4. A SIMPLE MODEL OF THE BULGARIAN EXPERIENCE: CURRENCY AND ASSET SUBSTITUTION DURING THE CRISIS

This chapter provides a *simple* theoretical framework to help understand the crisis episodes described in Chapter 3. We introduce a standard model of asset substitution to illustrate an important component of the Bulgarian financial crisis: the repeated shifts in the composition of households' portfolio shortly before and during the financial panic of 1996 – 1997.

In Section 4.1, we provide empirical evidence on currency and asset substitution in Bulgaria. A detailed description of the model can be found in Section 4.2. The estimating equations, data requirements and data sources are provided in Section 4.3. Section 4.4 closes the chapter with a summary of empirical findings and a few concluding remarks.

4.1 Currency and Asset Substitution in Bulgaria

The magnitude of asset substitution during the Bulgarian crisis has been addressed in Chapters 1 through 3. In this section, we rearticulate some of the empirical evidence provided in those chapters, and recast it within a more formal analytical framework.

4.1.1 Currency Substitution, Asset Substitution and Financial Panics: A Few Notes

For both theoretical and empirical reasons, it is important to distinguish between *currency* substitution and the (broader) concept of *asset* substitution. Currency substitution occurs when a foreign currency replaces the domestic currency as a medium of exchange. The extent of currency substitution can be evaluated through a variety of indicators. For example, Feige (2003) defines a Currency Substitution Index as the ratio of foreign currency in circulation (foreign notes) to the sum of domestic and foreign currency in circulation (page 20). Asset substitution, on the other hand, implies the use of foreign denominated monetary assets as stores of value. An Asset Substitution Index can be defined as the ratio of foreign-currency denominated (monetary) assets to domestic-currency denominated (monetary) assets, *excluding currency outside banks* (page 21).[168]

In the literature, currency substitution is generally defined as the demand for foreign fiat money by domestic residents; including both foreign currency notes and foreign currency deposits (held domestically or abroad). In this paper, part of foreign currency deposit holdings could in fact be characterized as asset substitution (demand deposits denominated in foreign currency could be viewed as "currency;" while time and savings deposits could be interpreted as monetary "assets"). As evidenced in Chapter 3, Bulgaria experienced both currency and asset substitutions over the last decade. How did the substitution indices behave in periods of heightened

[168] The IMF uses a "dollarization index," defined as the ratio of foreign currency deposits to broad money; Feige defines a "comprehensive dollarization index," where an estimate of foreign currency in circulation is added to the numerator and denominator of the IMF's index.

instability? Can we use data on the composition of Bulgarians' portfolio to better understand the financial panic of 1996-1997 and, in particular, comment on the formation of expectations during that period? But first, and more generally, how are the concepts of asset substitution and financial crises related?

Empirical evidence[169] suggests that the extent of currency substitution is determined by the level of real wealth, the volume of international transactions, certain institutional factors (such as the development of domestic financial markets, or the transaction costs incurred in the exchange of currencies) and, more importantly, by the difference between the real rate of return on domestic and foreign money. [170] The latter is commonly approximated by the expected rate of depreciation of the domestic currency. Standard portfolio-theoretic models of currency substitution (where a lifetime utility maximizing agent allocates her wealth between domestic and foreign monies -- and domestic and foreign non monetary assets) also suggest that expected depreciation is an important determinant of foreign currency holdings.[171]

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[169] Summarized in Ramirez-Rojas (1986)

[170] Other factors may exacerbate foreign currency holdings, such as inflation uncertainty (variability in the inflation rate), large negative real interest rates on domestic interest-bearing assets, or political risk.

[171] This financial approach to currency substitution, however, has been criticized. Thomas (1985), for example, observes that if borrowing opportunities exist in all currencies, a risk-less position can always be constructed by holding money in association with like-denominated liabilities. As a result, currency substitution cannot be explained by standard portfolio theory. The degree of currency substitution depends on real, rather than financial, factors, "on the form of an engineering production function" (page 352). Asset holdings, on the other hand, can still be accounted for by exchange rate expectations and the standard portfolio choice model. In other words, "portfolio theory is useful for explaining capital mobility, but not currency substitution" (page 354).

Dominant drivers of asset substitution *during financial panics* include the fear of deposit losses, expected depreciation and inflation, or both.[172] A financial panic, by definition, implies a *rapid* reallocation of households' portfolio; from bank deposits to currency outside banks (during a banking panic), or from assets denominated in domestic currency to assets denominated in foreign currency (during a currency crisis). What happens when both domestic banks and the domestic currency are under attack (during a "twin crisis")? Does a fragile banking system necessarily imply a preference for foreign notes? Some of these questions have been answered, albeit incompletely, in empirical analyses of asset substitution. For example, Feige (2003) observes that in transition economies, improvements in the banking system (as measured by an index of banking sector reforms) were inversely related to both currency substitution and asset substitution;[173] suggesting that greater confidence in the banking system induced not only a shift from foreign currency in circulation to foreign currency deposits; but also a shift from foreign currency deposits to domestic currency deposits.[174]

For the purpose of this paper, can we estimate a standard model of asset substitution while accounting for "structural breaks?" Can a financial panic be viewed as a "break" in an otherwise stable portfolio choice equation? How would an asset substitution model perform in addressing the Bulgarian crisis?

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[172] See Diamond and Dybvig (1983), Krugman (1979) and most other models presented in Chapter 1.

[173] From cross-country correlations

[174] Inversely, a decline of confidence in the banking system would lead to a shift of bank deposits into foreign currency in circulation, and a shift from domestic deposits into foreign currency deposits.

4.1.2 Evidence of Asset Substitution and Capital Flight in Bulgaria

As illustrated in Chapter 3, the Bulgarian economy went through periods of intense shifts in monetary asset holdings; with in particular:

- Rapid increases in foreign currency deposits (held in domestic banks), *shortly* before the March 1994 currency crash and through most of 1994 (Section 3.1);
- Reductions in both Lev and foreign currency deposits (held in domestic banks) in late 1995 and through most of 1996 (Section 3.4);
- Shifts in the composition of domestic currency deposits, with an increased preference for more liquid assets during periods of instability (Section 3.4 - Table 9);
- Shifts in the *composition* of foreign currency deposits (held in domestic banks) in late 1995 and through most of 1996 (discussed below);
- Increases in foreign cash holding, through most of 1996.

Of these, what is currency substitution? What is asset substitution? And what constitutes "capital flight"? Again, following Feige (2003) taxonomy, the use of foreign currency notes (and demand deposits) for transaction motives would constitute "currency substitution." The use of foreign currency deposits as a store of value (to hedge against expected inflation) would imply "asset substitution;" although, anecdotal evidence suggests that in the midst of the financial panic a substantial amount of foreign notes were held "under the mattress," as store of value. As discussed in Section 3.4, so-called "capital flight" includes both resident capital flight (withdrawal of foreign currency deposits held in domestic banks) and capital flight abroad (when financial assets are transferred to foreign banks abroad, or physically flee the country). Capital outflows are notoriously difficult to estimate. Estimates for

Bulgaria range from $1 billion in 1996 alone (see Table A-11 in the Appendices), to $7 billion in 1996-1997; both estimates are extremely large when related to Bulgaria's GDP of about $10 billion (in 1996).

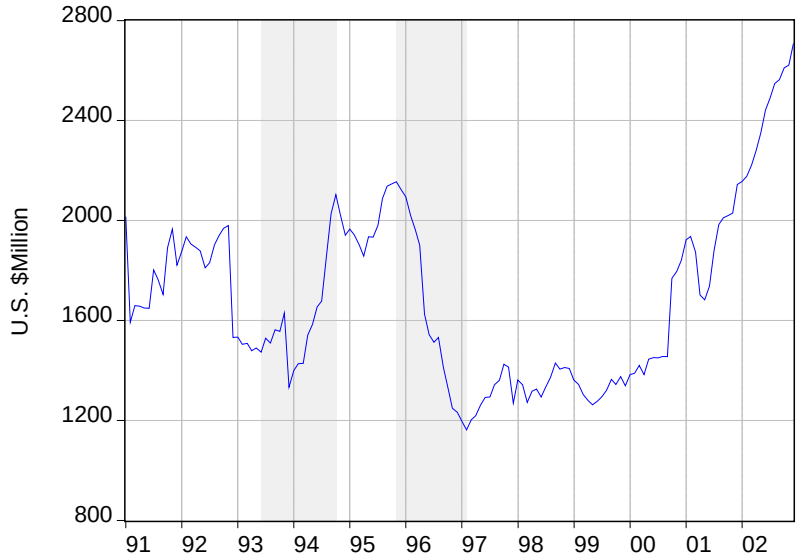
4.1.2.1 Foreign Currency Deposits Held in Domestic Banks

Foreign currency deposits in Bulgarian banks are displayed in Figure 26 below, from January 1991 through December 2002. The data was extracted from the BNB monetary surveys. Rapid increases in foreign currency deposits are evident from January 1994 through October 1995, and after January 2000 (along with the remonetization of the economy and renewed confidence in the banking system). Over the period, the most dramatic decline in those deposits occurred between November 1995 and February 1997.[175]

The portfolio shifts prevalent shortly before, and after, March 1994 can be explained by fears of depreciation associated with the level of foreign exchange reserves and reductions in the base interest rate. Other factors were important as well, as explained in Section 3.1. The rapid decline in deposits from late 1995 through early 1997 is, evidently, associated with the banking crisis endemic during that period.

