CERGE
Center for Economics Research and Graduate Education
Charles University Prague

Currency Substitution and Foreign Exchange Intervention in Emerging Markets

Olga Loiseau-Aslanidi

Dissertation

Prague, December 2010

Olga Loiseau-Aslanidi

Currency Substitution and Foreign Exchange Intervention in Emerging Markets

Dissertation

Prague, December 2010

Table of Contents

Dissertation Committee

Petr Zemcik (CERGE-EI; chair)

Kathryn M. E. Dominguez (University of Michigan)

Michal Kejak (CERGE-EI)

Evzen Kocenda (CERGE-EI and Anglo-American University)

Sergey Slobodyan (CERGE-EI)

Referees

Josef C. Brada (Arizona State University)

Ali M. Kutan (Southern Illinois University - Edwardsville)

Abstract

This dissertation consists of three essays that focus on the determinants and implications of exchange rate behavior in emerging markets. In particular, central bank foreign exchange intervention and currency substitution are examined. The first essay studies foreign exchange intervention conducted by the National Bank of Georgia. Various econometric methodologies are applied to study both the determinants and effectiveness of intervention. A unique daily data set is employed in the analysis. The major intervention motives of leaning-against-the-wind and of decreasing volatility are revealed. Intervention influences the exchange rate as intended after a one-day lag. However, this effectiveness is achieved at the price of increased volatility of the exchange rate. In the second and third essays, the issue of currency substitution is studied. Two-currency monetary models are specified to analyze and explain currency substitution from different perspectives. These models focus on economic observables that influence a household's decision to switch to a foreign currency, namely the exchange rate, interest rates of savings in foreign and domestic currencies, and domestic and foreign inflation. The second essay studies the significance and rationalizes currency substitution in Georgia. The paper finds that this issue is of first-order importance in Georgia. The actual dynamics of currency substitution is well explained by the model that accentuates the exchange rate. The third essay is a comparative study of currency substitution in the Czech Republic, Georgia, Croatia, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkey. Country-specific structural breaks are detected, rationalized, and introduced in the estimation based on theoretical monetary models. The main findings suggest that currency substitution is significant in Croatia, Georgia, Turkey, Tajikistan, and Kyrgyzstan, while it is not significant in the Czech Republic and Kazakhstan.

Acknowledgments

I would like to express my gratitude to Petr Zemčík for his encouraging thesis supervision and excellent guidance. I am very grateful for valuable comments and helpful suggestions (in alphabetic order) to Josef Brada, Kathryn Dominguez, Jan Hanousek, Michal Kejak, Evzen Kočenda, Ali Kutan, Sergey Slobodyan, and Jan Svejnar; participants at the Society for the Study of Emerging Markets conference on challenges and opportunities in emerging markets in July 2010 as well as research seminars participants at CERGE-EI; and three anonymous referees at the Emerging Markets Finance and Trade journal. I am thankful to Archil Imnaishvili and Edward Oganesyan for exclusive data provided. Thanks go to Richard Stock for editing the dissertation. And last, but not least, I am very grateful to my husband, Jean-Camille Loiseau, and my parents for their strong support. This dissertation research was partially supported by Research Grant 259027 from the Grant Agency of Charles University. Research for the second chapter of the dissertation was mainly conducted during a stay at the Gerald R. Ford School of Public Policy at the University of Michigan.

Introduction

This dissertation focuses on the connection between domestic and external economic sectors in emerging markets. The link between foreign and domestic currency holdings and the ability to influence the exchange rate are studied. The first two papers focus on Georgia, a country that has not received much attention in the academic literature. Central bank foreign exchange intervention and currency substitution are studied in these papers. The third essay compares the Georgian experience of currency substitution to that of the Czech Republic, Croatia, Turkey, Kazakhstan, Kyrgyzstan and Tajikistan.

The first chapter is motivated by frequent partially-sterilized interventions conducted by the National Bank of Georgia. There is no consensus in the scanty academic literature on the efficiency of such interventions in emerging markets. This paper presents new evidence on the determinants and the effectiveness of intervention in Georgia. Daily data covering more than eleven years is used for the analysis. To account for the ongoing transformation process in Georgia, structural breaks in the data are determined and explicitly introduced in the estimation. The results indicate that the National Bank of Georgia leans against the wind and aims to decrease exchange rate volatility. In general, the Bank wants to limit the pace of the appreciation of the local currency against the US dollar. Daily-frequency connection between the intervention and the level as well as the volatility of exchange rate is revealed. The immediate effect of intervention on the exchange rate is opposite to the intention. The intended effect on the level of the exchange rate is observed already the next day after the intervention is conducted. However, frequent interventions increase the conditional volatility of the exchange rate in Georgia.

