration the first country. An external debt „ D", expressed by national currency, is assumed of existing and for this, a vari able interest is paid; but for its facilitating, it is considered that no other net capital flows exist. A crisis is started at a certain moment of time, with authorities financing any shorts (or overs) of present account, determining in this way several changes at the reserves level. The uncertainty source is represented by the breakdowns over the trading balance „ T". If these are strong enough in order to determine a decrease *"t"* of R_t reserves under the critical level $\bar{R}$ to certain moment of time, then depreciation will take place. If S_t represents the spot rate of exchange at „ t" moment of time (the price of currency), and S_{t+1}^d its value within the following duration of potential depreciation (otherwise, one might meet $S_t = S_{t+1}$), then as concerns the bonds of national currency, the ex -ante profit per asset will be calculated according to relation:

$$M_t\left[\ln\left(\frac{1+r_t}{\frac{S_{t+1}}{S_t}}\right)\right] \sqcup r_t - \pi_t \ln\left(\frac{S_{t+1}^d}{S_t}\right) - (1-\pi_t)\ln(1+\delta) = r_t - \pi_t \ln(1+\delta) \sqcup r_t - \pi_t\delta,$$

where π_t represents the probability of depreciation occurre nce, „δ" the percentage size of expected depreciation.

Forwards, the probability of a crisis occurrence might be noticed as being influenced by those expectations that lead towards multiple equilibria, also.

The changes arisen at reserves level will be therefore calculated in accordance to relation:

$$R_{t+1} - R_t = T_{t+1} - (r^* + \pi_t \delta)D, \quad (1)$$

where r^* signifies the rate of exchange without risk

At the moment $t + 1$, a crisis will occur, if:

$$R_{t+1} - \bar{R} < 0. \quad (2)$$

Considering the relations (1) and (2), it results that probability, calculated at moment „*t*", of a currency crisis at moment $t + 1$, will therefore become:

$$\pi_t = \mathrm{P}_t[T_{t+1} - (r^* + \pi_t \delta)D + R_t - \bar{R} < 0]. \quad (3)$$

Using the notations

$$b_t = T_t - r^*D + R_{t-1} - \bar{R}, \ \alpha = \delta D \ \text{şi} \ \Phi_t = \mathrm{M}_t(b_{t+1}),$$

and replacing them in relation (3), it results:

$$\pi_t = \mathrm{P}_t(T_{t+1} - r^*D + R_t - \bar{R} < \pi_t \delta D) = \mathrm{P}_t(b_{t+1} < \alpha \pi_t). \quad (4)$$

The existence of multiple equilibria depends upon the values of variables α and Φ_t. It is assumed that the variation of b_t variable given by $\varepsilon_t = b_t - \Phi_{t-1}$ has a normal distribution, with zero average and variance σ^2. Expressing the probability π_t by considering the cumulative distribution terms and depending upon variation of b_t, the following can be written:

$$\pi_t = F_\sigma(\alpha \pi_t - \Phi_t), \quad (5)$$

where F_σ represents the cumulative distribution function of a normal distribution of variance σ^2. The relation (5) defines the forming of expectations by the investors. A necessary condition for multiple equilibria existence would be as:

$$z = \frac{\alpha}{\sqrt{2\pi}\sigma} > 1.$$

This can be considered as an imposed condition over the external debt level, and also over increasing the indebtness in case of a crisis.

The interval for multiple equilibria is defined of two tangency conditions between the 45° line and the function of cumulative distribution; these conditions are obtained when essential data are high, respectively, weak. If one take into consideration $w = \sqrt{2 \log z}$, then the two tangency conditions will define the next interval for Φ_t, where multiple equilibria are possible:

$$\alpha F_1(- w) + \sigma w < \Phi_t < \alpha F_1(w) - \sigma w. \quad (6)$$

The double inequality (6) mainly represents a condition over the reserves. If these exceed a certain value, then a crisis will become thinly probable; if they decrease under a certain minimal

value, occurring a crisis will become almost surely. Between these two values, Φ^{min} and Φ^{max}, multiple equilibria might take place.

The situations met in Mexico and Thailand prove an attack, followed by an essential depreciation, which might provoke several effects over the confidence and "health" of financial and non-financial corporations, having important debts on foreign currency.