[175] The abrupt fall of December 1992, shown in the chart, remains unexplained.

Figure 26: Foreign Currency Deposits in U.S. Dollars, January 1991 – December 2002, Millions of U.S. Dollars

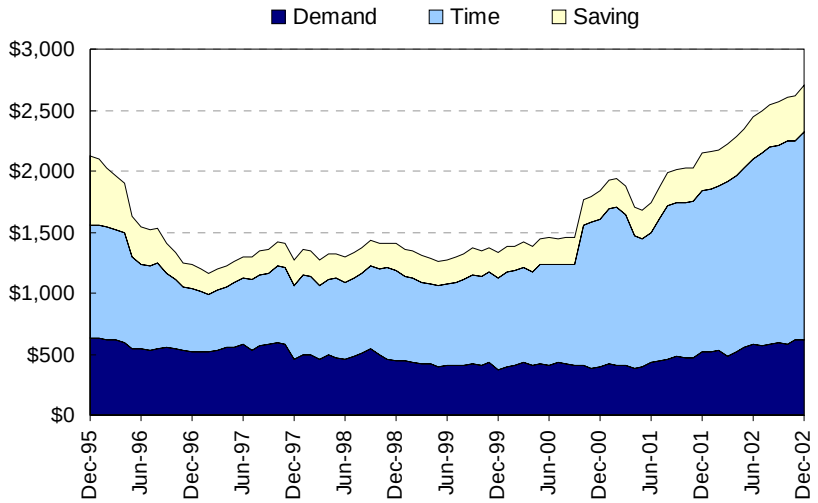


Source: BNB, Monetary Survey

Standard measures of dollarization (such as the IMF's ratio of foreign currency deposits to broad money) further highlight the difference between the two currency crises (March 1994 vs. 1996-1997). Although foreign currency deposits expressed in U.S. dollars were *decreasing* after November 1995; the ratio of foreign currency deposits to broad money increased sharply during that period. As discussed in Section 3.6.5, foreign currency deposits represented about 50 percent of broad money at the end of 1996; and 65 percent on the eve of the near-hyperinflation episode (see also Table A-6 in the Appendices). The main driver for changes in the dollarization ratio during that period was the exchange rate. This is something to keep in mind when interpreting the results provided later in this chapter.

Changes in the structure of foreign currency deposits from December 1995 through December 2002 are shown in Figure 27 and Figure 28, below.[176] As shown in Figure 27, demand deposits in foreign currency remained *relatively* flat throughout the period, possibly reflecting the stability of foreign currency holdings for (international) transaction purposes. On the other hand, both time and savings deposits (the majority of which were held by households[177]) declined sharply from December 1995 through February 1997.

Figure 27: Foreign Currency Deposits, Structure by Deposit Type, December 1995-December 2002, Millions of U.S. Dollars



Source: BNB, Monetary Survey

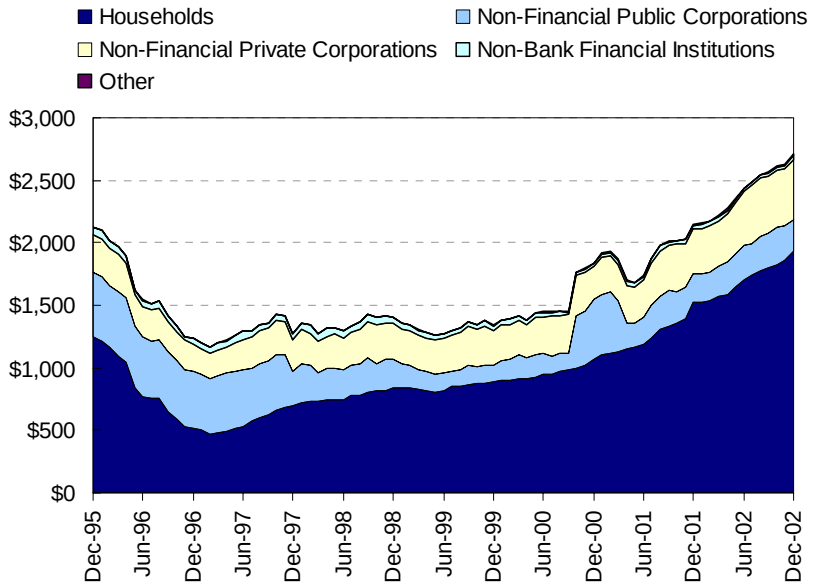
Changes in foreign currency deposits by economic sector (households, non-financial public corporations, non-financial private corporations, non-bank

[176] The breakdown of deposits by deposit type and economic sector is available from the BNB for deposits after December 1995 only.

[177] Households held the totality of savings deposits denominated in foreign currency; and about 65 percent of time deposits (average over 1996).

financial institutions, and others -- local government and social security funds) are shown in Figure 28, below.

Figure 28: Foreign Currency Deposits, Structure by Economic Sector, December 1995-December 2002, Millions of U.S. Dollars



Source: BNB, Monetary Survey

Again, variations in foreign currency deposits were primarily driven by the behavior of households. The deposits held by non-household sectors varied relatively little during the period.

4.1.2.2 Foreign Currency Deposits Held Abroad

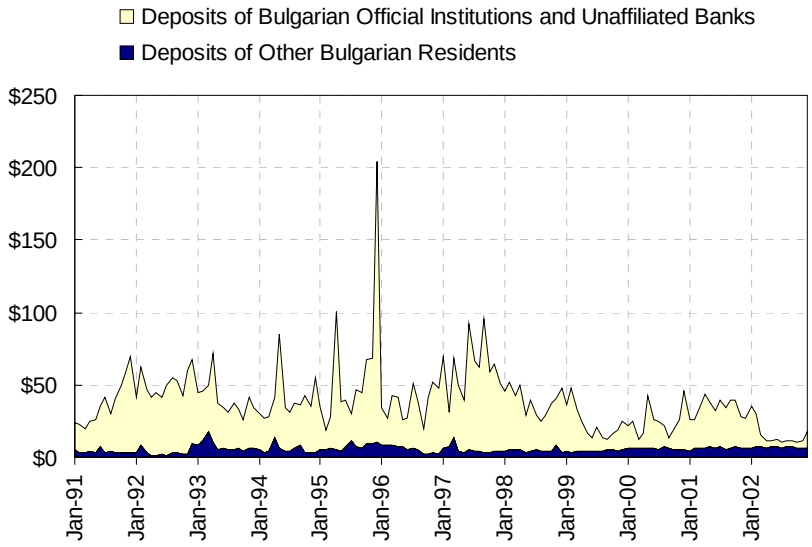
A non-negligible fraction of Bulgarian households reportedly held deposits in foreign banks abroad. Detailed time series on these deposits, however, are

difficult to access.[178] The only monthly data series that could be retrieved for this study are those provided through the International Capital System of the U.S. Treasury Department: U.S. banking liabilities to foreigners.[179] Two of these series (deposits of Bulgarian Official Institutions and Unaffiliated Banks, and Deposits of Other Bulgarian Residents) are plotted in Figure 29 below, for the period January 1991 – December 2002.

[178] The Internal Monetary Fund collects and publishes data on foreign currency deposits held abroad, by country of origin of residents. Unfortunately, Bulgaria is not among the reporting countries (see http://www.imf.org/external/np/sta/ir/colist.htm). A few data series are available from the European Central Bank (http://www.ecb.int/pub/pdf/mb200312en.pdf) and the Deutsche Bundesbank (http://www.bundesbank.de/stat/download/stat_sonder/statso9_en.pdf); but these are not broken down by country of origin.