The second chapter studies the significance of currency substitution (dollarization) in Georgia and rationalizes its level. This work is motivated by the large and persistent holdings of US dollars in Georgia following its economic transformation. The academic literature suggests that dollarization plays a role that is more significant in emerging markets than in developed economies. However, the evidence on dollarization is highly dependent on country specificities, the time period, and the implemented methodology. In this paper, the money-in-utility-function framework with households' main motives for switching to a foreign currency is specified. The motives are changes in the exchange rate, the interest rates of savings in foreign and domestic currencies, and domestic and foreign inflation. In addition, households update their preferences according to accumulated knowledge on dollarization. This aims to capture all the possible factors that influenced the dollarization process in the past. Both the elasticity of currency substitution between domestic and foreign currencies, and the share of foreign currency in total household's money holdings are estimated using monthly Georgian data. The results show that the demand for US dollars is responsive to fluctuations in fundamentals. The US dollar has a significant 60 percent share in households' total liquidity in Georgia. Moreover, the US dollar is a strong substitute for the domestic currency in terms of reducing transaction costs. The demand for the dollar becomes less responsive to fluctuations in the exchange rate when news are introduced due to learning adjustment. In order to rationalize the actual dollarization, models with different motives for dollar holdings are compared. This allows identifying the exchange rate as the best predictor of dollarization in Georgia.

The third chapter examines households' currency substitution in several countries based on the implications of money-in-utility-function models. A new data set is compiled to estimate and compare the significance of household dollarization in the Czech Republic, Georgia, Croatia, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkey. As monthly consumption series are not available for each country, households' optimal choices between foreign and domestic money are derived in terms of observables and parameters. Structural breaks that are exogenous from the perspective of the models are detected, discussed, and added to the estimation. The results show that the share of foreign currency in total domestic liquidity is positively significant in all countries. The share of foreign currency in total liquidity is economically small in the Czech Republic (10-22 percent) and in Kazakhstan (15-48 percent). The highest share is in Croatia (91-93 percent). Foreign currency accounts for more than half of the total domestic liquidity in Georgia, Tajikistan, and Turkey. The economic significance of currency substitution decreases over time in Croatia, Georgia, and Turkey, and increases in Tajikistan, Kyrgyzstan and Kazakhstan. Foreign currency is a strong substitute for the local currency in Georgia, Kyrgyzstan and Turkey.

Determinants and Effectiveness of Foreign Exchange Market Intervention in Georgia

Abstract:

This paper uses unique daily data to study the determinants and the effectiveness of partially sterilized intervention by the National Bank of Georgia (NBG) during the period 1996-2007. Detected structural breaks in the exchange rate and the intervention series are important for NBG intervention motives and effectiveness. The central bank reaction functions indicate that the NBG leans against the wind while smoothing the exchange rate. The intended effect on the level of the exchange rate is observed the next day after the intervention is conducted. However, the conditional volatility increases with intervention.

Keywords: foreign exchange intervention, Georgia, structural break, determinants of intervention, effectiveness of intervention

JEL classification: C13, E44, E58, F31.

1.1 Introduction

Foreign exchange intervention is a commonly used tool of exchange rate management in advanced and developing economies. Intervention is mainly conducted by central banks in order to influence the exchange rate level and to "calm a disorderly market". The recent evidence on advanced countries suggests that intervention typically has an impact on the level and volatility of the exchange rate (Sarno and Taylor, 2001, Fatum and King, 2005). The literature on the direction of intervention impact is less homogeneous but the majority of studies tends towards stating increased volatility (Dominguez, 2003, 2006; counter-examples include Fatum and King, 2005 and Kim, 2007). This evidence is primarily focused on the effects of sterilized intervention.

Intervention in emerging market economies is not always fully and immediately sterilized. Such intervention is argued to have a stronger impact on the exchange rate than in advanced economies (Canales-Kriljenko, 2003).[1] However, evidence on the intervention effectiveness for emerging market economies remains fairly mixed (Disyatat and Galati, 2007). This paper contributes to this issue by presenting new evidence on the determinants and the effectiveness of the partially sterilized intervention of the National Bank of Georgia (NBG).

