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Two Approaches to Fixed Exchange Rate Crises

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SUMMARY: THIS PAPER PRESENTS TWO APPROACHES TO THE ANALYSIS OF FIXED EXCHANGE RATE CRISES. THE FIRST IS DUBBED MONETARY OR CANONICAL AND CONSIDERS A FIXED EXCHANGE RATE CRISIS AS TRIGGERED BY MONEY MARKET IMBALANCES AND IMITATIVE BEHAVIORAL DYNAMICS OF THE PUBLIC, FIRMS AND BANKS. THE SECOND IS MORE WIDELY APPLIED AS IT BUILDS ON THE CONSTRUCTION OF A SYSTEM OF INDICATORS FOR EARLY WARNING AND IS BASED ON A SYNTHETIC INDEX OF UNCERTAINTY. THE TWO APPROACHES SUMMARIZE MAJOR CONTRIBUTIONS IN THE SIZEABLE VOLUME OF LITERATURE ON FIXED EXCHANGE RATE CRISES AS WELL AS SOME SPECIFIC CONCLUSIONS OF THE AUTHORS PROMPTED BY BULGARIA'S EXPERIENCE WITH A FIXED EXCHANGE RATE UNDER A CURRENCY BOARD ARRANGEMENT. THE TWO APPROACHES HAVE BEEN APPLIED TO BULGARIA IN THE WAKE OF CURRENCY BOARD INTRODUCTION. LITERATURE ON ATTACKS ON FIXED EXCHANGE RATES IS PRESENTED IN TWO EXTENSIVE APPENDICES. THE FIRST APPENDIX REVIEWS THE CONTAGION MODEL UNDER CURRENCY PANIC, AND THE SECOND DESCRIBES POSSIBLE EARLY WARNING INDICATORS APPLIED TO COUNTRIES HAVING OPTED FOR A FIXED-EXCHANGE-RATE STABILIZATION.

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Le matin du 16 avril le docteur Bernard Rieux sortit de son cabinet et buta sur un rat mort, au milieu du palier. Sur le moment il écarta la bête sans y prendre garde et descendit l'escalier. Mais, arrivé dans la rue, la penseé lui vint que ce rat n'était pas à sa place et il retourna sur ses pas pour avertir le concierge[1] .

Camus, La peste, 1947, ed. 1997, Gallimard, p. 15

La mort du concierge, il est possible de le dire, marqua la fin de cette période remplie de signes déconcertants et le début d'une autre, relativement plus difficile, où la surprise des premiers temps se transforma peu à peu en panique[2] .

Camus, La peste, 1947, ed. 1997, Gallimard, p. 28

I. Objects of the Study and Methodology

The literature on fixed exchange rate attacks has grown tremendously in recent years. While publications tend to be standardized, it is difficult to single out a specific contribution. This imitative dynamics amongst economists was prompted by the problems of countries implementing exchange-rate-based stabilization programs, as well as by the magnitude of financial crises in emerging markets.

In this paper we rather eschew traditional presentation of speculative attacks on fixed exchange rates as first and second generation models. We have prepared a special appendix for Bulgarian readers. We see *our contribution* in the following: presentation of a monetary model of attack and defense against a fixed exchange rate under a currency board arrangement, emphasis on imitative currency crisis (appendix 1), construction of a system of indicators and a synthetic indicator of uncertainty, in particular application of this methodology to Bulgarian conditions. A detailed description of the system of possible indicators for observation of fixed exchange rate stability is presented in appendix 2.

---

[1] *16 April in the morning, on the way out of his cabinet, Dr Bernard Rieux came across a dead rat in the middle of the stairs. The next instant he got it out of his way without giving a second thought and went down the stairs. But as he went out into the street, a thought occurred to him that the rat was not on the right place and he returned to warn the janitor.* ***(Camus. The Plague, 1947, p. 15.)***

[2] *The janitor's death put an end to the period full of contradictory signs and marked the beginning of another, harder one where initial surprise turned little by little into panic.* ***(Camus. The Plague, p. 28.)***

First of all we would like to emphasize the great difficulty of predicting a fixed exchange rate crisis in a specific country.

This can be explained by two peculiarities. *First*, besides fundamental causes of a crisis (which can be approximated with the so-called early warning indicators) there exist domestic imbalances and shocks which provoke a systemic collapse. *Second*, once triggered, the fixed exchange rate crisis follows an imitative multiple equilibria dynamics whereby information is transmitted through panic participants. Monetary authorities' reactions in defending the exchange rate depend not only on economic factors but on political factors as well.

It is assumed that the *currency board* imposes an additional limitation on the fixed exchange rate arrangement. It is expressed in money supply automation and the absence of an alternative for sterilization, that is substitution of external for internal sources of reserve money and vice versa. While this makes the budget the center of fiscal power, it provides options to conduct quasi-monetary policy as well.

It is critical to construct crises response and management program. Exit strategies for fixed exchange rate attack still need be explored and summarized (Eichengreen, B., P. Masson, 1998).

In the spirit of *Lucas critique* (1976), we focus on another specific aspect: constructing a *system of early warning indicators* and its publicizing lessens its efficiency (because once made known to economic agents, it causes changes in their behavior)[3].

Attack on a fixed exchange rate is largely unpredictable. Once started, panic follows its contagious dynamics. The 'contagious' effect is stopped by external constraints or by the process itself. The form of this dynamics has not yet been fully explored – it may be both random (sensitive to initial conditions/fundamentals and self-fulfilling), and stochastic. In both cases, however, the period of *predicting is limited*.

II. The Canonical Monetary Model of an Attack on a Fixed Exchange Rate under a Currency Board

Currency crisis mechanics can be described in different ways (Krugman, P., 1979, Azariadis, C., 1981, Azariadis, C., R. Guesnerie, 1982, Flood, R., P. Garber, 1984, Grilli, V., 1990, Goldberg, L., 1991,

[3] *The market, taking into account these indicators' dynamics and the risk of a currency crisis induced by a change in economic agents' behavior, would accelerate the crisis. On the other hand, authorities would take actions to prevent a currency crisis. Changes occur both in terms of attack and defense of the fixed exchange rate.*

Miller, V., 1996, 1996a, Obstfeld, M., 1994, 1996, Velasco, A., 1996, Claessens, S., 1991, Flood, R., N. Marion, 1998).

We have restricted ourselves to the following basic assumption: *attack on a fixed exchange rate is triggered by imbalances between reserve money demand and supply*. The latter incorporates all shocks and imbalances spilling over from other markets. The reserve money market can be described as the clash between the *attack* (***A***), concentrated in the demand for reserve money, and the *defense* (***D***), induced by reserve money supply and monetary authorities' decisions.

Attack

Initially an attack is launched by the public and businesses, then spills over to the banking system and ultimately to the currency board. The public converts its deposits into banknotes (an element of reserve money) and subsequently into the reserve currency. Demand for banknotes and foreign currency will invariably pass through the imitative dynamics of panic which incorporates individuals' expectations.

Individual behavior is determined by its intertemporal utility function which is strongly dependent on anticipations of devaluation.

$$U_P = U(c_t, m_t) + \phi\, U(c_{t+1}, m_{t+1}) + \phi^2\, U(c_{t+2}, m_{t+2}) + \ldots + \phi^h\, U(c_{t+h}, m_{t+h})$$

$$m_t = m_t\, [E_t(e_{t+1}) - e_t]$$

$\phi < 1$ – discount factor,

where c is consumption, m is money stock of the public, a function of expected devaluation of the exchange rate $[E_t(e_{t+1}) - e_t]$.

Furthermore, the attack incorporates *bank* behavior and the banking crisis. Banks have to optimize intertemporally their profits π and reserves R_t (an element of reserve money). The utility function takes the form:

$$U_b = U(\pi_t, R_t) + \psi\, U(\pi_{t+1}, R_{t+1}) + \psi^2\, U(\pi_{t+2}, R_{t+2}) + \ldots + \psi^m\, U(\pi_{t+m}, R_{t+m})$$

$\psi < 1$ – discount factor.

As a whole, the attack is *endogenous* and is determined by the interacting behavior of the public, companies and commercial banks. Panic, being a collective mass process, is included in the dynamics of the attack. *The attack is concentrated on the demand for reserve money*, in particular *the gap between demand for and supply of reserve money*.

Contagion

Before proceeding to fixed exchange rate defense we will outline the root sources of panic (in this case currency) which forms an integral part of the attack on the fixed level. It poses specific requirements to its defense.

Whether starting unexpectedly or not, the attack on a fixed exchange rate enters a panic path. *Panic* is a mass behavioral process which is well studied by cognitive sciences (Le Bon, G., 1895, Tard, G., 1890, Blumer, H., 1951, Moskovici, S., 1981, etc.). Recently it has attracted economists' attention (Banerjee, A., 1992, 1993, Topol, R., 1991, Orléan, A., 1990, 1992, 1993, Guttentag, J., R. Herring, 1986, Shiller, 1986, Torjman, 1997)[4].

Imitation or mimetic behavior is at the heart of human activity. This basic assumption of Girard, R. (1972) helps to explore panic dynamics. Imitation and conformism form the crowd or 'herd bahavior' (term of Banerjee, A., 1992). Everyone does what the others do even when one's own information suggests the contrary. The object on which individual reactions are focused becomes more valuable when it is desired by everyone else.

This is a new variety of rationality (Bayesian rationality[5]) assuming that the person who is being imitated is in possession of information which you do not possess. From an individual point of view, it is optimal to join the 'herd'. Thus multiple equilibria dynamics is formed. In equilibria agents follow other signals even if they are unsure about their reliability. Banerjee, A. (1993) shows that mechanisms of constraint need be found at the break-even point to make people follow their own information, otherwise there exist external negative information effects which precipitate welfare reduction. Ignoring one's own information has an additional externalizing effect on subsequent participants in the process of contagion. If everyone chooses one's own signal, this would encourage the others to follow him.