[179] Available at http://www.ustreas.gov/tic/ticliab.html; the data series are constructed from submissions of monthly reports by banks and other depository institutions in the U.S., International Banking Facilities, bank holding companies, and other brokers and dealers in the U.S. who have liabilities to foreign residents.

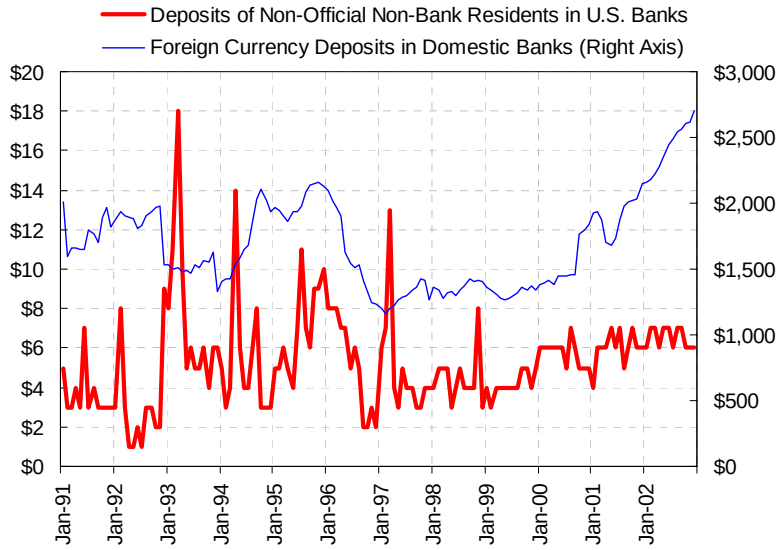
Figure 29: Dollar Deposits in U.S. Commercial Banks, January 1991-December 2002, Millions of U.S. Dollars



Source: U.S. Treasury Department, Treasury International Capital Reporting System

The deposits of non-official Bulgarian residents (possibly households) in U.S. commercial banks are *extremely* small (they never exceeded $20 million over reporting period). The deposits of official institutions and unaffiliated banks are of limited interest as they probably encompass part of the foreign exchange reserves of the central bank. How do the deposits of non-official Bulgarians in U.S. banks compare to those held domestically? As shown in the figure below, the series on deposits held in U.S. banks is extremely volatile (and probably contains more noise than information). The two series, however, *seem to vary together*, with an increase in deposits held abroad in 1994-1995, and a decline through most of 1996. There are four notable exceptions, with four peaks in U.S. banks deposits: in March 1993, *April* 1994, July 1995 and *March* 1997.

Figure 30: Dollar Deposits in U.S. Commercial Banks and Foreign Currency Deposits Held Domestically, January 1991-December 2002, Millions of U.S. Dollars



Sources: U.S. Treasury Department, Treasury International Capital Reporting System and BNB Monetary Survey

Contrary to expectations, there are no signs of capital inflows (into the U.S. banking system) in 1996 – early 1997. The use of data series from German or other European banks might have provided a different picture.

4.1.2.3 Foreign Currency Cash

Foreign currency cash holdings are extremely difficult to evaluate. Potential data sources have been discussed in Feige (2003) and U.S. Treasury Department (2003). They include:

- Interviews of residents and local experts (such as those conducted by the U.S. Treasury Department for its report to the Congress on the use and counterfeiting of dollars abroad [180]);
- Customs data on cross-border currency flows (such as those compiled from the U.S. Customs' Currency and Monetary Instruments Reports (CMIR));
- Balance of Payments statistics (under the "Currency and Deposits" item of the Financial Account - Other Investment Assets); and
- Indirect methods (such as the denomination displacement method, the seasonal method, or the biometric method).

Unfortunately, there are no time series available for Bulgaria over the period of interest (1991 – 1997). Two point estimates have been found instead, both restricted to holdings of U.S. dollars: Feige (2003), based on "adjusted" CMIR data; and U.S. Treasury Department (2003), based on interviews with Bulgarian officials conducted in November 1997.

These estimates, shown in Table 15 below, are surprisingly similar: $1.1 billion for Feige, and $1.0 billion for the U.S. Treasury (or about $120 per habitant).

[180] The teams led by the U.S. Treasury Department interviewed officials from U.S. embassies, consulates, and related institutions; officials of the host country finance ministries and central banks; counterfeiting enforcement officials; currency dealers and handlers at banks, currency exchanges, and valuables handling services; and various trade associations representing these groups; U.S. Treasury Department (2003), page 13.

Table 15: Estimates of Foreign Currency in Circulation, *Dollars Only*

Source	Dollars in Circulation ($Million)	Holding Per Capita ($)
Feige (2002), page 13 Based on CMIR data *(adjusted)* Estimate for 2001	$1,100	$125
U.S. Treasury Department (2003), page 26 Based on Interviews November 1997 Visit	$1,000	$120

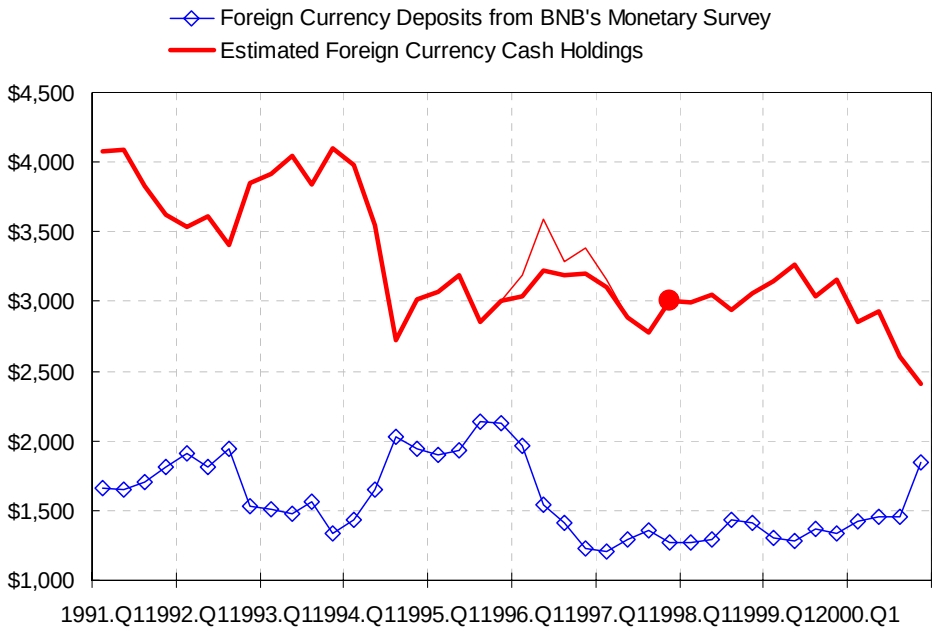
Furthermore, using statistics reported in Feige (2003),[181] we could infer that U.S. dollars represented about *one third* of foreign currencies in circulation in late 1997, resulting in a total $3.0 billion worth of foreign notes (denominated in U.S. Dollars, Deutsche Marks, Swiss Francs or others).

This point estimate was combined with balance-of-payments statistics on "Currency and Deposits" (*net of* foreign currency flows in and out of Bulgarian commercial banks, obtained from the BNB) to derive a (very crude) quarterly series on foreign cash holdings over the period of interest. This series is shown in Figure 31, below.

Note that balance-of-payments statistics are restricted to recorded transactions between residents and non-residents; the "Currency and Deposits" item (on the assets side) cover both foreign currency - notes and coins - held by residents, and deposits denominated in domestic or foreign currencies.

[181] U.S. dollars represented about 18% of foreign currencies in circulation in Croatia, 37% in the Czech Republic, 30% in Hungary, 14% in Slovenia, and 31% in the Slovak Republic. These estimates were based on survey data averaged over 1997-2001. Feige (2003), page 12.

Figure 31: Estimated Foreign Cash Holdings, 1991.Q1 – 2000.Q4, Millions of U.S. Dollars



In spite of the *considerable* uncertainty introduced by the methodology used to derive the above chart, *some* of the implied variations in foreign cash holdings make sense. Thus, adjusted balance-of-payments data seem to indicate a surge in foreign currency holdings in the months leading to the March 1994 currency crash. Similarly, the data indicate an increased preference for cash during most of 1996. Clearly, other variations are more dubious; such as the drop in foreign cash holdings in late 1996 – early 1997 or through most of 1994 (post-crash).