A major difficulty in evaluating the causes and the impact of intervention in emerging market economies has always been the lack of data. High frequency data became available only recently for some developing economies. However, the lack of available official data for the group of the seven poorest countries of the Commonwealth of Independent States (CIS-7)[2] countries resulted in a gap in the existing literature. This paper aims to fill this gap by analyzing intervention in an emerging CIS-7 economy. This paper employs a unique daily data set that includes the precise dates and extent of intervention operations of the NBG during the period 1996-2007.

Although the empirical literature on emerging market countries is still relatively limited, recent papers show mixed evidence on the effect of intervention on the exchange rate level and volatility.[3] Domaç and Mendoza (2004) find that the central banks of Mexico and Turkey conducted effective foreign exchange sales (but not purchases) in influencing the level and reducing the volatility of the exchange rates. Guimarães and

[1] Canales-Kriljenko (2003) identifies reasons why central bank intervention in emerging markets may have more of an impact on the exchange rate: the lack of full sterilization, the large size of interventions relative to currency market turnover, the informational advantage of the central bank over market participants, and moral suasion.

[2] The CIS-7 countries include Armenia, Azerbaijan, Georgia, Kyrgyzstan, Moldova, Tajikistan and Uzbekistan. There is no available intervention data for Armenia, Tajikistan or Uzbekistan. Only monthly frequency data starting from 2000 is available for Moldova. For Georgia and Kyrgyzstan, there is daily data starting from 2002 and 2009, respectively.

[3] Disyatat and Galati (2007) provide an extensive review of the existing mixed evidence on the effectiveness of intervention in emerging market countries.

Karacadag (2004) show that sales of foreign currency have a small impact on the exchange rate level and increase short-term volatility in Mexico. In Turkey, intervention does not affect exchange rate levels, reducing its short-term volatility. Akinci et al. (2005) find that only large and isolated purchases of the foreign currency in Turkey reduce volatility and the exchange rate level is not affected. Geręl and Holub (2006) find that intervention in the Czech Republic has only an immediate impact on the exchange rate that lasts up to 2-3 months in some episodes. Égert (2007) shows that short-run interventions to ease appreciation are successful in Croatia, the Czech Republic, Slovakia and Turkey and that intervention is not effective in Romania. Partial sterilization in Croatia does not improve the effectiveness of intervention as compared to other countries' mostly sterilized interventions. Thus, he suggests that unsterilized intervention does not automatically influence the exchange rate in emerging markets.

There are less studies focusing on the motives of central banks to intervene. Edison (1993) and Almekinders (1995) survey the literature prior to 1992. In general, most of these studies find strong evidence for leaning against the wind (preventing the exchange rate from moving in one direction via deliberate operations that result in its movement in the opposite direction). However, as most of the central banks did not publish official high-frequency data of intervention, the results on motives differ across countries depending on the proxies for the intervention variable, the data frequency, and the methodology applied (Gersl, 2006). More recently, high frequency data is used in the analysis of the motives of central banks to intervene in advanced economies.[4] For emerging markets, intervention determinants are studied in Akinci et al. (2005b). They find that the Central Bank of Turkey reacts to changes in volatility and deviations from the long-run trend of the exchange rate.

This paper contributes to the existing literature by analyzing the determinants and effectiveness of intervention in Georgia. Daily data of the NBG intervention activity

[4]Baillie and Osterberg (1997) find that the probability of intervention in the USA and Germany is determined by the deviation from targeted level and by the volatility of exchange rates. Kim and Sheen (2002) identifies similar motives for Australia.

for the period 1996-2007 is used in the analysis. Prior to the estimation, an endogenous search for structural breaks in the data is performed to account for the ongoing transformation process in Georgia.[5] This information is explicitly used in the estimation analysis of the determinants and effectiveness of intervention. In order to determine factors that trigger the NBG intervention, daily central bank reaction functions are estimated by OLS with lagged variables and IV. Exchange rate change is shown to be a determinant of intervention indicating simultaneity when analyzing effectiveness. As a result, a procedure similar to the 2SLS estimation and a GARCH-M model with lagged variables are used in addressing the effectiveness of the NBG intervention.

The results suggest that partially sterilized intervention allows the NBG to influence the level and the volatility of the exchange rate. The detected structural breaks in the exchange rate and the intervention series play a significant role in the NBG intervention motives and effectiveness. The NBG generally leans against the wind and wants to decrease the exchange rate volatility. The immediate effect of intervention on the exchange rate is opposite to the intention. The intended effect on the level of the exchange rate is observed the next day after the intervention is conducted. Nevertheless, the effectiveness-in-mean has a price, namely, the daily intervention activity increases the volatility of the exchange rate.