2. DISSEMINATION OF CURRENCY CRISIS OF THAILAND TOWARDS OTHER STATES OF SOUTH-EAST ASIA

The currency crisis started in June 1997 in Thailand has expanded straight away towards other states of South-East Asia, producing negative effects over the economies of these countries. These crisis effects have been emphasized by an amazing similarity as concerns the exchange rates evolution, related to American dollar of Indonesia, Malaysia, Philippines and Thailand, after a long time of relative stability, as can be seen in Figure 1.

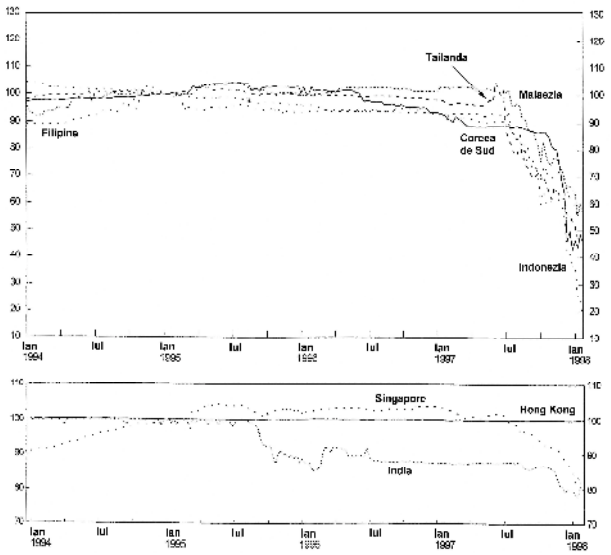

Figure 1. US dDollar per Domestic Currency Unit

The coincidence of speculative attacks over many currencies discovers one of its causes on the economical development of the states based upon the industry, by means of monsoon al effects, which have involved the rates of interest and capital flows. The trading connections with the industrialized countries can contribute towards the existence of certain monsoon al effects over the developing markets. In this way, it become interesting to analyze the charac teristics of commerce related to these states. The crisis affecting the states of South -East Asia has seemed to be in accordance to the impact produced by exchange rates fluctuations yen/dollar, considering the high volume of these countries' trade, carried out both with United States and Japan, as can be seen in Table nr.1.

Table nr.1 Selected Southeast Asia Countries:
Exports to Various Countries (in millions of US Dollars)

Country					
	USA	JapAn	Other Southeast Asia		All counties
				Of which*: Thailand	
Indonesia	7,948	13,839	5,539	854	48,059

	(16.5%)	(28.8%)	(11.5%)	(1.8%)	(100%)
Malaysia	14,245	10,484	21,377	3,207	78,246
	(18.2%)	(13.4%)	(27.3%)	(4.1%)	(100%)
Philippines	6,966	3,668	2,791	780	20,543
	(33.9%)	(17.9%)	(13.6%)	(3.8%)	(100%)
Singapore	23,062	10,254	31,908	7,069	125,118
	(18.4%)	(8.2%)	(25.5%)	(5.7%)	(100%)
Thailand	10,026	9,373	10,240		55,789
	(18.0%)	(16.8%)	(18.4%)	--	(100%)

Source: *Direction of Trade Statistics Yearbook*: 1990-1996 (IMF, 1997)
* Indonezia, Malaezia, Filipine, Singapore, Tailanda

Starting from this point of view, the high weight of dollar within these trading connections has lead to a powerful effective nominal appreciation as concerns the currencies of these states, when dollar has been appreciated by relating towards yen, during April 1995-July 1997, fact described in Figure 2.