At the time of panic *rumors* spread, a specific form of information transmission mechanism. The probability to succumb to rumors is an increasing function of the number of persons having succumbed to them.

---

[4] See also the detailed description of the psychological basis of systemic financial crises in Nenovsky, N. Systemic Financial Crises, BNB Monthly Bulletin, issue 3, 1997.

[5] The term 'Bayesian rationality' is derived from Bayesian statistics, a branch of applied statistics based on analysis of conditional aposteriori probability capturing apriori information (see Wonnacott, R., T. Wonnacott, 1985).

The attack on a fixed exchange rate is a special case of a mass behavioral process of panic. This attack is self-fulfilling. The level of the exchange rate to be predicted by agents is the result of their joint actions. The state of complete uncertainty, when agents cannot or have partial knowledge of the actual level of the exchange rate, results in imitative behavior. The subsequent result is a new type of convention and a new level of the exchange rate.

Defense

Defense is largely static and exogenously set (this is particularly true for a currency board because there is no possibility for response).

Reserve money supply is determined by the dynamics in the structure of the currency board balance sheet and mostly by foreign exchange movements (i.e. balance of payments). The only behavioral element stems from the government which has to minimize the selected loss function[6], a result of the utility function of the government, trading off between loss of confidence and the need of flexibility.

The *utility function* of the government is:

$U_G = U_G$ [confidence (approximated with the fixed exchange rate), flexibility]

The loss function of the government to be minimized by it is:

$$L = (a/2)(e - e^*)^2 + (b/2)(f - f^*)^2 + (c/2)(y - y^*)^2 + Cost\,[(e^e - e)/e]$$

where:

e is the current level of the exchange rate;

e^* is the fixed level of the exchange rate;

f is the current level of international reserves;

f^* is the desirable level of international reserves by monetary authorities;

y is the current level of income;

y^* is the potential level of income;

$cost\,[(e^e - e)/e]$ are expenses incurred by the government on abandoning the fixed exchange rate;

a, b, c are the weights selected by the government and reflecting its preferences in terms of deviations of listed variables from their desirable levels.

---

[6] *The loss function is employed to express public preferences for major macroeconomic variables. It is based on the understanding that the central bank strives to achieve optimal levels of major macroeconomic indicators through its policy from a public point of view. The loss function shows loss of public welfare due to deviation of certain variables from their desirable levels (see Walsh, C., 1998).*

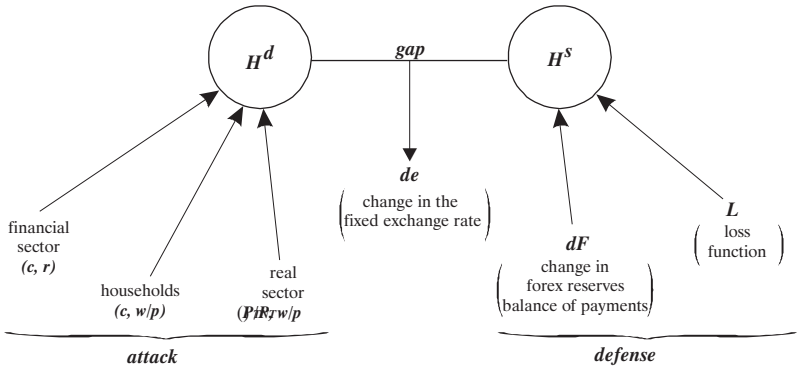
The probability of an exchange rate crisis is a function of the imbalance between demand for and supply of reserve money. Thus an exchange rate crisis and the probability of an attack can be interpreted as a result of uncooperative game between attack and defense or supergame with training[7]. *Uncertainty and asymmetric information* underlie the clash between attackers and defenders. Uncertainty arises both in terms of reserve money demand and supply and the loss function (it is not known for how long the government will defend the exchange rate)[8].

Diagram

Chart 1 outlines a speculative attack on a fixed exchange rate arising from the gap in the reserve money market.

Chart 1

MODEL OF AN ATTACK ON A FIXED EXCHANGE RATE THROUGH THE GAP IN THE RESERVE MONEY MARKET



c is the *banknotes and coins in circulation*/*deposits* ratio;

r is the *CB reserves*/*deposits* ratio;

w*/*p is the real wage;

P_T/P_{NT} is the ratio between prices of international tradable goods and prices of nontradable goods in international markets.

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[7] *Supergame with training means a dynamic, recurring uncooperative play as a result of which individual rationality of players make them to cooperate, to adopt a common strategy (see Guerrin, B., 1997).*

[8] *The contagious dynamics of currency panic and spreading rumors reflect the necessity of monetary authorities' information policy and the need of destroying harmful information.*

We can approximate the attack with ***dg***, i.e. the change in the gap between demand for and supply of reserve money, and defense with the change in forex reserves ***dF***. The probability of an attack on the exchange rate is p_g, and the probability of a defense of the exchange rate is p_F. Then the total probability of attack and defense of the exchange rate is:

$$p = p_g dg + p_F dF$$

The derivative ***dg/dF*** is a specific indicator of the stability of the fixed exchange rate. It should tend to unity. There exists a critical threshold in the direction above the bisector in the area of equilibrium ***(dg, dF)*** at which an attack on the exchange rate actually occurs whereas the defense is unable to sustain the level of the exchange rate.

The Model

Before we proceed to empirically testing for reserve money demand and supply, we will present a *generalized theoretical model* which, in our opinion, embodies separate behavioral paths. We do not measure behavioral processes separately (they interact) because the whole set of information on their dynamics is *concentrated in* reserve money demand and supply.

The model can be defined using the following system of equations:

(1) $(H/P)^d_t = \alpha_1 y_t^{\alpha 2} i_t^{-\alpha 3} [E_t(e_{t+1}) - e_t]^{-\alpha 4} e^{\varepsilon t}$

(2) $H^s_t = F_t - G_t - B_t = \beta_1 r^{\beta 2} c^{\beta 3}$

$r = R/D,\ c = C/D$

(3) $r = r\ (r^d - r)$

(4) $c = \hat{c} + \rho(F),\ \rho(F) \geq 0$

(5) $P_t = Q_t^{\lambda}\ (Q_t * e_t)^{(1-\lambda)}$

(6) $\lambda = (X+M)/Y$

(7) $i_t = i_t^* + [E_t(e_{t+1}) - e_t]$

(8) $g = (H/P)^d_t - (H/P)^s_t$

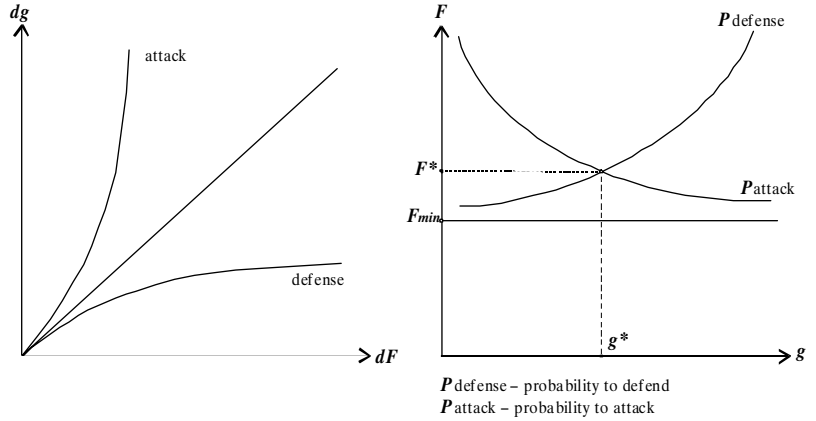
(9) $dg(t)/g(t) = \mu dt + \sigma_m dz_m(t)$

(10) $\hat{e} = \hat{e}\ (dg/dt)$

(11) $Pb(de/e) = Pb(\hat{e})$

Equation (1) is the function of real demand for reserve money $(H/P)^d_t$, where ***y*** is approximator of the real sector, ***i*** is the interest rate, $[E_t(e_{t+1}) - e_t]$ is the anticipated devaluation of the fixed exchange rate

Chart 1a



e, and ***P*** is the price index. Equation (2) features reserve money supply H^s, which can be viewed as accounting identity (reserve money is defined as the difference between currency board assets and government and banking department deposits, ***F*** are foreign exchange reserves of the issue department, ***C*** is currency in circulation, ***R*** are commercial bank reserves, ***G*** is the government deposit at the Issue Department balance sheet, and ***B*** is the deposit of the Banking Department. Equation (2) can be featured as a function incorporating individual and banks' behavior which depend on the commercial bank *reserves/deposits* ratio ***r*** and the public's propensity to hold banknotes, i. e. the *banknotes/deposits* ratio ***c***. Commercial banks accomodate changes in the *reserves/deposits* ratio by trying to direct it to the level desired by them r^d (3). Propensity to hold banknotes ***c*** is described in (4), where $\hat{c}$ is the long-term trend, and $\rho(F)$ is an increase in the *banknotes/deposits* ratio before the attack as an increasing function of the volume of issue department foreign exchange reserves ***F***. The price index is a weighted average of the prices of nontradables ***Q*** whose share is λ, and tradables with a share of $(1-\lambda)$. Prices of nontradables are multiplied by the exchange rate at direct quotation (5). The weight λ is the proportion of the sum of exports ***X*** and imports ***M***, divided by the gross domestic product ***Y*** (6). Equation (7) features uncovered interest-rate parity, where ***i*** is the domestic interest rate, ***i**** is an exogenously set interest rate abroad, and $[E_t(e_{t+1}) - e_t]$ is the level of anticipated devaluation of the national currency.