The rest of the paper is organized as follows. Section 2 briefly describes the methodologies commonly used in the literature and applied in this paper. Section 3 briefly describes intervention activity in Georgia. The data used in the estimation is described in Section 4. Section 5 reports empirical findings for the structural break tests in the data, intervention determinants, and intervention effectiveness. Section 6 concludes.

[5] The timing of country-specific events does not necessarily coincide with structural breaks in the macroeconomic data. For example, Kočenda (2005) finds that a break in the exchange rate occurs before the exchange rate policy shifts in a number of European transition countries.

1.2 Methodology

1.2.1 Structural Break and Stationarity Tests

When investigating the determinants and effectiveness of intervention, one has to take into account the possibility of structural breaks in a series. Country-specific and period-specific events often result in structural breaks in time series (Kočenda, 2005). When an existing break is neglected, the estimation results are inconsistent. Besides, a break biases stationarity tests towards detecting a unit root while series are stationary with break (broken stationary).[6]

There is a wide variety of structural break and broken stationarity tests in the literature. In this paper, the Vogelsang (1997) and Perron (1989) tests are applied to the exchange rates and to the intervention time series. The test proposed by Vogelsang (1997) endogenously searches for a single break point in a series. The specification of this test is robust to the unit-root dynamics of the series, does not impose restrictions on the nature of the data and the distribution of errors, and can be applied to a general polynomial function of time. The null hypothesis of no break against the alternative of a break in at least one of the trend polynomials or in the intercept is tested for a data generating process.

The break detected by the Vogelsang test is used as the expected break in the Perron test for an exogenous structural break and the broken stationarity. The Perron's null hypothesis is that a series has a unit root with an exogenous structural break that occurs at a given date. The alternative hypothesis is stationarity around a deterministic time trend with an exogenous change in the intercept and/or linear trend (broken trend stationarity). This test is reasonably robust to the presence of GARCH errors (Brooks and Alistair, 2002).

When data is broken trend stationary, the series become stationary after detrending

[6] Nelson and Plosser (1982) could not reject the null hypothesis of the unit root in macroeconomic time series for the USA. However, Perron (1989) showed that allowing for a single break in the intersept or the slope of the trend function, most of these series are stationary around the trend.

with a structural change incorporated. With a detected structural break in a series, there are two ways to proceed. First, an estimation over different sub-samples can be performed. Another method to overcome this problem is to use a dummy variable that represents a structural change. Depending on the nature of the break, an intercept or a slope dummy variable is introduced. The benefit of the dummy variable approach is that no degrees of freedom will be lost through a loss of observations. In the paper, the dummy variable approach is followed.

1.2.2 Determinants of Intervention

A number of researchers focus on the investigation of intervention motives. Ideally, the central bank reaction function is derived from a theoretical model, typically based on the loss function of the central bank (for example, Almekinders, 1995). However, most studies on intervention determinants postulate a central bank reaction function without any theoretical background (*ad hoc*). Both continuous and binary daily *ad hoc* reaction functions are estimated in this study.

Edison (1993) and Gersl (2006) survey literature on *ad hoc* reaction functions. A typical *ad hoc* central bank reaction function shows how intervention is dependent on the changes in the exchange rate level, deviation from the exchange rate target, and previous period's intervention as a proxy for unobservable factors that may influence intervention and controls for first order autocorrelation that is usually found in the intervention data. Based on the estimated coefficients, the leaning-against-the-wind (or leaning-with-the-wind) and the targeting-exchange-rate motives are tested.

Central banks react asymmetrically to appreciations and depreciations (Gersl, 2006). Separating the appreciation and the depreciation sub-periods allows the inclusion of a volatility[7] measure in the reaction function. The direct inclusion of exchange rate volatility into the reaction function estimated across periods with different directions of

[7] Squared changes in exchange rate or moving standard deviation/variance are used in the literature as volatility measures (for example, Hillebrand and Schnabl, 2006).

exchange rate movements is likely to lead to an insignificant coefficient. Moreover, the sign of the volatility coefficient would not be clearly interpretable. The volatility measure is always positive but the same degree of volatility in the depreciation sub-period has the opposite effect on the intervention than in the appreciation sub-period.