4.2 A Simple Model of Asset Substitution

The shifts in the composition of Bulgarian households' portfolio in the months leading to the crisis (documented above) can be accounted for, at least

partially, within a standard model of asset substitution. The model selected for this exercise is Agénor and Khan's 1996 model of currency substitution, introduced in "Foreign Currency Deposits and the Demand for Money in Developing Countries." The model is presented in Section 4.2.1 below. Modifications brought to the model (simplifications to better fit the Bulgarian experience) are discussed in Section 4.2.2.

4.2.1 Agénor and Khan's (1996) Model

Agénor and Khan (1996) examine the demand for domestic and foreign currencies by residents of developing countries. Their purpose is to explain currency substitution, the process by which foreign currency holdings substitute for domestic money balances as "a store of value, unit of account and/or medium of exchange."[182]

4.2.1.1 Approach and Summary of Findings

In the model, a rational *forward-looking* consumer chooses between four types of assets (domestic money, foreign money, bonds denominated in domestic currency, and bonds denominated in foreign currency) to maximize lifetime utility. The consumer is subject to a cash-in-advance constraint, forcing her to hold both domestic and foreign currency in order to carry out transactions. Optimality conditions indicate that the marginal rate of substitution between domestic and foreign currencies is inversely related to the ratio of their opportunity costs. In particular, an expected future depreciation of the domestic currency would cause residents to shift out of domestic money into foreign money, and vice versa. The model also accounts for the costs of adjustment in currency holdings (which may result from restrictions on convertibility, capital controls, and other institutional or structural factors inherent to

[182] A broader definition than Feige (2003), as it encompasses "asset substitution" as well.

the domestic financial system), and differentiates between *optimal* and *actual* currency holdings.

Given important limitations on foreign currency data, the model was estimated with residents' holdings of foreign currency deposits *abroad*: the empirical analysis did not consider foreign currency deposits held in domestic banks, nor non-bank foreign money balances (foreign notes in circulation). Quarterly data from October 1981 to June 1991 was collected for ten developing countries. Estimation results indicated that *most* of the variations in the ratio of domestic to foreign currency holdings (narrow money to foreign currency deposits held abroad) were explained by changes in foreign interest rates and future expected depreciation.[183] More importantly, the assumption that portfolio decisions rely partly on forward-looking variables was supported by the data.

4.2.1.2 Methodological Framework

Agénor and Khan's methodological framework (utilized later in this chapter) can be summarized as follows:

- Step 1: Derive q^d_t, the optimal ratio of domestic to foreign currency holdings, using a standard utility maximization approach under rational (forward looking) expectations;
- Step 2: Derive q_t, the actual ratio of domestic to foreign currency holdings, using the buffer-stock approach of Cuthbertson and Taylor (1990) where a representative agent minimizes a quadratic loss function, conditional on information available at time *t-1*. The loss function has two components: the

[183] As reflected in the premium in the parallel exchange market

cost of adjustments in currency holdings (a linear function of $(q_t - q_{t-1})$), and the cost of being out-of-equilibrium (a linear function of $(q_t - q^d_t)$);

- Step 3: Invoke the solution proposed in Sargent (1987), for the quadratic cost function minimization problem;[184] and derive optimality conditions for the "actual" currency ratio;
- Step 4: Combine the findings from Steps 1 and 3 to define an estimating equation for the observed currency ratio. The estimating equation is of the general form:

$$q_t = f\left(q_{t-1}, \textit{Expected Opportunity Cost Ratio}_{\,t+k} \right)_{k=1..p}$$

Where k is a shift operator and p the forward horizon.

- Step 5: Estimate the above equation using the "Errors in Variables Method" (EVM), where the unobservable future expected opportunity cost ratio is replaced by its realized value.

In a nutshell, the authors' approach is equivalent to relating the ratio of domestic to foreign currency holdings to *some measure of expected depreciation*, an approach prevalent in the literature on currency substitution.[185]

4.2.2 Model Updates

4.2.2.1 Model Overview

As stated in the introduction, Agénor and Khan's model was adjusted to better reflect the conditions in Bulgaria. In particular:

Assets Available to the Representative Agent: Residents are assumed to hold four types of assets, *relabeled* as follows: i) domestic currency notes and demand

[184] As explained in Cuthbertson (1990), page 9; Agénor and Khan (1996) page 116

[185] See Ortiz (1983), Ramirez-Rojas (1986) or Calvo and Rodriguez (1977)

deposits (narrow money, *M*); ii) foreign currency notes and demand deposits denominated in foreign currency (*m**); iii) domestic currency deposits (time and savings Lev deposits, *D*) held in domestic banks; and iv) foreign currency deposits (time and savings deposits denominated in foreign currency, *d**) held in domestic banks. There are *initially* no foreign currency deposits held abroad (i.e., outside the domestic financial system). Domestic currency deposits (time and savings) earn interest *i* per unit of time. Foreign currency deposits (time and savings) earn interest *i**. Demand deposits (in domestic or foreign currency) are assumed to earn zero (or negligible) interests. Note that the interest on time and savings deposits can be viewed as the opportunity cost of holding narrow money.[186] Finally, domestic and foreign cash remain imperfectly substitutable assets (as expressed in the cash-in-advance constraint introduced below).

Exchange Rate Regime: Agénor and Khan assumed (and used data on) a parallel exchange rate. In the original model, two goods (one legal, one illegal) were imported and consumed. Illegal transactions were settled in the parallel foreign exchange market; legal transactions were settled at the official exchange rate. The model was simplified here by removing the illegal good, and the distinction between an official and a parallel exchange rate.[187]

Other adjustments (such as the introduction of a perceived risk of deposit losses, or shifts in optimal asset holdings and in the speed of adjustment during

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[186] This is one of the specifications tested in Slavova (2000) in her empirical investigation of money demand in Bulgaria.

[187] Thus preventing the use of the observed premium in the parallel exchange market as a proxy for expected depreciation

"panics") remain to be made. The revised (simplified) assumptions, optimality conditions, and estimating equations are presented below.

4.2.2.2 Detailed Theoretical Setup

A single representative agent, in a small open economy, maximizes a discounted sum of future instantaneous utilities. The individual's objective function can be written as follows:

$$\sum_{t=0}^{\infty} \gamma^t V(c_t) \qquad \textit{Equation (1)}$$

Where γ is a discount factor; V a strictly concave and twice continuously differentiable utility function;[188] and c_t a measure of real consumption (real expenditures on a consumer good).

The consumer's accumulation program satisfies the following constraints:

$$A_t = M_t + D_t + s_t\,(m^*_t + d^*_t) \qquad \textit{Equation (2)}$$

And:

$$\Delta A_t = A_t - A_{t-1} = s_t q + i_{t-1} D_{t-1} + s_t i^*_{t-1} d^*_{t-1} - s_t c_t + \Delta s_t\,(m^*_{t-1} + d^*_{t-1}) \qquad \textit{Equation (3)}$$

Where A_t is the agent's nominal wealth defined as the sum of her domestic and foreign asset holdings, and q is total output (exogenous).

Real wealth can be obtained by dividing Equation (2) by the (official) exchange rate s_t.[189]

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[188] For simplicity, the consumer's instantaneous utility function is assumed to be of logarithmic form $V(c_t) = \log(c_t)$.

[189] Purchasing power parity is assumed. With $p^*_t = 1$, $p_t = s_t$. In Agénor and Khan (1996), total output q consists of a single exportable good; and consumption is fully imported. There are actually two

$$a_t = m_t + d_t + m^*_t + d^*_t \qquad \textit{Equation (2')}$$

Where $a_t \equiv A_t / s_t$; $m_t \equiv M_t / s_t$ and $d_t \equiv D_t / s_t$.

Similarly, the flow budget constraint of the representative consumer can be rewritten, in real terms, as:

$$a_t - a_{t-1} = q - c_t + [i_{t-1} - \varepsilon_t (1 + i_{t-1})] d_{t-1} + i^*_{t-1}\, d^*_{t-1} - \varepsilon_t\, m_{t-1} \qquad \textit{Equation (3')}$$

Where ε_t is the rate of depreciation of the domestic currency ($\Delta s_t / s_t$).