Equation (8) is *basic* in the model. It shows the gap between reserve money demand and supply, i. e. the deficit or surplus of 'central' (reserve money) liquidity in the economy. Its behavior is described by a process of diffusion in (9) (a constant process, an analogue of random walk). Its second part contains a Vinerian process thus synthesizing uncertainty in the money market. In (10) the shadow exchange rate $\hat{e}$ is defined as the level of the exchange rate after the attack on the fixed exchange rate. This level is a function of the money market gap. The conditional probability of a speculative attack depends on the level of the shadow exchange rate (11).

Empirical Test

To study the gap dynamics in the reserve money market, we first estimate the *demand for reserve money.*

Different approximators of transaction variables were used in the equations: households' incomes and expenses and wages.

The model employs monthly data for the period starting after currency board introduction in July 1997 till October 1998.

The equation below has the best specifications:

$$dlog(H/P)^d_t = \underset{(0.29)}{0.01} - \underset{(-1.59)}{0.24}\, dlog\,(H/P)_{t-1} + \underset{(4.83)}{1.23}\, dlog\,(W/P)_t + \underset{(3.22)}{3.5}\, dlog\,(e)_t + MA(1) + MA(2)$$

$$R^2 = 0.85 \quad R^2_{adj} = 0.74 \quad DW = 2.1 \quad F = 0.008,$$

where variables are:

H **–** reserve money;

P **–** consumer price index;

W **–** average monthly wage;

e **–** average monthly exchange rate of the lev against the US dollar.

Chart 2 shows the dynamics of the observed and generated value of reserve money from the above equation.

Let us denote the generated series of reserve money demand with h^d, and supply, which is set by the Issue Department balance sheet, with h^s.

The difference between the two is just what we are interested in – the gap:

$$g = h^d - h^s.$$

Its dynamics is featured on Chart 3 where the zero line shows reserve money market equilibrium. Its volatility is also evident from its statistical distribution (Chart 4).

Chart 2

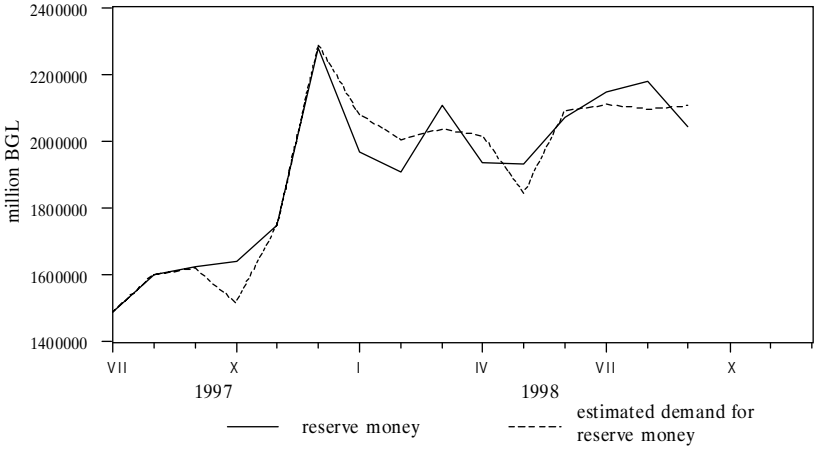


Chart 3

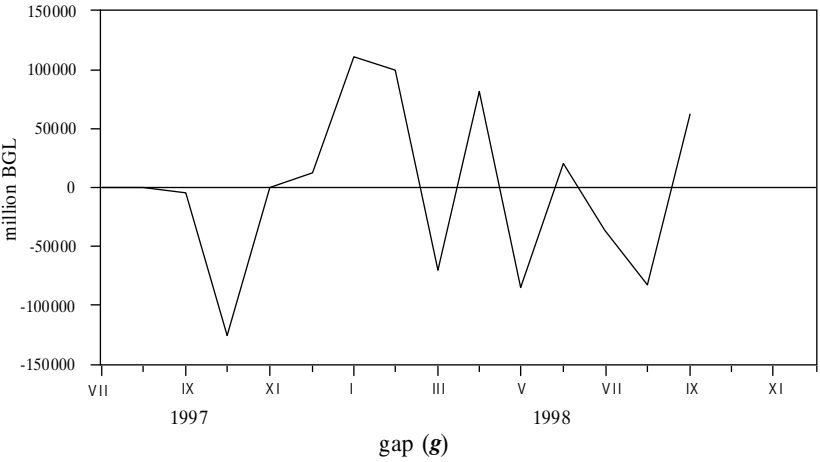
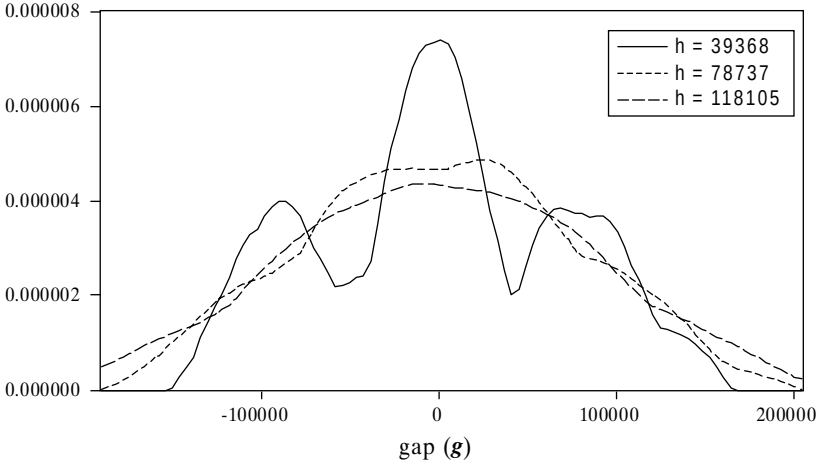


Chart 4

KERNEL DENSITY



The 'peaks' of distribution show several equilibrium positions around which the market oscillates. This is typical of the volatility of multiple equilibria dynamics when a given variable's behavior leaves its fundamental factors and is based on imitation of economic agents. The theoretical basis for such dynamics is presented in appendix 1.

III. The Indicator Approach to Speculative Attacks on Fixed Exchange Rates

There are two basic methodological interpretations of the indicator approach. The first uses the deviation between indicators' values immediately before an attack is launched in a period of tranquility to estimate the probability of a speculative attack. In the second one indicators are independent variables in probit and logit models to assess the probability of a speculative attack.

Kaminsky and Reinhart seminal study (1997) lists indicators employed in the models of different authors. Depending on the results displayed by a specific indicator, it is estimated based on the proportion between the number of studies in which it was used and the statistically significant results displayed.

As we have already used some of these indicators in other studies

on Bulgaria, here we concentrate on the probit model with monthly data (Nenovsky, N., K. Hristov, 1998, Yotzov, V., N. Nenovsky, K. Hristov, I. Petrova, B. Petrov, 1998).

Defining the Concept of a Speculative Attack

A speculative attack is a more general concept than a currency crisis since it occurs if there is a successful speculative attack followed by depreciation of the national currency. Reversely, if the speculative attack is unsuccessful and no devaluation occurs, but there is a massive loss of central bank foreign exchange reserves or a dramatic increase in interest rates (both in support of the exchange rate), a currency crisis is in place.

Therefore, to define the term speculative attack or pressure it is necessary to take into account changes both in the levels of the exchange rate and foreign exchange reserves of the central bank (Sachs, Tornel, Velasco, 1996; Kaminsky, Reinhart, 1996) and interest rates (Eichengreen, Rose, Wyplosz, 1996).

The first group of cited authors construct an index comprised of the weighted average values of the exchange rate and foreign exchange reserves, while the second group include the interest differential between the reserve currency and the local currency. The weights are selected so that both components of the index should have equal values of conditional volatility. If the value of the index exceeds a given threshold value of the standard deviation plus the mean value, it is assumed that a currency crisis is in place (in Kaminski, Reinhart, 1996, three times the standard deviation plus the mean). In Eichengreen, Rose, Wyplosz (1996) this threshold is one and a half the standard deviation plus the mean value in the series.

There is a *second approach* applied in Frankel and Rose (1996). In their view, for the countries in the emerging markets group different components of the speculative attack indicator must be used consistent with nonmarket setting of interest rates and imprecise information on foreign exchange reserves in the relevant country (since it does not capture a fixed exchange rate defense in the form of emergency rescue loans from the IMF, bilateral agreements with donor countries or private financial institutions). An additional benefit of their approach they see in the example that in protecting the exchange rate monetary authorities often impose capital controls (tightening of the existing regime respectively) and/or raising the minimum reserve requirement ratio.

Above specifications lead to redefinition in Frankel and Rose of the

index of Eichengreen, Rose, Wyplosz (1996) and the adoption of a new definition. They define a currency crisis as a decrease in the value of the local currency of at least 25%. In countries with annual rate of inflation above this percent an additional requirement is included – the decrease in the value of the local currency not only exceeds 25%, but exceeds the previous year's decrease by a margin of 10%.

Choice of a Speculative Attack Index

In constructing a speculative attack index we decided on applying the methodology used in Eichengreen, Rose, Wyplosz (1996) consistent with the use of two major tools in the defense against speculative attacks in the period 1991 –1997: central bank intervention in the foreign exchange market and interest rates set by it. For the sample period, changes in the forex regime were not used to defend the exchange rate, while changes in the level of minimum reserve requirements had rather strategical than operational functions. This entails limitations in using the methodology applied to emerging markets.

For the purposes of our study, we include three variables in the speculative attack index. They synthesize information about interest rates, central bank foreign exchange reserves and the level of the exchange rate.