The main problem with estimating the reaction function by OLS lies in potential simultaneity (and endogeneity) bias. The change in the exchange rate may be to some extent dependent on intervention. This problem is especially severe if the estimation is conducted using low-frequency data (weekly, quarterly, or monthly). If interventions are effective, the probability of endogenous determination increases.

The usual practice to deal with the simultaneity problem is to replace the current values of the exchange rate with lagged values (for example, Dominguez and Frankel, 1993). This method is risky when applying it to low frequency data as lagged values of exchange rates might be correlated with the lagged intervention variable that is included as an explanatory variable. Another possibility is to use the current and lagged values of exchange rate as IV for the current exchange rate or to follow the Arellano-Bond (AB, Arellano and Bond, 1991) approach. In the initial version of the AB model, the first differences of predetermined and endogenous variables are instrumented with suitable lags of their own levels. In this paper, all three approaches are used to check the robustness of results.

Separating the actual decision to intervene from the decision on the amount to intervene, binary choice models (for example, Probit and Logit models) are frequently used to estimate the probability of intervention rather than the precise amount. The vector of explanatory variables includes the factors that trigger but do not explicitly refer to the direction of intervention, such as the change in the exchange rate, the deviation of the exchange rate from the targeted level, and the previous day's intervention amount. The exchange rate volatility is included as an explanatory variable when the model is estimated over a sub-sample of the exchange rate appreciation (depreciation).

1.2.3 Effectiveness of Intervention

In testing the effectiveness of intervention on the exchange rate level, the instrumental variables/the two stage least squares (IV/2SLS) approach is widely used to account for potential endogeneity bias. For example, Égert and Komárek (2005) use lagged intervention as an instrument for current intervention, while Disyatat and Galati (2005) use predicted values from the reaction function as instruments. Another approach is a procedure similar to the two stage least squares (2SLS) estimation (Galati, Melick and Micu, 2005). First, the reaction function of the central bank is estimated using the lagged exchange rate as IV for the current exchange rate, and the predicted values are obtained. Then, the impact of intervention on the exchange rate level is estimated using these predicted values of intervention as IV for the current intervention. Analyzing the effectiveness of the NBG interventions, the latter approach is used. The simultaneity problem is clearly present as the NBG leans against the wind looking at accumulated exchange rate changes.

The IV methodology can be also used to test the portfolio balance channel of unsterilized and sterilized interventions' effects on the exchange rate (see Dominguez and Frankel, 1993b).[8] In portfolio balance theory, the risk premium equation is estimated using the IV method to capture the potential simultaneity bias.[9] Different IV that are correlated with the spot exchange rate and actual asset suppliers, but uncorrelated with error term, are used. For example, these are lagged intervention, news about changes in the exchange rate policy, and secret/official intervention dummy (Dominguez and Frankel, 1993b).

Since the generalized autoregressive conditional heteroskedastic (GARCH) model

[8] Various channels of the effect of interventions on the exchange rate level and volatility are tested in the literature. Humpage and Osterberg (1992), Dominguez and Frankel (1993b), and Baillie and Osterberg (1997) find a significant portfolio balance channel; on the other hand, Dominguez and Frankel (1993a) survey studies that do not. Dominguez (1992) confirms the signaling effect, but Klein and Rosengren (1991) find evidence to the contrary. Dominguez (2003) argues that the central bank interventions influence intra-daily foreign exchange returns and volatility through information and noise trading channels. All these studies focus on strerilized intervention.

[9] Humpage and Osterberg (1992) use a GARCH methodology to examine whether daily interventions influence the risk premium.

was proposed by Bollerslev (1986), it has been widely used to analyze the impact of intervention on the exchange rate level and volatility.[10] Many studies analyze the effectiveness of intervention using a baseline GARCH (1,1) model for the change in the exchange rate, estimating both the effect of intervention on levels (in the mean equation) and on conditional volatility (in the variance equation). Several studies (for example, Dominguez, 1998 and Guimaraes and Karacadag, 2004) extend the baseline GARCH framework for analyzing the effectiveness of intervention by introducing conditional variance (standard deviation or variance in logarithmic form) into the mean equation (GARCH-M). This class of models initially is well-suited to study asset markets as an asset's riskiness can be measured as the variance of its return. In the foreign exchange market case, the mean of an asset's return (change in the exchange rate) depends on its (logarithm of) conditional variance.[11] The impact of the NBG interventions on the level and the volatility of the exchange rate is tested using GARCH-M model.[12]

The commonly used conditional distributions of the error term are the Normal (Gaussian) distribution, Student's t-distribution, and the Generalized Error Distribution (GED, Nelson, 1991). Most of the empirical studies simply assume Normal or Student's distribution. The GED distribution is used to avoid the overestimation of volatility in the case of the leptokurtic distribution of conditional volatility derived from the data.[13] This distribution is used to complete the GARCH-M specification in this paper.