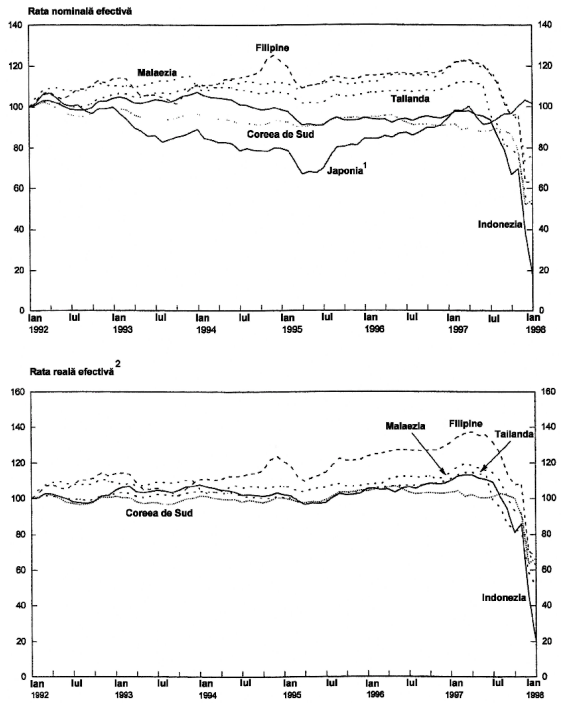

Figure 2. Effective Exchange Rates and the Japanese yen per U.S. Dollar Rate

Nevertheless, the moment of dollar's maximal appreciation related to yen is foregoing with at least one year the crisis of exchange rates of South-East Asia; taking into consideration the essential differences between the trading characteristics of the region's states has become necessary.

The spillover effects represent another potential explanation of overlapping in time of those speculative attacks. Notwithstanding, the data presented in Table nr.1 shows the fact that exports towards Thailand represent a very small percentage of the exports done towards other states from region, fact that leads to conclusion that, as concerns the Asiatic crisis, the effects of overflowing had an unassertive part. As crisis have been disseminated within region, the effects of regional competitiveness have been naturally amplified. As seen in Table nr.2, several estimations of losses in competitiveness, related to each of the five countries more affected by crisis , are presented.

Table nr.2 Real Effective Exchange Rates of some Asian Economies (*January 1997 = 100*)

	Korea	Indonesia	Malaysia	Philippines	Thailand
1997 Jan	100.0	100.0	100.0	100.0	100.0
Feb	100.2	102.5	102.2	101.8	101.6
Mar	97.1	102.8	103.3	103.0	102.6
Apr	98.0	102.9	102.6	103.4	102.6
May	96.8	101.1	101.2	102.0	101.9
Jun	96.8	100.1	99.8	101.7	101.3
Jul	97.9	98.8	99.0	98.6	87.5
Aug	99.5	91.4	95.0	93.8	85.1
Sep	99.4	85.7	87.5	85.7	77.1
Oct	99.2	74.1	81.0	81.4	75.8
Nov	90.5	79.7	80.2	83.6	74.1
Dec	66.0	60.7	75.6	81.0	67.4
1998 Jan	60.6	33.5	67.7	72.6	59.1
Feb	63.6	39.6	77.1	75.3	68.1
Mar	71.3	38.1	77.5	80.0	75.7

Taking into account the previous table, one mig ht notice that until November, when the Korean *won* has started to significantly depreciate as related to very small changes occurred until that time, the overflowing regional effects of competitiveness were significantly weak. Moreover, there was no doubt that, by means of this channel, a crisis might have been started in South Korea.

The analysis previously presented over different types of basic effects, towards disseminating the currency crisis of South-East Asia, has proved to be quit approximat ely. This suggest that an essential part of these crisis was taken by th e effects of pure contagion.

The part of contagion effects is described by simultaneous manifestations of the crisis produced, without having connections occurred over the fundamenta l macro-economical data.

Forwards, several simple calculations will be presented, in order to analyze if fundamental data of the states affected by the crisis were favorab le towards multiple equilibria existence and according to payments balance model pr oposed by Masson. In order to appreciate the potential relevance of the model, the following issue has to be solved: the debt value of a country has to be limited to the debt represented by the internal currency owned by foreigners or it should include all the external debt (which would be natural, if we take into account that risk of not paying and the risk of depreciation are almost similar). One have chosen the second situation as concerns this main analysis done over the Asiatic crisis; its aim consists in achieving the highest image towards potential contribution of different types of effects. This approach is also justified by the fact that Asiatic crisis had at least an essential external size, and a great part of the external debt included the foreign currency.