The consumer is subject to a liquidity-in-advance constraint, which requires her to hold both domestic and foreign money (narrow money) in order to carry out transactions. This is expressed in Equation (4) below.

$$c_t \leq L\,(m_t,\, m^*_t) \qquad \textit{Equation (4)}$$

In other words, total real expenditures on *c* cannot exceed the flow of liquidity services produced by the use of domestic *and* foreign currencies. The liquidity services function can be assumed of the Cobb-Douglas form, as expressed in:

$$L\,(m_t,\, m^*_t) = (m_t)^{\delta} + (m^*_t)^{1-\delta} \quad \text{with } 0 \leq \delta \leq 1 \qquad \textit{Equation (5)}$$

4.2.2.3 Optimality Conditions

The consumer chooses an optimal sequence $\{c_t,\, m_t,\, m^*_t,\, d_t,\, d^*_t\}_{\,t = 0 \text{ to } \infty}$, to maximize (1) subject to (2)-(5). Assuming that Equation (4), the liquidity-in-advance constraint, holds with equality, it can be shown that the optimality conditions for this

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consumption goods, both imported, one legally, the other illegally – justifying the assumption of a dual exchange rate market.

control problem yield the following solution for the *composition* of money holdings:[190]

$$\frac{m_t}{m^*_t} = \left(\frac{\delta}{1-\delta}\right)\left[\frac{i^*_t}{(1-\varepsilon_{t+1})\, i_t}\right] \qquad \textit{Equation (6)}$$

And

$$(1 - \varepsilon_{t+1})\, i_t = i^*_t + \varepsilon_{t+1} \qquad \textit{Equation (7)}$$

Equation (7) is a standard interest parity condition. Equation (6) indicates that the marginal rate of substitution between domestic and foreign currencies is inversely related to the ratio of their opportunity costs.[191]

4.2.2.4 Adjustment Costs and Actual Money Holdings

The framework used in the derivation of *actual* money holdings borrows from Sargent (1979). As explained in Cuthbertson (1990), this framework has proved extremely popular in the literature on money demand as it provides, in particular, a basis for a *tractable* forward-looking model of asset demand. First, note that the formulation of q^d_t in Equation (6) does not account for institutional and structural factors that may influence the currency ratio. These factors, as discussed in Section 4.1.1, comprise the transaction costs incurred in the exchange of currencies, and the degree of diversification of the domestic financial system. They are introduced in the model by rewriting Equation (6) as follows:

$$q^d_t \equiv \log(m_t / m^*_t) = \kappa_0 + \kappa_1 z_t, \text{ with } \kappa_1 > 0 \qquad \textit{Equation (8)}$$

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[190] See Appendix G for details about the derivation of the (simplified) optimality conditions.

[191] Agénor and Khan (1996), page 107

Where: $z_t = \log [\, i^* / (\, i^*_t + \varepsilon_{t+1}) \,]$ *Equation (9)*

In the above formulation, institutional and structural factors would be reflected in the size of the coefficient κ_1.

Following Sargent (1979), agents are assumed to pursue their currency ratio target q^d_t subject to the costs of being out of long-run equilibrium, *and* the costs of adjustment in currency holdings. Formally, consumers choose the short-run currency ratio so as to *minimize* the expected discounted present value of a quadratic loss function, L, conditional on information available at time *t-1*:

$$L = E_{t-1} \sum_{k=0}^{\infty} \lambda^k [\alpha_0 (q_{t+k} - q^d{}_{t+k})^2 + \alpha_1 (q_{t+k} - q_{t+k-1})^2] \qquad \textit{Equation (10)}$$

Where α_i are positive weights; and E_{t-1} denotes the conditional expectation operator for information up to time *t-1*.

The actual currency ratio q_t is chosen so as to minimize Equation (10) for all $k = 0, 1, 2, \ldots \infty$. The solution to this optimization problem is given by:

$$E_{t-1} q_t = \lambda_1 q_{t-1} + (1 - \lambda_1)(1 - \gamma\lambda_1) \sum_{j=0}^{\infty} (\gamma\lambda_1)^j E_{t-1} q^d{}_{t+j} \qquad \textit{Equation (11)}$$

Where $0 < \lambda_1 < 1$ is the stable root of the Euler equation obtained from the first order conditions.[192]

Using (8) and (11), the equation describing the behavior of the actual currency ratio is therefore given by:

$$q_t = (1 - \lambda_1)\kappa_0 + \lambda_1 q_{t-1} + (1 - \lambda_1)(1 - \gamma\lambda_1)\kappa_1 \sum_{j=0}^{\infty} (\gamma\lambda_1)^j E_{t-1} z_{t+j} + \upsilon_t \qquad \textit{Equation (12)}$$

---

[192] See Cuthbertson (1990) page 9, or Agénor and Khan (1996) page 108.

Where υ_t is a random disturbance, resulting from the assumption of rational expectations.

The above equation shows that the actual currency ratio depends on a backward-looking component (q_{t-1}) and a set of forward-looking variables: a geometrically declining weighted sum of the opportunity cost variable.

4.2.2.5 Portfolio Adjustments during Financial Panics

We recognize that the model introduced above is not well suited for capturing the rapid shifts in asset holdings characterizing financial panics. However, the model could be used to evaluate the extent to which: i) the "optimal" portfolio composition evolves during periods of heightened instability; ii) adjustments in portfolio holdings accelerate during those periods; and iii) the expectation horizon (and the validity of the forward-looking assumption) changes as the economy moves toward a crisis zone. The model adjustments required to test these hypotheses remain to be made.

4.3 Estimating Equation, Data Requirements and Data Sources

A few notes on the estimating equation are provided first. The variables and data elements used in the empirical investigation are introduced in Section 4.3.2.

4.3.1 Estimating Equation and Simplifying Assumptions

The estimating equation is Equation (12), reproduced below:

$$q_t = (1-\lambda_1)\kappa_0 + \lambda_1 q_{t-1} + (1-\lambda_1)(1-\gamma\lambda_1)\kappa_1 \sum_{j=0}^{\infty} (\gamma\lambda_1)^j E_{t-1} z_{t+j} + \upsilon_t \qquad \textit{Equation (12')}$$

As in Agénor and Khan (1996), two important simplifications are made before completing the estimation:

- All the unobservable components (the multiple-period ahead predictions of the opportunity cost variable z_t) are replaced by their *realized* values, in accordance to the Errors-in-Variables Method (EVM); and
- "Backward-forward" parameter restrictions are imposed to bypass the non-linearities introduced by the discount factor γ (and avoid the use of non-linear estimation techniques). These parameter restrictions are tested using a Wald test.

Both simplifications, and their implications, are further discussed in Section 4.4.

4.3.2 Definition and Construction of the Variables

The data needed to estimate Equation (12), and the corresponding data sources, are summarized in Table 16, below.

A number of specifications are tested when constructing the currency ratio. Domestic currency holdings M are alternatively interpreted as currency in circulation, narrow money (M1) and broad Lev money (M2 excluding foreign currency deposits). Similarly, foreign currency holdings are interpreted as either foreign currency deposits in domestic banks, foreign currency deposits held abroad (in the U.S. banking system), and foreign currency notes in circulation.

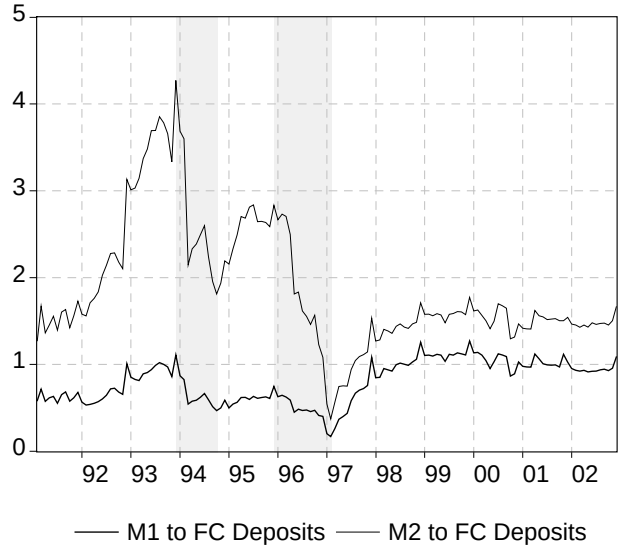
Table 16: Summary of Data Requirements and Data Sources

Model Variables	Interpretation / Proxy	Data Sources
Domestic currency holdings, *M*	Domestic currency in circulation	BNB Monetary Surveys
	Narrow money, M1	BNB Monetary Surveys
	Lev component of broad money, Lev M2	BNB Monetary Surveys
Foreign currency holdings, *m**	Foreign currency deposits in domestic banks	BNB Monetary Surveys
	Foreign currency deposits held abroad	U.S. Treasury Department, International Capital System
	Foreign currency notes in circulation	U.S. Treasury Department, Balance of Payments statistics, author's calculation
Future expected depreciation, $E_{t-1}(\varepsilon_{t+k})$	k-period ahead *actual* depreciation of the Lev w.r.t. U.S. dollar	BNB
Interest rate on foreign currency deposits, *i**	Three-month Eurodollar rate	IFS