Following GARCH estimation, it is important to verify that the standardized residuals are independent and identically distributed (iid). In order to test the residual's

[10] See Baillie and Osterberg (1997); Gersl (2006); Guimaraes and Karacadag (2004); Dominguez (1998); Egert and Komarek (2005); Ito (2003); Hillebrand and Schnabl (2003); and many others.

[11] Some studies use the exponential GARCH, the threshold GARCH, and the component GARCH models for robustness check and to account for possible asymmetries in the conditional variance equation (for example, Égert and Komárek, 2005).

[12] According to Akaike and Schwarz information criteria and required restrictions on coefficients, GARCH-M is the best GARCH-type model (EGARCH, TGARCH, simple GARCH, GARCH-M).

[13] Rahman and Saadi (2005) show that although the day of the week effect in the mean is independent of the imposed error distribution, this result is sensitive to error distribution in the conditional volatility case.

iid, in this paper, two tests are applied, namely the BDS (Brock, Dechert, Scheinkman, and LeBaron, 1996) and the Kočenda (Kočenda, 2001; Kočenda and Briatka, 2005) tests. The BDS test's null hypothesis is that the series are iid and the alternative is unspecified. The *ex ante* dependence on tolerance distance and embedding dimension represents the main weakness of the BDS test. Kočenda's alternative test eliminates the arbitrariness in the choice of the proximity parameter leaving only the choice of embedding dimension. In this paper, both the BDS and the Kočenda tests are applied.

1.3 Foreign Exchange Intervention in Georgia

The Georgian economy went through a transition recession in the period 1991–1994. This recession was the deepest among all the Former Soviet Union countries. The economy suffered from hyperinflation and general economic and political instability. Stabilization, structural, and currency reforms were conducted in the period 1995–1996. In October 1995, a new currency, the Georgian lari, was introduced. The lari was pegged *de facto* to the US dollar. Inflation dropped to a single-digit rate in the first half of 1998.

The Russian economic crisis of 1998 had a negative impact on the Georgian economy. Russia was the main trade partner of Georgia in the period 1996-2007. The exchange rate regime was switched to "free-floating" from early 1999. The IMF characterizes the exchange rate regime in Georgia as managed floating with no predetermined path for the exchange rate (ADB, 2007).

The NBG conducts monetary and exchange rate policies to "achieve and maintain the purchasing power of the national currency, maintain price stability, and ensure the liquidity, solvency, and market-based stable functioning of the financial and credit systems" (Organic Law of Georgia on the NBG). The NBG uses foreign exchange intervention, open market operations with refinancing loans, deposit certificates and government notes auctions, overnight credits and overnight deposits, and minimum reserve requirements as policy instruments.

The NBG interventions are conducted at the Tbilisi Interbank Foreign Exchange (TIFEX) market. The trade at the TIFEX market is held mostly in USD.[14] The market participants are local commercial banks and the NBG. Every working day, before the TIFEX trade session starts, the NBG computes the demand-supply ratio for the foreign currency from the local commercial banks based on the preliminary bids received by the TIFEX electronic system. According to the NBG, it decides on the volume of intervention based on this demand-supply ratio, the current economic conditions, and the trends in monetary and foreign exchange policy. The NBG claims to intervene mainly in order to keep the exchange rate stable and stabilize the foreign exchange market.

The NBG aims to conduct sterilized foreign exchange intervention.[15] However, due to an underdeveloped capital market and the high cost of interest payments, the intervention activity is only partially sterilized. Intervention was only partially sterilized in the period 1996-2004. From December 1998 until the second part of 2004, following the IMF recommendations, the NBG only purchased the US dollar to rebuild its stock of foreign exchange reserves. However, the NBG did not sterilize its intervention in 2004.[16] After 2005, the NBG continued to sterilize its intervention to account for the increasingly large amount of capital inflows. For example, the NBG sterilized three quarters of its intervention through the newly introduced auction of deposit certificates in 2006.[17] In summary, the foreign exchange intervention activity in Georgia can be described as only partially sterilized.