Two indices are constructed – the first (I_0) employs the percentage change in the exchange rate (based on the previous month's exchange rate) and the interest differential of the lev against the US dollar, de_0 and di_0 respectively; the second, I_1 is comprised of the same variables but in terms of the Deutschemark, de_1 and di_1 respectively; dF reflects the percentage change in central bank foreign exchange reserves from the previous month.

Indices are composed as follows:

$$I_0 = (di_0/\sigma_{di_0}) + (de_0/\sigma_{de_0}) - (dF/\sigma_{dF})$$

$$I_1 = (di_1/\sigma_{di_1}) + (de_1/\sigma_{de_1}) - (dF/\sigma_{dF}).$$

Weights of individual variables reflect standard deviations in corresponding series of data and are included to obtain equal values of total conditional volatility. Calculated standard deviations of selected variables are:

$$\sigma_{dF} = 13.064, \quad \sigma_{di_0} = 9.146, \quad \sigma_{de0} = 0.208$$

$$\sigma_{de_1} = 0.1998, \quad \sigma_{di_1} = 14.612,$$

where

di_0 is the interest differential between investment in levs and in US

dollars;

di_1 is the interest differential between investment in levs and in Deutschemarks.

Interest differentials are computed according to the method used in the compilation of BNB Monthly Bulletin.

de_0 и de_1 are percentage changes in the exchange rate for the US dollar and the Deutschemark from the previous period.

$CRISE_0$ and $CRISE_1$ are selected critical values of the index for which a speculative attack on the fixed exchange rate takes place.

The Data Set

The sample of monthly data covers the period from early 1992 through October 1998.[9] All the data are reported on the last business day of the corresponding calendar month.

After the method of setting the base interest rate was modified in early 1997 the interest rate on the respective currency used in the computation of interest differential had to be adjusted. Thus, for the period prior to 1997 effective end-of-month US discount rate and German repo rate are used as analogues of the base interest rate set by the BNB over the same period. Since early 1997 the yield on three-month treasury bills and the three-month FIBOR[10] are used. Changes made in the method of computing interest differential aim to eliminate the impact of such factors like certainty and maturity of the respective security on the size of the differential. These factors determine credit and liquidity risks.

Critical Threshold of the Index Recording a Speculative Attack

A critical threshold is that value of the index beyond which a speculative attack occurs. The critical value of the index should be selected so as to minimize the probability of receiving false signals. Therefore, to find the variant that suggests the lowest probability of error, we need to compare several options.

The method of computing the critical threshold is that used in Eichengreen, Rose, Wyplosz (1996). It is computed using the following equation:

[9] *The period of floating exchange rate and discretionary monetary policy is up to June 1997.*

[10] *FIBOR – interest rate on three-month interbank deposits set in the Frankfurt money market.*

$$CRISE_{ij} = \mu(I_i) + X\,\sigma(I_i)$$
$$i = 0, 1 \qquad j = 0, 1, 2.$$

If we take the exchange rate of the lev against the US dollar and the interest differential between them, ***i*** takes the value of 0, and 1 for the exchange rate of the lev and the interest differential against the Deutschemark. The mean of the index is $\mu(I)$, and $\sigma(I)$ is its standard deviation; ***X*** takes values respectively of 1, 1.5 and 2. To each of these correspond values of ***CRISE*** denoted as a second index ***j***, 0, 1 and 2 respectively. The choice of an ***X*** value is directly dependent on the preferred level of choice between the likelihood of making error of type one[11] and type two[12]. A comparison of the results shows that a lower value of ***X*** will make the indicator more sensitive to capturing speculative attacks but at the cost of higher probability of false signals, and vice versa.

Table 1

NUMBER OF REPORTED DEVIATIONS FROM THE CRITICAL LEVEL FOR DIFFERENT VALUES OF X OVER THE SAMPLE PERIOD

X	**1.0**	**1.5**	**2.0**
I_0	9	8	3
I_1	10	8	5

The number of recorded deviations from the critical level for $X = 1$ is 9 and 10 respectively.

The Binary Dependent Probit Model

To estimate the probability of the speculative attack index to overshoot the critical value, we use a binary dependent probit model with a binary variable denoted as CR_i, and independent variables listed below:

$CR_i = 1$, if $i_i \geq CRISE_i$ and $CR_i = 0$, if $i_i < CRISE_i$ $(i = 0, 1)$.

In contrast with regression, in the probit model the dependent variable takes binary values of 0 or 1 depending on whether the index exceeds the critical value ***CRISE*** or not.

[11] *Type one error involves an actually occurring currency crisis but not recorded.*
[12] *Type two error involves recording of a crisis by the indicator without actually occurring.*

Independent Variables in the Binary Dependent Probit Model

Independent variables are those indicators that take values having a statistically significant effect on the estimated variable. As indicators are assumed to flash signals before the crisis erupts, they are examined with a lag.

In determining the optimum set of indicators to explain the behavior of the speculative attack indicator we use the following variables:

monthly change in the real effective exchange rate (***DREER***, see Chart 6);

monthly change in imports and exports;

monthly change in the capital account (***KA***) (see Chart 7);

monthly change in the current account (***CA***);

monthly change in credit aggregates;

monthly change in the ratio of ***M2*** to BNB forex reserves;

monthly change in budget deficit;

monthly change in unemployment.

As monthly balance of payments statistics has been compiled since early 1997, the set of indicators does not cover the whole period between 1990 and 1998. This entailed limitation of its length to 28 observations.

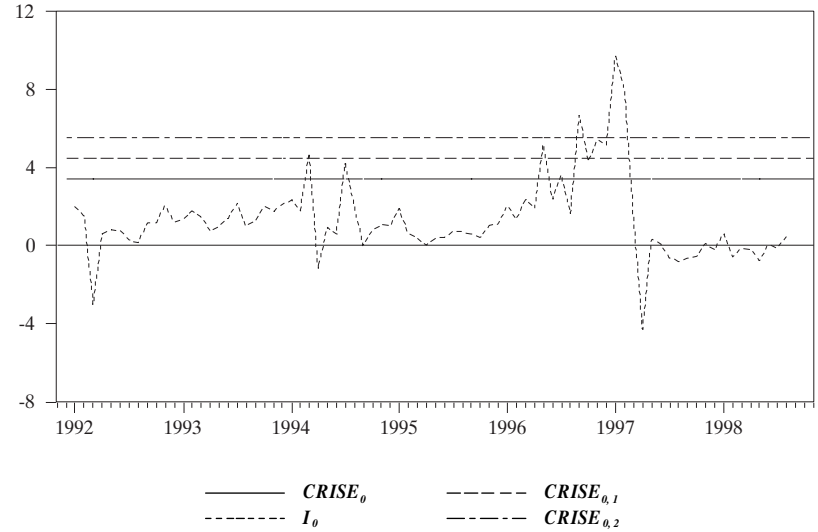
What Do the Results Show?

Application of the binary dependent probit model (models 1 and 2 in appendix 3) shows strong statistical significance of the indicators for the capital account, the real effective exchange rate, and the speculative attack in the preceding period (all variables with one month lag).

Interpretation of the signs of the coefficients for independent variables shows less likelihood of an attack against the fixed exchange rate as the capital account balance increases and the real effective exchange rate volatility decreases. The higher the value of the speculative attack index in the transition period, the higher the probability of an attack is.

Chart 5

INDICES OF A SPECULATIVE ATTACK ON THE EXCHANGE RATE



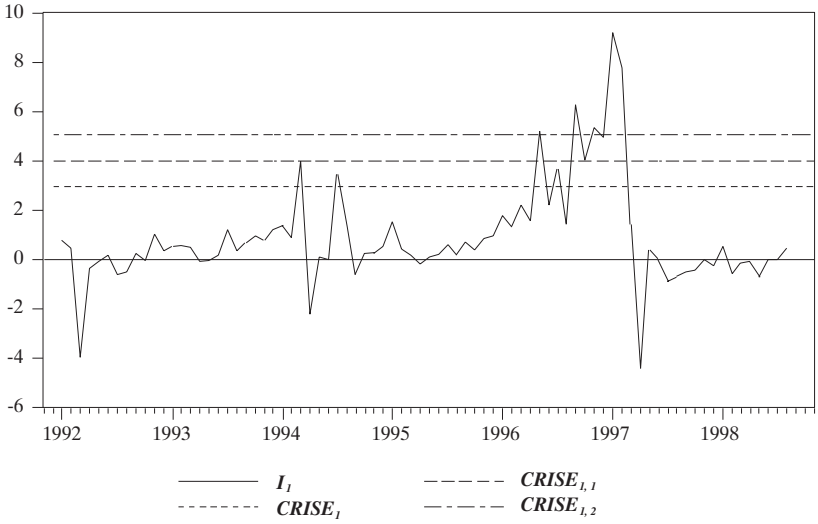


Chart 6

REAL EFFECTIVE EXCHANGE RATE (BASED ON PRODUCER PRICE INDEX) AND CHANGE IN THE REAL EFFECTIVE EXCHANGE RATE

(November 1991 = 100)