Table nr.3 External Debt, Reserves, Trade Balance and Criteria for Multiple Equilibria, 1994 and 1996 (in percent of GDP)

Country(σ)	Date	D_t	R_t	T_t	z_t	Φ_t^{min}	Φ_t^{max}	Φ_t
India (0.46)	1994	33.3	6.7	-0.7	7.22	1.11	7.22	3.50*

	1996	27.2	5.8	-1.6	5.90	1.07	5.73	2.80*
Indonesia (1.23)	1994	55.5	6.9	2.3	4.54	2.71	11.29	4.72*
	1996	46.9	8.1	1.3	3.81	2.61	9.14	7.46*
Korea (2.38)	1994	14.9	6.7	-0.7	0.62	--	--	5.43
	1996	21.2	7.0	-4.0	0.88	--	--	3.20
Malaysia (3.53)	1994	39.5	35.1	-1.6	1.12	4.85	5.15	31.97
	1996	38.6	27.0	0.7	1.46	4.77	4.98	26.30
Philippines (2.76)	1994	57.9	9.4	-6.3	2.10	4.98	9.52	-0.72**
	1996	51.1	12.0	-9.8	1.84	4.77	7.98	0.44**
Thailand (2.47)	1994	46.2	20.9	-4.3	1.86	4.28	7.22	13.57
	1996	50.1	20.9	-5.7	2.02	4.40	8.10	13.47

* Inside the region of multiple equilibria

** Fundamental is below multiple equilibria region, that means in crisis region

Table nr.3 presents several relevant data at the end of 1994 and 1996, which preceded the crisis of South-East Asia. One will use the simplest version of the model, so as to notice the potential existence of multiple equilibria (by using relation (3) of the above paragraph). The model suggests that a fundamental component, noted Φ_t, has to take certain values, so that the multiple equilibria might take place. This fundamental component is an increasing function related to the level of reserves and the expected trading balance, and a decreasing function related to the value of debt and the rate of external debt. The calculation assumes that critical level of reserves, $\bar{R}$, is zero (meaning that depreciation is not produced until the reserves are completely exhausted). This assuming is tough non-realistic, and a positive value for this minimal threshold might have an effect consisting in reducing the values of Φ_t, previously calculated. The probability of multiple equilibria also depends upon the value of debt, upon the size of a potential depreciation and upon the variation of trading balance. In the view of implementing these parameters, a self-regressive process was estimated for each country, process of first order over the trading balance (as percentage of GDP), and the standard error of estimating this regression (during 1980-1996) was considered an approximation for σ. As rate of foreign debt, the yearly rate of American treasury effects was used. The data concerning reserves level, of debts and trading balances, all regarded as parts of GDP are presented in Table nr.3. Although difficult on appreciating over "ex-ante" expectations related to depreciations, a depreciation δ of 25 % was assumed. This is significantly smaller than the real lev el registered in several Asian countries, but it can be considered as an approximation od initial currency adjustments. A higher value of δ would bring towards the increasing of „z" values and of interval size ($\Phi^{\min}$, $\Phi^{\max}$).

Interesting on emphasize is the fact that in most situations (but not necessarily for all of them), there is an interval of values of Φ_t, for which multiple equilibria might take place: it is about improper values of z_t, as result of an essential external debt. The exception was represented by South Korea, which had an indebtness level relatively weak, but leading towards values of z_t that didn't allow multiple equilibria.

Although, the value of fundamental data Φ_t, which reflects among others the reserves level, hasn't been always within the intern al part of multiple equilibria region. For instance, Malaysia,

even if registering multiple equilibria, had a level of fundamental data over that maximum allowed, where they were mainly provided to occur, since its reserves were high.

The results achieved have shown that effects of contagion were possible in situation of crisis of 1994 – 1995 and 1997, although these crisis haven't corresponded to general models of contagion, by considering all points of view. As certain consideration, one might say that countries avoided by the worst effects of crisis seemed to be in a quite good situation, as concerns the level of fundamental data, on which this model of payments balance is based upon. This observation was valid only for certain countries (for instance, Brazil, Chile or Columbia). Instead, Korea and Malaysia, considered apart, should have been immune to multiple equilibria, fact that brings us to the following conclusion: other factors have also played an essential part on disseminating the currency values over these states.

3. CONCLUSIONS

The results achieved showed that effects of contagion have been possible in situation of crisis since 1994-1995 and 1997, although these crisis haven't corresponded to general models of contagion by considering all points of view. According to certain consideration, one might say that countries avoided by the worst effects of crisis seemed to be in a quite good situation, as concerns the level of fundamental data, on which this model of payments balance is based upon. This observation was valid only for certain countries (for instance, Brazil, Chile or Columbia). Instead, Korea and Malaysia, considered apart, should have been immune to multiple equilibria, fact that brings us to the following conclusion: other factors have also played an essential part on disseminating the currency values over these states.

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