[14]The time series of Euro and Russian ruble interventions are much shorter and are not analyzed in this paper.

[15]For references see Inflation Reports, Annual Reports of the National Bank of Georgia, Asian Development Bank Report (2007), Maliszewski (2003), and Bakradze and Billmeier (2007).

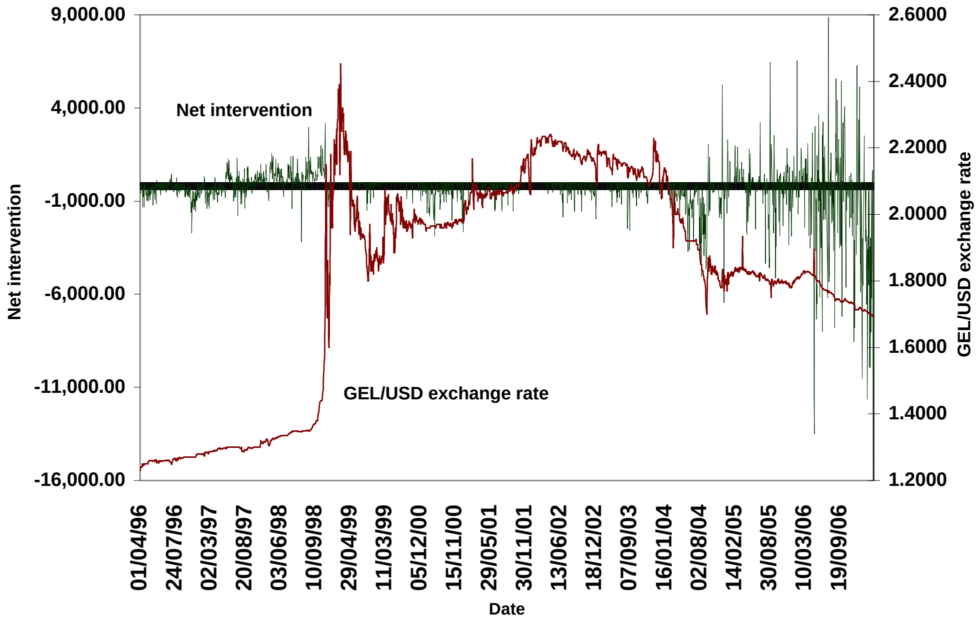
[16]This resulted in almost 50-percent growth rates of reserve and broad money at the end of 2004 that stabilized in 2005-2006.

[17]It replaced the deposit auction and securitized treasury bonds.

1.4 Data Description

The data set used in this paper is unique. It includes precise dates and amounts of NBG interventions (sales and purchases of the US dollar) at a daily frequency for the period 1996-2007. This data is exclusively provided by the NBG research department. Other time series are the daily exchange rates of the lari against the US dollar and the Russian rubble in units of lari per one unit of foreign currency.[18] Finally, the US short-term interest rates on 1-, 3-, and 6-month certificates of deposit (time deposits) are used. Due to the lack of daily data for Georgia, monthly interest rates on Georgian and US time deposits are used in robustness tests.

Figure 1. Daily GEL/USD Exchange Rate and Net intervention 1996-2007



The NBG net daily intervention and the GEL/USD exchange rate are shown in Figure 1. The net intervention (net USD sale) is defined as the amount of USD sold minus USD purchased by the NBG. The daily data covers the period 01/01/1996 – 19/04/2007. The "peak" interventions are caused by high USD demand or supply

[18] Both exchange rates are obtained from the NBG website (www.nbg.gov.ge).

by local commercial banks and are not related to any specific shock or event in the economy.

Table 1 provides the summary statistics and the stationarity tests for the GEL/USD exchange rate (*usd*); the GEL/RUR exchange rate (*rur*); net intervention (*net*); and the average short-term interest rate on the American certificates of deposit (*ir*). Conventional stationarity tests indicate that all the series, except the US interest rate, might be non-stationary. However, these series may be stationary with a break (broken trend stationary). In the next section, structural break and broken stationarity tests are performed.

Table 1. Data summary statistics

	usd	rur	net	ir
Observations	2748	2748	2748	2748
Mean	1.81	0.10	-334.36	4.05
Median	1.86	0.07	0.00	5.06
Maximum	2.45	0.25	8870.00	6.75
Minimum	1.23	0.05	-89230	1.02
Std. Dev.	0.33	0.06	2137.13	1.84
Skewness	-0.57	1.28	-27.23	-0.21
Kurtosis	1.96	2.71	1098.27	1.73
UR tests result	mixed	mixed	mixed	stat

Notes: The UR decision is based on the results of ADF, PP, KPSS, and WS tests at the 5% significance level.