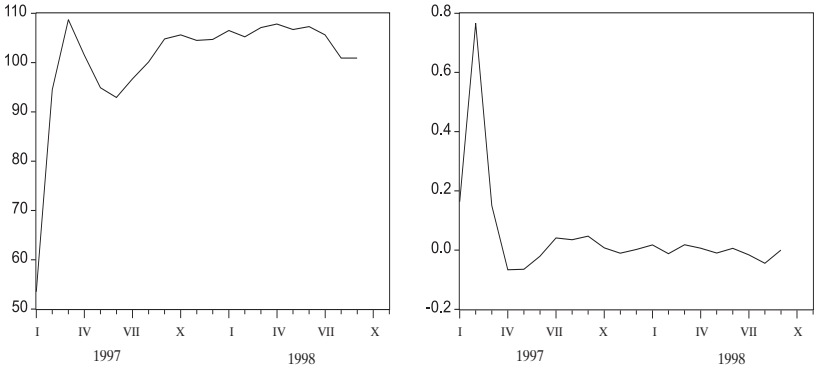


Chart 7

CHANGE IN THE BOP CAPITAL ACCOUNT BALANCE

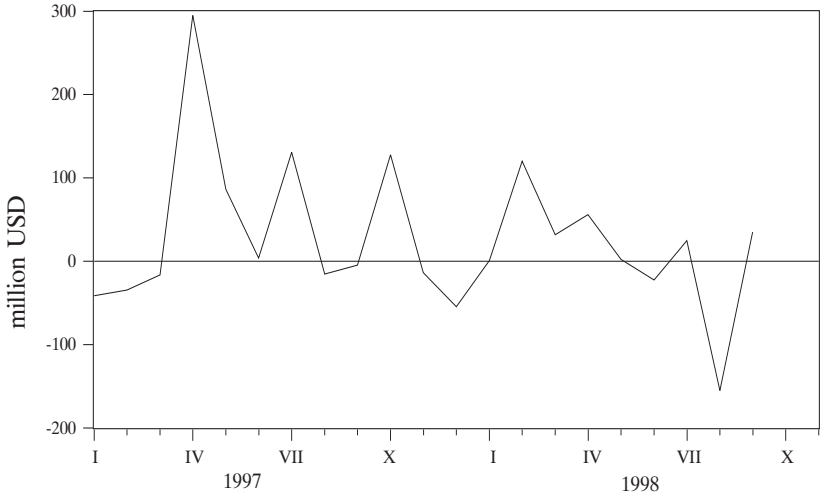


Chart 8

DEPENDENT VARIABLE VALUES
(PROBABILITY OF CURRENCY CRISIS REALIZATION)

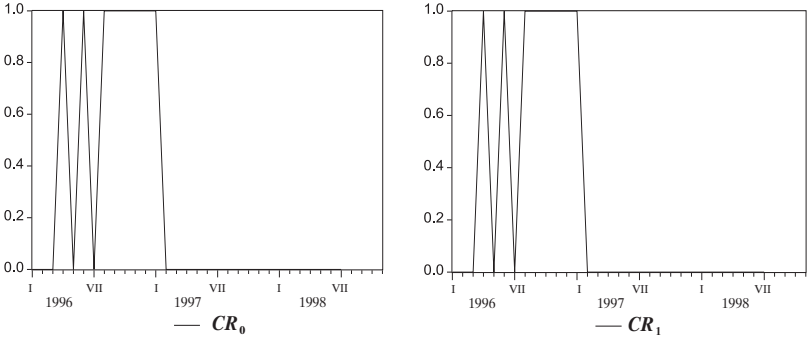


Chart 9

ESTIMATED AND ACTUAL VALUES

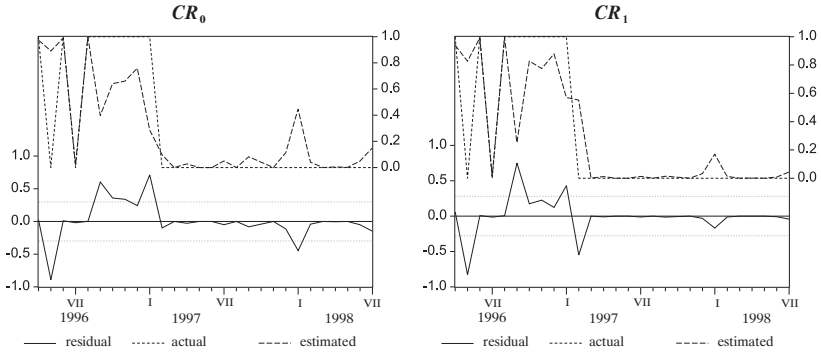


Chart 8 exhibits the periods of attack on the exchange rate in the past. Chart 9 shows the explanatory strength of the models.

IV. Conclusion

The present study pursuits two goals. *First*, to present two possible approaches to the analysis of eventual attacks on the fixed exchange rate, called in this paper monetary and indicator approaches (a synthetic indicator of Bulgaria's currency crisis is defined). *Second*, a detailed survey of the literature on attacks on fixed exchange rates is reviewed in the two appendices.

Theoretical results may be presented as follows.

Attacks on fixed exchange rates are unpredictable to a great extent as they combine both fundamental imbalances in the economy and a reversal in the expectations of economic agents.

The bigger the macroeconomic imbalances, the more favorable the environment for successful speculative attacks is.

The assumption that money demand and supply under a currency board are always balanced is not absolutely true. A speculative attack on the fixed exchange rate is possible as a result of disequilibrium between supply of and demand for reserve money. In general, the more stable the money market (particularly reserve money market), the less probable the successful attack on the fixed exchange rate is.

Speculative attacks represent mass herd behavior and *may occur even under good macroeconomic indicators*. Foreign exchange panic has its own information dynamics and may be stopped by external constraints, or by a mechanism forcing economic agents to follow their own information, not to imitate each other.

Protection of the exchange rate depends to a great extent on the *government loss function*, i. e. trade-off between flexibility and credibility. The choice to protect the exchange rate is largely political.

Experience shows that if the crisis *is self-fulfilling, normal fiscal and monetary policy tightening proves inefficient*. Crisis dynamics reflects entirely economic agents' expectations. Measures intended for structural changes in the economy are more efficient, but they cannot be implemented in the short run.

Changes in the capital account balance under the constructed index of a speculative attack show that capital account *liberalization enhances* the probability of self-fulfilling currency crises *due to increased mobility of portfolio investments*[13]. Changes in investors' expectations result in multiple equilibria under a fixed exchange rate.

[13] *On the other hand, free capital movement helps improve diversification of economic agents' portfolios, thus protecting economic agents from unfavorable price movements in financial assets.*

Indicators of an attack on the fixed exchange rate have sufficient explanatory power relative to previous currency crises. Observation of capital account developments, changes in the real effective exchange rate dynamics and the previous period's value of the speculative attack index prove to be of key importance in determining the probability of a future speculative attack on the fixed exchange rate.

Appendices

Appendix 1

The Model of Foreign Exchange Market Contagion

This paper presents briefly a summarized model. This model is an adaptation to the financial market model made by Orléan, A. (1992). We consider this model as one of the best in the economic literature dealing with herd behavior and critical phenomena. This type of model is based on Bayesian rationality of economic agents, i. e. the behavior of other economic agents is taken into account in decision-making. Actually, any rational agent interprets other forex market participants' purchases and sales as resulting from hidden information. The Bayesian rule defines a law on interdependence between economic agents in the form of a ratio of the personal opinion (apriori) of a particular agent to the average opinion of market participants. These weights result from the accuracy in associating signals obtained from both types of information.

We assume the state of the forex market as an arbitrary value which may take two values (+) and (-) with probability p_+ and p_-. The attack on the fixed exchange rate is (+) and the lack of attack is (-). The exchange rate fundamental characteristics takes values R equal to V_- (no attack, the level of the fixed exchange rate is sustained) and V_+ (there is an attack, a new level of exchange rate fixing or free floating of the exchange rate). Thus, $EV = P_- V_- + P_+ V_+$.

Each agent has two sources of information: fundamental signal σ (this may be the real effective exchange rate or the state of the balance of payments current account) and study of the forex market. The state of the forex market may be defined as f, for instance the proportion of agents who have chosen (–). According to the Bayesian rule, there is a probability $p(-/+)$, i. e. an agent with a personal choice (+) who has changed his opinion and reacts as (–):

(1) $p(-|+)\,(f) = [T/(T+R)]\,f + [R/(T+R)]\,p_- = [1/(1+r)]f + [r/(1+r)]\,p_-$,

where R is the accuracy derived from the fundamental factor, and T is the accuracy of the forex market assessment. The principal parameter is the degree of credibility of each agent in his own opinion related to that in the market $(r = R/T)$. The weaker the proportion, the stronger the interdependence between forex market agents is. Similarly, the change from (–) to (+) may be determined as follows:

(2) $p(+|-)(f) = [T/(T+R)](1-f) + [R/(T+R)]p_+ = [1/(1+r)](1-f) + [r/(1+r)]\ p_+$.

According to equations (1) and (2) the probability one agent to be in (+) or (–) state depends on the fundamental factor ***f*** which determines the maintenance of the fixed exchange rate.

Each agent $a \in A$ is characterized by state ***s(a)***. This state is identified with the expected future value of the exchange rate or the choice of foreign exchange strategy (based on the fundamental factor or simply on the forex market state). If E_a is the environment of the agent ***a***, the environment is defined as reflection (application): $E_a: A - \{a\} \rightarrow S$, which determines the state of all other agents besides ***a***. This is formulated as $\pi_a(S|E_a)$, i. e. the probability that $a \in A$ is in state ***S*** under environment E_a. This conditional probability is microeconomic.

The most essential in this model is the transition from micro to macro. The microeconomic structure is defined as ***P*** – a set of conditional probabilities π_a. The macroeconomic behavior determined by the general probability μ (called phase), caused by ***P***, is:

$\mu[s(a) = s|E_a] = \pi_a(s|E_a],\ s \in S,\ a \in A.$

When the set ***P***, indicating microconditions in the forex market, has many global phases, the process π_a is called *nonergodic* (Orléan, A., 1992). In other words, the microeconomic characteristic of the market is not sufficient to determine the macroeconomic state. The nonergodic process reflects the fact that interaction dynamics plays a key role at a macrolevel: one and the same set of microeconomic characteristics may result in different macroconditions. In the economic literature this phenomenon is known as *multiple equilibria dynamics*. Where ***P*** is nonergodic, one exogenous shock may cause a specific dynamics of the system (phase transition characterized by a sharp shift from one equilibrium into another).