Two specifications of the currency ratio (narrow money M1 to foreign currency deposits in domestic banks; and broad Lev money to foreign currency deposits in domestic banks) are shown in Figure 32, below. A *proxy* for the opportunity cost variable (the *time-t* depreciation rate of the Lev relative to the U.S. Dollar) is displayed in Figure 33.[193]

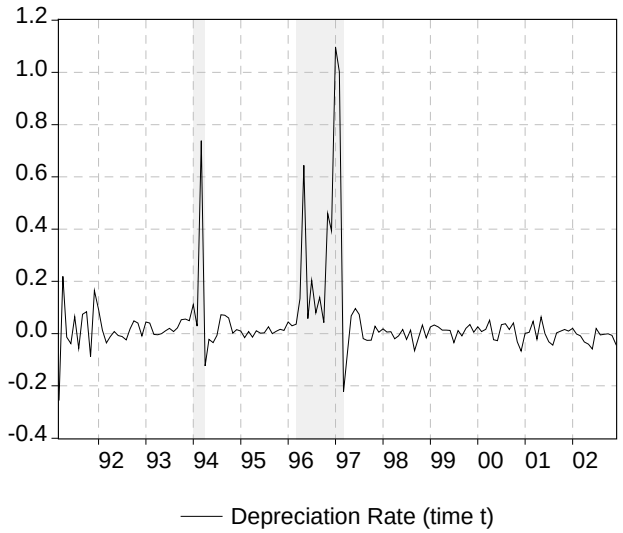
[193] The fluctuations in the exchange rate of the Lev w.r.t. the U.S. Dollar after July 1997 (and the introduction of the currency board) reflect solely the fluctuations in the DM/$ exchange rate.

Figure 32: Ratio of Domestic to Foreign Currency Holdings, March 1991 – December 2002



Note: Foreign currency holdings are limited to foreign currency deposits in domestic banks; M2 is restricted to its domestic components (i.e., includes currency in circulation, demand, time and savings deposits, all in Lev)

Figure 33: Depreciation of the Lev with respect to the U.S. Dollar, March 1991 – December 2002



What is most striking about the ratio of domestic to foreign currency holdings is not its abrupt reduction in February 1997, but rather its leveling-off in early 1999 to a level far inferior to its pre-currency board level for the M2-based ratio, and to a level similar to its late-1993 level for the M1-based ratio.[194] This implies, unfortunately, that the model introduced in this chapter will probably capture only a fraction of the dynamics at work during the period.

Are the series stationary?[195] As demonstrated by Perron (1989) and others, the unit root hypothesis may be difficult to reject if the data series display a structural break (a shift in level and/or in trend). Therefore, structural breaks should be accounted for when testing for a unit root.

The table below summarizes and compares the outcome of a number of testing procedures. For all procedures and data series, a model with both intercept and trend dummies was used.

Finally, note that the opportunity cost variable z_t was found stationary under all specifications, without structural breaks, and therefore is not shown in the table.

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[194] The leveling off of m/m^* may be due to the functioning of the currency board itself, strictly restricting monetary growth.

[195] For three out of the ten countries used by Agénor and Khan (1996), the currency ratio and the opportunity cost ratio appeared to be integrated of order one, with evidence of cointegration in only one case. For all other countries, both variables were stationary in levels.

Table 17: Unit Root Tests, Variables in Level

Variable	No Structural Breaks		One Structural Break		Two Structural Breaks	
	ADF	Outcome	LM	Outcome	LM	Outcome
M1 to Foreign Currency Deposits held in Domestic Banks	-2.039	Cannot Reject H_0	-3.324 (May 96)	*	-11.198 (Sep 96) (Mar 97)	***
Lev M2 to Foreign Currency Deposits held in Domestic Banks	-2.378	Cannot Reject H_0	-4.607 (Nov 96)	***	-6.082 (Nov 93) (May 98)	***
M1 to foreign currency deposits held abroad	-4.182	***	-4.067 (Jun 99)	**	-5.996 (Jul 93) (Nov 97)	***
Domestic currency in circulation to foreign currency in circulation	-3.657	**	-4.665 (1995.Q1)	***	-8.154 (1993.Q4) (1996.Q1)	***

Notes: 1. The data in parentheses indicate when the structural break was identified

2. All ADF tests conducted with a trend and an intercept, and up to 4 lagged differences.

3. Data series were examined from January 1992 through December 2002; except M1 to foreign currency deposits held abroad (January 1993 – December 2002), and domestic currency in circulation to foreign currency in circulation (quarterly data, from 1991.Q1 through 1999.Q4).

4. The 1%, 5% and 10% critical values for the minimum LM test with one break are: −4.239, −3.566 and −3.211, respectively. The 1%, 5% and 10% critical values for the minimum LM test with two breaks are: −4.545, −3.842 and −3.504, respectively. *, ** and *** denote significant at the 10%, 5%, and 1% levels, respectively.

As shown in the table, all the data series are stationary in level when controlling for structural breaks. Lee and Strazicich's minimum LM testing procedures were used in the identification of the break(s) and the estimation of the test statistics.[196] Other unit root tests are provided in the Appendices. [197]

[196] Lee and Strazicich (2001), and Lee and Strazicich (2002)

4.4 Summary of Empirical Findings and Concluding Remarks

Empirical results are presented first, in Section 4.4.1. Their importance in fostering our understanding of the crisis is discussed in Section 4.4.2. A brief agenda for future research concludes the chapter.

4.4.1 Empirical Results

The Errors in Variable Method (EVM) used in this paper requires some form of Instrumental Variables (IV) estimation procedure, as demonstrated in Cuthbertson (1990). Furthermore, under EVM and rational expectations, the model error term follows a moving average process. As a result, some correction for serial correlation is required for the coefficient estimates to be efficient.[198]

4.4.1.1 Forward Looking Model

Estimation results for the forward-looking model are presented in Table 18 below, under four specifications:

(1) M1 to foreign currency deposits held in domestic banks;

(2) Lev M2 to foreign currency deposits held in domestic banks;

(3) M1 to foreign currency deposits held abroad; and

(4) Domestic currency in circulation to foreign currency in circulation.

The table presents *unrestricted* estimates for the coefficients of Equation (12). The estimates were obtained from two-stage least squares with the following

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[197] LM testing procedures were implemented in Ox Version 3.30, a programming language developed by Jurgen A. Doornik, Department of Economics and Nuffield College, University of Oxford. The computer codes, initially written in GAUSS by Junsoo Lee, University of Central Florida, were run using the Ox-Gauss library.

[198] Cuthbertson (1990)

instruments: four lags of q and z, dummy variables for seasonal effects and/or identified breaks, and the constant term. The numbers in parentheses are t-statistics. Diagnostic variables are provided in the lower part of the table.[199] The model was initially estimated with up to four leads on the expectational variable z_t. The number of leads was progressively reduced until an adequate specification was found.[200]

Table 18: Estimation Results, Forward Looking Model

Variables	**Specification**			
	(1)	**(2)**	**(3)**	**(4)**
Constant	-0.016 (-1.028)	0.033 (2.343)	2.491 (5.406)	-0.235 (-1.086)
q_{t-1}	0.800 (12.173)	0.942 (47.503)	0.575 (7.102)	0.735 (4.053)
z_t	-0.401 (-1.764)	-0.398 (-2.849)	-2.754 (-2.404)	0.350 (0.602)
z_{t+1}	-0.386 (-1.145)	0.098 (0.464)	-0.582 (-0.308)	0.737 (0.917)
z_{t+2}	-0.476 (-1.245)	0.041 (0.225)	--	--
R^2	0.885	0.960	0.257	0.283
SE	0.128	0.084	0.505	0.443
LM	1.568	16.844	N/A	11.966
ARCH	15.882	3.379	11.688	0.838
JB	293.966	108.971	69.881	1.946

The LM and ARCH test statistics were estimated with 4 lags.

Under all specifications (except (4)), the opportunity cost variable z is approximated with the one-period ahead rate of depreciation of the Lev, ε_{t+1}

The LM F-statistic could not be computed under specification (3), but the correlogram indicated no serial correlation.

Equation (4) was estimated over the period 1991.Q1 – 1999.Q4 with a seasonal dummy for the fourth quarter.