In this case equations (1) and (2) determine ***P***. The set of states contains two states $S = (-, +)$. The environment is indicated only through ***f***; ***R*** depends on the characteristics of financial assets (in this case the currency); ***T*** depends to a great extent on an agent's idea of other agents' behavior. If each of the agents presumes that other agents' opinion is based on independent observations of the fundamental signal σ, then ***T*** – the accuracy (by definition it is opposite to the variation) is: $N/V(\sigma)$, where ***N*** is the number of forex market participants and $V(\sigma)$ volatility of the signal.

According to Kahneman, D., P. Slovic, A. Tversky (1982), ***T*** displays the following dynamics:

(3) $T(f) = hf^2$

(4) $T(1-f) = h(1-f)^2$.

The bigger f (in this case the state of the current account is improving or foreign exchange reserves are growing), the higher the accuracy of the signal, and the higher the probability of a signal shift from (+) to (–) dynamics (a signal for attack shifts into a signal for nonattack).

Equations (1), (2), (3) and (4) completely describe diffusion of opinions in the forex market. If $P(f, t)$ is the probability at a point in time t and the initial conditions are known $P(f, 0)$, its deformation in time should be estimated. It is possible to compute stationary distributions of $P_s(f)$ to which diffusion dynamics strives. Equations (3) and (4) display that signal significance σ in relation to market observations is measured by R/h and is designated as s.

According to the fundamental data on the forex market, it is assumed that $p_+ = p_-$, i.e. $f = 1/2$. Thus, the average market opinion s coincides with EV.

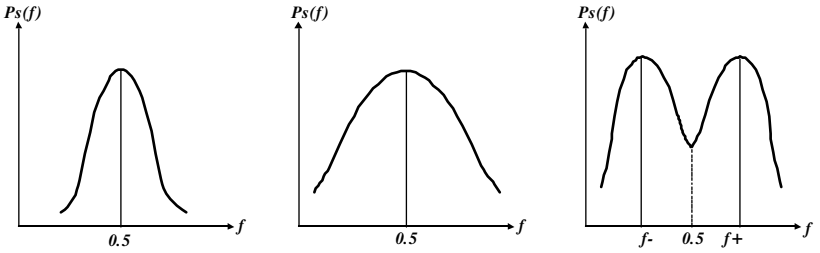
If s is too high, this suggests independence of personal choice. Each agent remains true to his own opinion. In this case the distribution is close to normal with an average value of 0.5 and variation $N/V(\sigma)$. The lower value of s describes a situation in which agents' credibility in the fundamental factor σ is lower, and hence the market opinion assumes greater significance. Consequently, the imitation component is given added weight. Also, the average value is about 0.5 while the variation is greater.

When s has reached a particular critical value s_c, the information from the market prompts self-accelerating dynamics resulting in a deviation from fundamental factors (Shiller, R.,1981). Stationary distribution becomes *bimodal* and has two levels f_- and f_+. The bigger the deviation of f_- and f_+ from 0.5, the stronger the variation. When s tends to 0 and +1, all market participants are unanimous.

If the market is close to f_- (f_+) (Chart 12), the probability of phase transition is insignificant, given a great number of participants N. The probability becomes 0 for $N \to \infty$. There are two possible stationary distributions of these probabilities, Dirac figures δ_- and δ_+ for f_- and f_+ (Orléan, A.,1992). The average opinion has two equilibrium positions. It may converge to one or the other position with probabilities depending on the initial conditions. However, if the stationary state is reached, the average opinion does not change.

Since the actual number of forex market participants N is big, the market opinion f oscillates for a long time around f_+ (respectively f_-)

Chart 12



no imitation, only fundamental factors

weak imitation plus fundamental factors

only imitation, no fundamental factors

as it moves in the form ***exp(N)*** (see details in Kahneman and Tversky, 1982). In a particular moment a dramatic change occurs resulting in f_+ ***(f_)***. This is the *phase transition.* The probability of this shift for large values of ***N*** is negligible but not 0. It is reasonable to say that extremes are always adjusted but most often from extremes in the opposite direction and never to some standard level. In this case the average value of the market is ***EV*** (fundamental), reached by alternation of extremes in both directions (complete imitation or lack of imitation).

In practice, one of the limitations of the model $p_- = p_+$ is not always fulfilled, i.e. $p_- \neq p_+$. Changes in the fundamental factor impact imitation, i.e. the phase transition is not entirely random: it is activated by *additional information about fundamental factors* (in this case the state of forex reserves and current account).

In general, this model indicates panic dynamics, namely how insufficiently informed agents imitate informed ones. It also suggests that imitation is ambivalent and may entirely deviate from true fundamental information.

Appendix 2

An Overview of Indicator Approaches to Attacks on Fixed Exchange Rates

Summary of the Literature on Indicator Approaches

Regarding the methodology used, Kaminsky and Reinhart (1998) distinguish four groups of economic analyses dealing with the study of speculative attacks.

The first group of papers provide mainly a qualitative discussion of the causes and developments leading to currency crises, introducing one or several indicators. No formal tests are conducted to evaluate the usefulness of the various indicators in predicting crises. As various authors attach greater importance to these indicators, they prove to be more significant in the empirical sample of their studies.

The second group of papers examine the facts of the period leading up to and immediately following the currency crisis. Sometimes the pre-crisis behavior of a variable is compared to the control group variables of countries where no currency crises occurred, or with behavior of the same variables during 'tranquil' periods for the same group of countries. Parametric and nonparametric tests are used to assess whether there are systematic differences between the pre-crisis episodes and the control group. These tests can be useful in narrowing the list of potential indicators, as not all the variables included in the analysis ended up showing abnormal behavior in advance of crises.

The third group of papers estimate the probability of devaluation one or several periods ahead, along the lines pioneered by Blanco and Garber (1986) in their discussion of the Mexican crisis of the early 1980s, based on an explicit logit or probit theoretical model. These papers help to narrow the list of useful indicators up to statistically significant ones for the method applied.

The fourth group of papers are based on the methodology used in Kaminsky and Reinhart (1998). This paper presents a nonparametric approach to evaluate the usefulness of several variables in signaling an impending crisis. This methodology can be interpreted as an extension of the methodology used in the second group of papers.

Approaches to Assessment of the Probability of a Speculative Attack

Regarding the methodology, there are two major approaches. *The first* is based on probit and logit econometric model of predicting the probability of a speculative attack. In this approach, a system of inde-

pendent variables which most thoroughly describes the behavior of the dependent variable in past periods is used. *The second approach* compares the difference in values of the selected indicators for the periods prior to the speculative attack and their values in 'tranquil' periods, thereby estimating the probability of a speculative attack.

The major disadvantages of the first approach are: it focuses on the variables that have an explanatory power regarding the probability of a speculative attack in the past; this approach disregards the influence of other variables which did not have a statistical significance in the past (which does not mean that in the future they will not have such significance).

Kaminsky and Reinhart (1998) highlight additional disadvantages of this model: inability to rank the variables predicting speculative attacks in the best way in order to reduce the probability of false signals; uncertainty of the depth of macroeconomic imbalances which impedes initiation of preventive measures.

Indicators

Macroeconomic and Monetary Indicators

Share of budget deficit in GDP

This reflects the probability of a shock on the fixed exchange rate caused by increased money demand by the government. Under a currency board, excessive demand cannot be met by the central bank. In similar situations governments often resort to state banks as they exercise direct or indirect control over them. This leads to a disequilibrium in the forex market, an increase in interest rates, pressure on borrowers for advance repayment of loans, deterioration of bank profitability and prerequisites for insolvency.

Share of government expenditure in GDP

A high share of government expenditure in GDP may prompt irrationality and imbalances in the balance of payments current account since supply would be unable to meet dramatically increased government spending.

Share of public sector credit in domestic credit

Government as an indirect borrower (through public enterprises) is a potential source of moral hazard which may threaten the banking system solvency and prompt unreasonable use of resources. Although public sector ownership is beyond government commitments, public sector obligations are directly or indirectly guaranteed by the govern-

ment and the guarantee often transforms into government budget expenditure.

Gap between money demand and supply

Imbalances between money demand and supply lead to general economic instability with sources of different nature. Under a fixed exchange rate, this would impact interest rates. If any attempt to manipulate the interest rate is made, its balancing role worsens to be replaced by the shadow exchange rate.

Money supply growth

Fast growth rate of money supply coupled with the lack of increase in forex reserves (net foreign assets of the monetary authorities) indicate a lending boom which, under a fixed exchange rate, may lead to an increased consumption and deteriorating balance of payments current account.

M2 monetary aggreagate/gross international forex reserves ratio

This ratio reflects the extent of central bank forex reserves cover for broad money and indicates the degree of conversion of bank deposits into foreign currency under a fixed exchange rate as a result of a possible run on the banking system. This indicator shows the ability of the economy to respond to liquidity shocks as a result of withdrawal of deposits from the banking system and/or portfolio investment.

Indicators reflecting the balance of payments state

These are general indicators characterizing the state of individual items in the balance of payments. As a rule, they should not be reviewed separately due to their interdependence. For instance, a huge current account deficit does not necessarily threaten the exchange rate. If this deficit is funded by inflow of foreign investment or credits, the extent of their reversibility should be analyzed in order to estimate the vulnerability of the exchange rate maintained.