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[199] Including the Lagrange Multiplier (LM) test for serial correlation (F-statistic); the Jarque-Bera (JB) normality test; and Engle's test for Auto-Regressive Conditional Heteroskedasticity (ARCH)

[200] Following, once again, Agénor and Khan's approach

As can be seen in the table, the model performs rather poorly under all specifications. The coefficient of determination (R^2) is relatively high under specifications (1) and (2); but the residuals from both equations are serially correlated and heteroskedastic, as indicated by the LM and ARCH test statistics. Models (3) and (4) explain less than 30 percent of the variations in the currency ratio. The Jarque-Bera normality test statistic (*JB*) rejects the hypothesis of normality of the residuals under all specifications, except (4).

While keeping in mind that the coefficient standard errors (and associated t-statistics) are biased under serial correlation and heteroskedasticity, it appears that the forward horizon (the number of leads in the formation of expectations) is limited in all four models. Interestingly enough, the two countries in Agénor and Khan's sample which experienced serious instability over the estimation period (Brazil and Mexico) also had relatively short expectation horizons.

4.4.1.3 Test Statistics for Backward-Forward Restrictions

Wald test statistics for the validity of the parameter restrictions imposed by rational expectations[201] are shown in Table 19, below, for three values of γ (the discount factor): 0.1, 0.5 and 1.0.

[201] As shown in Equation (12), these restrictions result from the term $(\gamma\lambda_1)^j$, which appears in the coefficients attached to all successive values of the expectational variable *z*. Observing that λ_1 is the coefficient on the lagged *q* ratio, the restrictions can be expressed as $\beta_j = \beta_{j-1}.\lambda_1.\gamma$, where β_j is the coefficient on the *j*-period ahead opportunity cost variable. There are as many restrictions as there are leads on the expectational variable in the estimating equation. For more details see Agénor and Khan (1996) pages 109 and 113.

Table 19: Test Statistics for Backward-Forward Restrictions

Specification	Number of Restrictions	Discount Factor		
		$\gamma = 0.1$	**$\gamma = 0.5$**	**$\gamma = 1.0$**
(1)	2	2.170 *0.338*	1.253 *0.534*	0.282 *0.868*
(2)	2	0.595 *0.743*	1.932 *0.381*	4.075 *0.130*
(3)	1	0.048 *0.827*	0.009 *0.923*	0.166 *0.684*
(4)	1	0.793 *0.373*	0.579 *0.447*	0.320 *0.571*

The test statistics follow a $\chi 2$ with *m* degrees of freedom, where *m* is the number of restrictions. The numbers in italics shown in the table are p-values.

As can be seen in the table, the restrictions imposed by rational expectations *cannot be rejected* under any of the specifications. The implied *long-run* elasticity of the currency ratio with respect to the opportunity cost variable can therefore be estimated from the unrestricted coefficients provided in Table 18.

Table 20: Implied Long-Run Elasticity of the Currency Ratio with Respect to the Opportunity Cost Variable

	Specification			
	(1)	**(2)**	**(3)**	**(4)**
κ_1	-6.315	-4.466	-7.849	4.102

Recall that the opportunity cost variable is approximated with the one-period ahead rate of depreciation of the Lev under all specifications, except (4) where the exact definition was used (see Equation (9)).

All the coefficient estimates have the expected sign. Their magnitude is also in line with evidence from other countries.[202]

Overall, the forward-looking model performs quite *poorly*. This may result from poor data quality, inadequate model specifications, or both.[203] Alternative model specifications, assumptions regarding the formation of exchange rate expectations, and estimating techniques are explored in the rest of the chapter.

4.4.1.4 Shifts in Expectations and Central Bank's Foreign Exchange Reserves

In this section, we examine the behavior of the currency ratio using a simple regime-switching model, where the weights for transitioning from one regime to another reflect the level of the foreign exchange reserves of the BNB (*treated* as an *exogenous* variable). The model was estimated [204] with the ratio of M1 to foreign currency deposits as the dependent variable y, the level of foreign exchange reserves as the transition variable x, and four lags of y as explanatory variables. Three regimes were assumed (the *number* of regimes is exogenous).

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[202] The coefficient estimates reported in Agénor and Khan (1996) range from a low 0.911 (for Nigeria) to a high 6.167 (for Brazil). The two countries that experienced instability over the sampling period (Brazil and Mexico) had the highest and third highest elasticity estimates.

[203] A version of the model where the z variable is defined as an index of foreign exchange market turbulences (a weighted average of changes in the exchange rate and changes in the BNB international reserves) was also tested. This specification led to slightly higher R^2 and minor improvements in the test statistics for serial correlation. The forward horizons, however, remained relatively short.

[204] Using the MSVAR Ox library developed by Hans-Martin Krolzig, Department of Economics and Nuffield College, University of Oxford

In the threshold autoregressive model (TAR) used here, the regime shifts are triggered by the variable *x* crossing the threshold value c, as expressed in:[205]

$$y_t = \left(\upsilon_1 + \sum_{i=1}^{k} \alpha_{1i}\, y_{t-i} \right)\left(1 - P(x_t;c)\right) + \left(\upsilon_2 + \sum_{i=1}^{k} \alpha_{2i}\, y_{t-i} \right)\left(P(x_t;c)\right) + \varepsilon_t \qquad \textit{Equation (13)}$$

Where: $\varepsilon_t \sim$ IID $(0; \sigma^2)$ and the indicator function $P(x_t;c)$ is of the type:

$$P(x_t;c) = \begin{cases} 1 & \text{if } g(x_t) > c \\ 0 & \text{if } g(x_t) \le c \end{cases} \qquad \textit{Equation (14)}$$

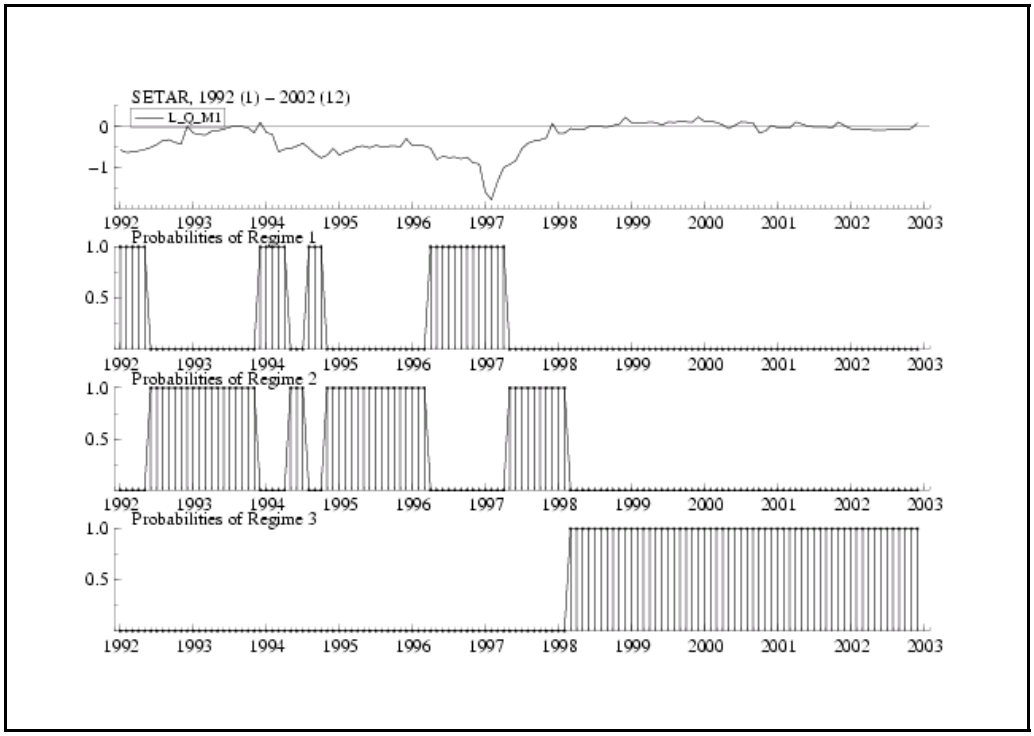
A summary of findings pertaining to the identification of regime shifts and the associated threshold values is provided in Table 21 and Figure 34 below.

Table 21: Regime Classification, January 1992 – December 2002

Regimes	Threshold	Period	Months	Description
Regime 1	< $746 million	1992:1 - 1992:5 1993:12 - 1994:4 1994:8 - 1994:10 1996:4 - 1997:4	26	*Instability*
Regime 2	[$746 - $2,151[million	1992:6 - 1993:11 1994:5 - 1994:7 1994:11 - 1996:3 1997:5 - 1998:2	48	*Relative calm*
Regime 3	≥ $2,151 million	1998:3 - 2002:12	58	*Currency board*

[205] This formulation of the TAR model is from Krolzig (2002), page 9

Figure 34: Currency Ratio and Regime Classification



The threshold identified by the model for entering Regime 1 ($756 million) is remarkably close to the value reported in the literature (the $700 million psychological barrier discussed in Section 3.2.3), suggesting that variations in the *q* ratio did reflect investors' expectations and that these expectations, in turn, responded to changes in the international reserves of the BNB.

Coefficient estimates for the TAR model are shown in the table below. Periods of heightened instability (Regime 1) are characterized by a larger coefficient on q_{t-1}. There are, apparently, no differences in the dynamics of the currency ratio between periods of relative calm (Regime 2) and post-1997 (Regime 3).

The *multivariate equivalent* of the model presented here was estimated with one lagged value of the currency ratio, and up to four *lags* of the depreciation rate

as independent variables. Under all three regimes and various lag structures, none of the lagged depreciation rate variables had a coefficient significantly different from zero.

Table 22: Currency Ratio Dynamics, January 1992 – December 2002

	Coefficient Estimate	Standard Error	t-Statistic
Regime 1 – Instability (Reserves < $746 million)			
Constant	-0.122	0.073	-1.660
q_{t-1}	**0.855**	0.178	4.803
q_{t-2}	-0.287	0.266	-1.077
q_{t-3}	-0.257	0.286	-0.901
q_{t-4}	0.714	0.263	2.712
Regime 2 – Relative Calm (Reserves in [$746 - $2,151[million)			
Constant	-0.035	0.029	-1.179
q_{t-1}	**0.576**	0.136	4.245
q_{t-2}	0.188	0.152	1.237
q_{t-3}	0.078	0.145	0.537
q_{t-4}	-0.043	0.104	-0.412
Regime 3 – Currency Board (Reserves ≥ $2,151 million)			
Constant	0.010	0.009	1.162
q_{t-1}	**0.614**	0.134	4.572
q_{t-2}	-0.094	0.149	-0.634
q_{t-3}	0.136	0.128	1.067
q_{t-4}	0.060	0.106	0.569

All variables are in log

4.4.1.5 Other Empirical Findings

Given the relatively poor performance of the forward-looking model (for obvious reasons), we explore a number of alternative estimating equations to help explain the variations in the currency ratio. This section borrows from some of the research work reported in Ortiz (1983) and Ramirez-Rojas (1986).

Ortiz (1983) estimates the following equation with data for Mexico:

$$\ln (D/F)_t = b_0 + b_1\, ED_{t-1} + b_2\, ED_{t-2} + b_3\, ER_{t-1} + b_4\, ER_{t-2} + b_5\, PR + b_6 \ln (D/F)_{t-1} \qquad \textit{Equation (13)}$$

Where D is domestic currency demand deposits, F foreign currency demand deposits, ED an expected devaluation proxy (the difference between the official and real exchange rate), ER a proxy for the foreign exchange risk (the deviation of real exchange rate from trend), and PR a dummy variable for political risk.

An alternative specification was evaluated by Ramirez-Rojas (1986), for Argentina:

$$\ln (M/F)_t = a_0 + a_1 ED_t + a_2 PR + a_3 \ln (M/F)_{t-1} \qquad \textit{Equation (14)}$$

Where M is total money stock, F foreign currency deposits (held domestically and abroad), ED expected depreciation (approximated by the current differential between inflation rates in Argentina and the United States), and PR a dummy for political instability.

Model estimates for Bulgaria using a number of expectation variables ED are provided in Table 23. The expectation variables tested below include: (1) past and current interest rate differentials (between Bulgaria's bank deposit rate and the 3-month Eurodollar rate); (2) past actual depreciation; (3) the current level of foreign exchange reserves; and (4) the span of time (in months) since the last IMF standby agreement. In the table the political risk variables *PR1* and *PR2* are dummy variables for January 1997 – February 1997, and March 1994 respectively. The seasonal variables *SEA1* and *SEA2* are dummy variables for December, and for December 1992 and December 1993 (when large unaccounted for changes in foreign currency deposits took place, respectively. Under all specifications, the dependent variable M/F_t is the ratio of M1 to foreign currency deposits in the domestic financial system.

Table 23: Data Fitting, Estimation Results

	Specification			
	(1)	**(2)**	**(3)**	**(4)**
Constant	-0.011 (-1.181)	-0.016 (-1.760)	-0.495 (-3.866)	-0.007 (-0.683)
M/F_{t-1}	0.882 (22.547)	0.960 (32.892)	0.863 (21.992)	0.939 (31.468)
ED_t	-0.014 (-3.149)	-0.013 (-1.383)	0.062 (3.737)	-0.003 (-2.678)
PR1	-0.568 (-5.498)	-0.667 (-6.578)	-0.661 (-6.829)	-0.664 (-6.684)
PR2	-0.375 (-4.807)	-0.404 (-5.063)	-0.353 (-4.549)	-0.355 (-4.411)
SEA1	0.137 (5.082)	0.138 (4.946)	0.121 (4.504)	0.138 (5.067)
SEA2	0.231 (3.807)	0.212 (3.399)	0.264 (4.318)	0.238 (3.842)
R^2	0.956	0.954	0.958	0.955
SE	0.077	0.079	0.076	0.078
LM(4)	0.953	0.244	0.632	0.392
ARCH(4)	0.363	0.528	0.763	1.286
JB	29.694	30.702	14.801	19.412

Estimated over the period January 1992 – December 2002

Dummies and slope dummies (on the lagged *M/F* variable) reflecting the structural breaks identified in Table 17 (September 1996 and March 1997) were also used in the estimation.

Under specifications (1) and (2), a polynomial distributed lag of degree 0 and length 4 was used for the expectation variable *ED*.

Overall, the models perform relatively well, explaining about 95 percent of the variations in the currency ratio. There are no signs of serial correlation, or heteroskedasticity. Three of the four expectational variables are statistically significant (the p-value associated with ED_t in model (2) is 0.16); all have the expected sign.

4.4.2 What does the Model Tell Us about the 1996-1997 Crisis?

Results from the forward looking model indicate that only a small portion of the variations in the currency ratio can be explained by changes in the opportunity cost variable and "expected" depreciation. In other instances, serious autocorrelation

problems prevented us from arriving at a meaningful conclusion regarding the impact of expectational variables. These findings, again, can be explained by a variety of factors, including misspecifications in the expectations-formation process; missing variables (possibly banking risk, or political risk); and data quality (such as the seemingly unaccounted-for shifts in foreign currency deposits in late 1992 and 1993, or poor time series on foreign currency notes and total foreign money balances).

The other approaches presented in the chapter provided more encouraging results. They illustrated, in particular, the importance of the BNB's foreign exchange reserves in the formation of exchange rate expectations, as captured by changes in the currency ratio.

But what does the model tell us about the nature and timing of the financial crisis in Bulgaria? First, it could be argued that the poor performance of the forward-looking model indicates that banking problems (and other factors not explicitly accounted for in the model) explain some of the variations in the currency ratio, rather than expected depreciation alone. This, again, would support Feige's 2003 findings that banking problems in transition economies were conductive to higher foreign currency holding, independently from any exchange rate considerations. Second, results from the threshold autoregressive model did confirm the existence of a "psychological" level of international reserves below which *accelerated* shifts in household portfolios occurred. The threshold identified by the model ($756 million), again, is extremely close to the level derived from anecdotal evidence, and reported in the literature. Finally, the reasonably high level of correlation between the currency ratio developed for this study and a number of *proxies* for expected depreciation (after controlling for political and seasonal impacts) suggest that the ratio *did* respond to

expectational effects and might be used in future (and potentially more insightful) analyses of the Bulgarian crisis.

4.4.3 Agenda for Future Research

The theoretical model and empirical procedures described in this chapter are open to *considerable* refinements, including:

- Introduce a banking risk and banking crisis component into the model;
- Discuss and model more explicitly the risk profile of the representative agent (risk adverse vs. risk lover), and evaluate its impact on portfolio decisions;
- Develop alternative measures of "expected" depreciation;
- Develop and utilize better measurements of foreign currency holdings, including measures of foreign currency notes, and foreign currency deposits held in neighboring countries (such as Germany); Feige, Faulend, Šonje and Šošic's 2000 study of dollarization in Croatia provides some methodological guidelines;
- Refine the model estimates; possibly through alternative testing procedures for the identification of structural breaks; and a break-down of the estimation period (January 1992 through December 2002) into various sub-periods; and
- Build on the regime-switching modeling approach and test alternative model specifications (alternative regime switching models and alternative selections of dependent and independent variables).