Current account as a share of GDP

The share of the balance of payments current account in GDP characterizes the extent of foreign financing in a particular economy. Levels exceeding 3.5% deficit in GDP are considered critical. If this deficit is funded by a capital account surplus (mainly by direct foreign investment), the fixed exchange rate may be considered less vulnerable to speculative attacks irrespective of the higher level than the critical deficit.

Real exchange rate

Deviation of the current exchange rate level from the long-term

trend is a reliable indicator of a particular country's competitiveness. Dornbusch, Goldfain, Valdes (1996) argue that in a period prior to a currency crisis, the real exchange rate is overvalued relative to its average value in 'tranquil' periods. In case of devaluation this deviation immediately reverses its direction which clearly shows that the initial overvaluation is not due to changes in consumers' preferences or any productivity shocks.

There are two possible reasons behind the real appreciation of the exchange rate: *first*, inflation (money supply growth reflecting increased investment requirements of the economy); and *second*, a positive differential in the profitability of the factors of production in macroeconomic terms. The first reason worsens the ability to protect the fixed exchange rate, while the second one has a positive effect. Under high capital flows mobility and comparable rates of return at the same degree of risk, labor productivity is of key importance.

Imports and exports dynamics

The volume of foreign trade as a share of GDP indicates the degree of an economy's openness. Other conditions being equal, the more open the economy, the stronger the impact of international commodity and capital markets, and hence the more vulnerable the economy to external shocks related to changes in these markets. The analysis of this indicator should be closely tied both with prices of major export items which reflect the state of commodity markets, and physical indicators measuring terms of trade.

Prices of major export items

Along with the above indicator, prices of major commodity items are of key significance for the compilation of the trade balance. Price fall in major export groups is one of the channels for transmission of external shocks in the economy and crisis contagion from countries with similar commodity structure of exports.

Capital Account

Gross international reserves/monthly imports ratio

This ratio reflects the degree of gross foreign exchange reserves cover for imports and shows the degree to which import needs of the economy can be met. It indicates the liquidity of the economy in general.

Portfolio investment/balance of payments current account balance

This indicator measures the degree of short-term deficit financing

of the current account. An eventual withdrawal of portfolio investment may lead to a depletion of central bank forex reserves and correspondingly to enhance the probability of an attack on the fixed exchange rate due to inconsistency caused by the short-term nature of portfolio investment and the long-term nature of current account deficit.

Direct investment/balance of payments current account balance

Similar to the preceding indicator, this one measures to what extent the current account deficit is financed by direct investment which, unlike portfolio investment, has lower degree of collectibility and its conversion into cash is more difficult.

Indicators driven by the foreign debt state

The share of foreign debt and payments on foreign debt service in GDP directly correspond to the country's ability to react against a possible attack on the fixed exchange rate using its forex reserves. Other conditions being equal, the bigger the foreign debt, the higher the risk of an attack on the fixed exchange rate, since governments prefer to preserve a portion of their gross forex reserves for repayment of future obligations.

Dynamics of public and publicly guaranteed foreign debt

The share of foreign government debt in GDP reflects the amount of a country's payments on foreign debt service. The bigger the indebtedness, the higher the expenditures on principal and interest repayments. This suggests that a country should allocate a significant portion of its gross foreign reserves on foreign debt repayment.

Maturity structure of foreign debt

Maturity structure of foreign debt is directly connected with the preceding indicator. The bulk of short-term loans in the structure of foreign debt reflects a greater concentration of payments within a shorter term, hence an increased need for foreign exchange reserves.

Short-term foreign debt/gross forex reserves ratio

This indicator displays vulnerability and liquidity of the economy to a possible speculative attack.

Expenditure on foreign debt service (as a portion of export revenue or share in foreign exchange reserves)

If export revenues are high, the bulk of fixed foreign debt payments can be covered by them, thereby releasing the burden on foreign exchange reserves and reducing the probability of an attack on the fixed exchange rate.

Monetary and Credit Indicators

Indicators Associated with Financial Liberalization

Financial liberalization is realized through various channels. A number of economists, among them McKinnon and Pill (1994), assume that full (open or hidden) guarantee on deposits may cause a boom in bank lending resulting in a banking crisis. *Increased interest rate volatility*, and hence capital flows, may be another consequence of financial liberalization. Liberalization results directly in a dramatic credit growth boosting fast economic growth. Usually the outcome of such a growth (based on consumption growth) is financial or foreign exchange collapse induced by rapid price rises in assets and a dramatic consecutive fall, which deteriorates commercial bank balance sheets.

Indicators of *financial liberalization* include: credit growth, multiplier variation, real lending rate, interest rate differential between assets and liabilities operations, consumer credit growth.

Credit as a share of GDP

Credit growth is a result of financial liberalization. While this fact itself is not a cause for concern, the structure of credit flows by use plays an important role. Very often lending boom is directed to customers. In countries where production capacities prove insufficient to immediately increase supply, or the national economy is uncompetitive, credit expansion often results in increased imports which directly worsens the balance of payments current account.

Share of private sector credit in GDP

According to Pill and Pradhan (1995), financial liberalization developments are best described by the private sector credit/GDP ratio. The higher the share of private sector credit, the higher the extent of liberalization in the financial system.

Increase in real interest rates

The abolition of interest rate ceilings on deposits and credits enhances commercial bank competitiveness in attracting resources, resulting in increased interest rates on liabilities operations. To compensate for the higher cost of attracted resources, banks have to raise real lending rates. This worsens borrowing firms' cash flows, generating bad loans which reflect on the state of the banking system and may erode its credibility. This may grow into a systemic crisis affecting sound banks.

Interest rate differential between assets and liabilities operations

The relationship between financial sector liberalization and the interest rate differential is straightforward. Commercial banks' pursuit of a maximum profit leads to an increase in the differential between assets and liabilities operations. This is typical of countries with underdeveloped capital markets (like Bulgaria), being an alternative funding source.

Money Multiplier variation

Money multiplier variations are indicative of the extent of economic liberalization due to enhanced volatility of commercial bank reserves and the currency outside banks/deposits ratio.

Indicators Relating to the State of the Banking System

Total amount of attracted deposits to deposits of nonresidents

This ratio measures liquidity and indicates vulnerability of a banking system in case of a run on deposits by nonresidents. Under worsened solvency of the banking system or a part of it in the context of a general liquidity shortage, this ratio may be become a signal for massive withdrawal of other depositors' funds.

Share of bad loans in banking system assets

This is a classical indicator for the state of commercial bank portfolio. The amount of commercial bank portfolio should be interpreted in compliance with capital adequacy indicators, since losses incurred from bad loans may be compensated by the capital reserves of the banking system.

Commercial bank net interest income to total financial assets

Net interest income is the major income source for a typical commercial bank. The amount of net interest income in absolute terms is indicative of banks' ability to efficiently reach a profitability level which will ensure bank stability in the future. Low values of this ratio signal problems in principal banking activity or shift to other activities.

Provisions on risk exposures classified as loss to pre-tax profit

If the share of the financial result allocated to provisions is large, this is indicative of an excessively high credit risk taken by the bank. This may worsen a bank's solvency in case of a persistent profitability crisis.

It should be noted that an excessively high capital adequacy represses bank profitability, and sometimes the high capital adequacy ratio reported does not necessarily mean a high capital base. It is likely

the degree of assets risk indicator to be deliberately undervalued in assets classification.

Share of deposits attracted in the interbank money market in total deposits

This indicator measures the degree of bank independence from the money market, being a short-term and extremely unreliable source of funds due to the high degree of collectibility of other banks' deposits.

According to Kaminsky, Lizondo, Reinhart (1998), indicators characterizing the state of the balance of payments are: the share of the current account balance in GDP; the real exchange rate; the trade balance; terms of trade; prices of major export items. Also, indicators reflecting the degree of financial liberalization may be used as very reliable warning signals of a currency crisis. In support of this, we add the conclusions of this study: exports growth, the size of real interest rates and the M2/foreign exchange reserves ratio send the most accurate signals of a currency crisis.

Appendix 3

Data Used and Results Obtained from the Empirical Test

Table 2

Model 1. PROBABILITY OF AN ATTACK ON THE USD/BGL EXCHANGE RATE

Dependent Variable: CR_0
Method: ML – Binary Probit
Date: 12/23/98 Time: 14:28
Sample(adjusted): 1996:04 1998:07
Included observations: 28 after adjusting endpoints
Convergence achieved after 6 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-2.225697	0.937008	-2.375324	0.0175
DREER(-1)	-5.149370	2.718864	-1.893941	0.0582
I_0(-1)	0.221892	0.143315	1.548276	0.1216
KA(-1)	-0.024713	0.012373	-1.997314	0.0458
Mean dependent var	0.285714	S.D. dependent var		0.460044
S.E. of regression	0.280050	Akaike info criterion		0.683542
Sum squared resid	1.882277	Schwarz criterion		0.873857
Log likelihood	-5.569587	Hannan-Quinn criter.		0.741723
Restr. log likelihood	-16.75155	Avg. log likelihood		-0.198914
LR statistic (3 df)	22.36392	McFadden R-squared		0.667518
Probability(LR stat)	5.48E-05			
Obs with Dep=0	20	Total obs		28
Obs with Dep=1	8			

Table 3

Model 2. PROBABILITY OF AN ATTACK ON THE DEM/BGL EXCHANGE RATE

Dependent Variable: CR_1
Method: ML – Binary Probit
Date: 12/23/98 Time: 14:28
Sample(adjusted): 1996:04 1998:07
Included observations: 28 after adjusting endpoints
Convergence achieved after 6 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-2.237707	0.944710	-2.368671	0.0179

I_1(-1)	0.237963	0.149708	1.589519	0.1119
DREER(-1)	-5.212602	2.740715	-1.901913	0.0572
KA(-1)	-0.024774	0.012652	-1.958224	0.0502

Mean dependent var	0.285714	S.D. dependent var	0.460044
S.E. of regression	0.278710	Akaike info criterion	0.678078
Sum squared resid	1.864299	Schwarz criterion	0.868393
Log likelihood	-5.493088	Hannan-Quinn criter.	0.736259
Restr. Log likelihood	-16.75155	Avg. log likelihood	-0.196182
LR statistic (3 df)	22.51692	McFadden R-squared	0.672085
Probability(LR stat)	5.09E-05		
Obs with Dep=0	20	Total obs	28
Obs with Dep=1	8		

Table 4

VALUES OF SPECULATIVE ATTACK INDICES AND THEIR COMPONENTS (CHANGE IN FOREX RESERVES, THE INTEREST DIFFERENTIAL AND THE EXCHANGE RATE)

obs	*DER*	DER_1	*DRES*	ID_0	ID_1	I_0	I_1
1991:12	NA	0.238666	NA	9.763209	4.344995	NA	NA
1992:01	0.092160	0.033609	-0.043210	11.22222	4.288462	2.553158	0.792204
1992:02	0.013434	-0.008550	-0.029032	11.22222	4.283381	2.447733	0.469685
1992:03	-0.035626	-0.039248	0.562686	11.22222	4.248092	-1.952267	-4.090587
1992:04	-0.011598	-0.013216	0.079893	11.22222	4.208333	1.637771	-0.369486
1992:05	0.008257	0.018980	0.064553	11.22222	4.188679	1.751837	-0.091263
1992:06	-0.007759	0.064877	0.060152	11.22222	4.188679	1.784563	0.177419
1992:07	-0.011295	0.010231	0.127433	11.43781	3.703669	1.327138	-0.637532
1992:08	-0.023726	0.032016	0.124023	10.50000	3.299065	1.165986	-0.528304
1992:09	0.018902	0.003735	-0.001884	9.500000	2.988604	1.903345	0.240961
1992:10	0.049028	-0.029078	0.016186	9.500000	3.272635	1.768977	-0.042356
1992:11	0.040000	0.001104	-0.112000	9.500000	3.307692	2.722168	1.068439
1992:12	-0.008502	-0.015574	-0.029118	9.500000	3.298874	2.105862	0.365775
1993:01	0.044508	0.069875	0.012096	11.00000	3.984424	2.097709	0.546257
1993:02	0.040266	0.003266	-0.034709	12.00000	4.467928	2.644625	0.585466
1993:03	-0.003382	0.000553	-0.025695	12.00000	4.585392	2.577603	0.512663
1993:04	-0.004525	0.026332	0.076769	12.00000	4.745856	1.815680	-0.105574
1993:05	0.000379	-0.010406	0.046561	12.00000	5.025492	2.040310	-0.050377
1993:06	0.010223	-0.049798	-0.015061	11.25000	4.697674	2.349371	0.182542
1993:07	0.019865	0.006933	-0.115433	11.25000	4.939394	3.095730	1.237355
1993:08	0.007718	0.038340	0.024291	10.25000	4.769231	1.857871	0.348012
1993:09	0.022247	0.059979	-0.003808	10.25000	4.806452	2.066815	0.670791
1993:10	0.052801	0.003214	-0.083319	10.25000	4.897772	2.658054	0.976545
1993:11	0.056252	0.039071	-0.019809	12.25000	6.230559	2.583548	0.781274
1993:12	0.049406	0.045199	-0.071456	12.25000	6.517730	2.967599	1.216793
1994:01	0.110364	0.109139	-0.047069	13.25000	7.142857	2.985131	1.407618
1994:02	0.028910	0.039559	-0.027757	13.25000	7.142857	2.841527	0.906304
1994:03	0.737758	0.768433	0.057210	14.75000	8.170306	2.508032	4.093077
1994:04	-0.124115	-0.120999	0.305231	14.75000	8.516616	0.663759	-2.299721
1994:05	-0.022679	-0.007112	0.066710	13.85849	9.000000	2.260091	0.093012
1994:06	-0.034718	0.005713	0.094838	13.00000	9.413223	1.880197	-0.021491

1994:07	-0.006523	-0.000765	-0.385270	13.00000	9.696095	5.450268	3.534941
1994:08	0.072782	0.069834	-0.047878	12.23529	9.769231	2.789350	1.394142
1994:09	0.070117	0.088456	0.253098	13.60000	11.47863	0.822706	-0.629345
1994:10	0.060784	0.099125	0.141499	13.60000	11.47863	1.652557	0.255353
1994:11	0.001848	-0.042228	0.042986	12.51852	11.47863	2.170014	0.261196
1994:12	0.015068	0.020014	0.047284	11.69565	11.47863	1.974400	0.549220
1995:01	0.009543	0.037783	-0.078478	11.69565	11.47863	2.909563	1.575732
1995:02	-0.015154	0.023288	0.064885	10.68000	11.47863	1.641535	0.435175
1995:03	0.007922	0.045693	0.116655	10.68000	11.47863	1.256571	0.165398
1995:04	-0.013906	0.006045	0.123121	8.760000	10.07078	0.826646	-0.184379
1995:05	0.010883	0.002298	0.072690	7.800000	8.981851	1.010725	0.095661
1995:06	0.001668	-0.002272	0.045003	6.840000	7.909091	1.025683	0.203475
1995:07	0.002422	0.007843	-0.018741	5.400000	6.272727	1.213295	0.615723
1995:08	0.026578	-0.047907	-0.008451	4.600000	5.363636	0.977677	0.189398
1995:09	0.000588	0.051768	-0.009602	4.600000	5.457565	0.986240	0.716921
1995:10	0.009115	0.026532	0.018186	4.600000	5.809339	0.779607	0.405003
1995:11	0.017045	0.003175	-0.057922	4.600000	5.944444	1.345544	0.860253
1995:12	0.012749	0.001237	-0.075478	4.600000	6.014028	1.476094	0.985679
1996:01	0.044979	0.007740	-0.181459	4.600000	6.186858	2.264165	1.819195
1996:02	0.029643	0.043630	-0.075792	5.880000	8.207709	1.732991	1.358448
1996:03	0.036282	0.027184	-0.185138	7.333333	10.57407	2.835116	2.251482
1996:04	0.134340	0.085320	-0.016581	10.33333	14.81395	2.178366	1.591710
1996:05	0.644375	0.662462	-0.029453	17.16667	24.34884	3.633076	5.317337
1996:06	0.057263	0.061850	-0.029467	17.16667	24.34884	3.633182	2.229683
1996:07	0.203782	0.244640	-0.106152	17.16667	24.34884	4.203408	3.739637
1996:08	0.079352	0.075743	0.086692	17.16667	24.70755	2.769428	1.462289
1996:09	0.138571	0.107407	-0.089806	49.16667	74.25000	10.44595	6.381422
1996:10	0.041960	0.029249	0.024731	39.16667	59.25000	7.605480	4.085197
1996:11	0.460001	0.463532	-0.000375	29.16667	44.25000	5.803390	5.461833
1996:12	0.392986	0.375367	-0.008256	29.16667	44.25000	5.861994	5.067178
1997:01	1.096850	0.985149	-0.129729	31.89256	48.75000	7.307381	9.418168
1997:02	1.001664	0.945354	0.039133	32.16667	48.75000	6.106241	7.957926
1997:03	-0.223319	-0.221150	0.152586	34.34202	53.25000	5.695235	1.430072
1997:04	-0.076100	-0.094977	0.712366	11.22042	17.85000	-3.065641	-4.544580
1997:05	0.068334	0.078872	0.095410	6.190865	10.02000	0.521759	0.392551
1997:06	0.095976	0.074961	0.066875	0.878378	1.685990	-0.322589	0.005301
1997:07	0.072850	0.009469	0.136445	0.059406	0.550725	-1.002789	-0.927641
1997:08	-0.018874	0.000000	0.103490	0.119086	0.610329	-0.745863	-0.727120
1997:09	-0.025539	0.000000	0.076744	0.177554	0.631090	-0.535353	-0.526794
1997:10	-0.024847	0.000000	0.062625	-0.013445	0.281659	-0.468350	-0.446097
1997:11	0.027923	0.000000	0.005829	0.121951	0.455696	-0.019088	-0.011664
1997:12	0.005376	0.000000	0.040588	0.241883	0.613924	-0.253706	-0.259135
1998:01	0.018407	0.000000	-0.067698	0.160920	0.547046	0.535401	0.541425
1998:02	0.006080	0.000000	0.085735	0.068740	0.447894	-0.623851	-0.606387
1998:03	0.007966	0.000000	0.026112	0.048093	0.398230	-0.184600	-0.166482
1998:04	-0.020003	0.000000	0.017228	0.061667	0.375810	-0.115844	-0.101983
1998:05	-0.008676	0.000000	0.100548	0.014925	0.321814	-0.744705	-0.725303
1998:06	0.015597	0.000000	0.006480	0.035058	0.359649	-0.041213	-0.023185
1998:07	-0.022760	0.000000	0.004827	0.040268	0.365639	-0.027888	-0.010480
1998:08	0.012889	0.000000	-0.060388	0.030303	0.360000	0.455074	0.474072
1998:09	-0.066190	0.000000	0.014956	0.059233	0.354120	-0.099433	-0.086597
1998:10	-0.015360	0.000000	0.016742	0.236220	0.374179	-0.077515	-0.098483
1998:11	0.033445	0.000000	8.80E-05	0.117647	0.313175	0.022743	0.021116
1998:12	-0.016152	0.000000	0.077320	0.121771	0.388128	-0.550732	-0.547969

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