1.5 Estimation Results

1.5.1 Results of Structural Break and Stationarity Tests

An endogenous search for structural breaks and a test for broken stationarity are reported in this section. The time series are the GEL/USD exchange rate (*usd*), the GEL/RUR exchange rate (*rur*), first differences of *usd* and *rur* ($dusd, drur$), and the net intervention (*net*). The detected breaks in net intervention and the first differences of exchange rates are important for the stationarity issue and for constructing dummy variables.

First, the Vogelsang and the Perron tests are applied to the series over the whole period 1996-2007. Second, the focus is on the period after the change to a floating exchange rate regime in December 1998. The results of the Vogelsang and Perron tests are given in Tables 2 and 3, respectively.

Table 2. Vogelsang test results

Variable	λ^*	Test statistic	5%CV	T_B^C	Sample
usd	0.01	31.17	10.85 (18.20)	19/11/98	01/01/96-19/04/07
dusd	0.01	27.51	10.85 (18.20)	16/03/99	01/01/96-19/04/07
rur	0.01	333.50	10.85 (18.20)	26/08/98	01/01/96-19/04/07
drur	0.01	19.63	10.85 (18.20)	09/09/98	01/01/96-19/04/07
net	0.01	119.26	10.85 (18.20)	27/11/06	01/01/96-19/04/07
usd	0.15	40.68	9.00(17.88)	21/11/01	01/12/98-19/04/07
dusd	0.15	22.08	9.00(17.88)	27/12/01	01/12/98-19/04/07

Notes: H_0: no break; H_A: break in intercept and/or trend; order of trend polynomial p=0; K is determined by the Campbell-Perron method; λ^* is a trimming parameter; T_B^C is the estimated break time; 5% critical values are given for stationary and unit root cases in parentheses (source: Vogelsang, 1997).

Table 3. Perron test results

Variable	T_B	Test statistic	5%CV	λ	Sample
		Daily Data			
usd	19/11/98	-4.59	-3.99	0.25	01/01/96-19/04/07
dusd	16/03/99	-21.10	-3.99	0.25	01/01/96-19/04/07
rur	26/08/98	-10.49	-3.99	0.23	01/01/96-19/04/07
drur	09/09/98	-19.39	-3.99	0.23	01/01/96-19/04/07
net	27/11/06	-22.26	-3.80	0.97	01/01/96-19/04/07
dnet	29/11/06	-23.52	-3.80	0.97	01/01/96-19/04/07

Notes: H_0: unit root with exogenous break in trend or/and intercept, H_A: broken stationarity; K is determined by the Campbell-Perron method; T_B is the predetermined break date; λ is the pre-break fraction; critical values source: Perron (1989).

To summarize the results, the Vogelsang test rejected the null hypothesis of no break in favour of a break in the trend or the intercept. It detected two main structural breaks (T_B^C in Tables 2 and 3) in both the intercept and linear trend for *usd*, and only in the intercept for *dusd*. The first break is a preamble to the exchange rate policy change from a managed to a free floating regime for *usd*, and is after the exchange rate regime change for *dusd*. The second break marks the end of the lari's continuous depreciation and is not associated with any policy step. Note that this break happens before the lari actually started to appreciate in 2002.

The GEL/RUR exchange rate series (*rur*) has a structural break in both the intercept and linear trend. Following the ruble denomination in January 1998, the Russian crisis took place in August 1998. The break in the intercept of *drur* occurs in September 1998.

The net intervention series *net* and *dnet* have structural breaks in intercepts in

November and December 2006, respectively. The NBG was purchasing large amounts of USD, responding to a very high demand for the lari by local commercial banks. Thus, these breaks are not connected to any exchange rate or intervention policy changes.

The Perron test indicates that daily exchange rates and net intervention series are broken trend stationary with the breaks detected by the Vogelsang test.

1.5.2 Evidence on Determinants of Intervention

In this subsection, the determinants of the NBG intervention are examined. Daily continuous reaction functions are estimated over three samples. The first sample is the whole data span 1996-2007. Second, the focus is on the sub-sample from December 1998 until September 2004 characterized by interventions of the same sign: only USD purchases. The third period is the sub-sample February 2002 - April 2007 characterized by continuous appreciation of the lari. The chosen sub-samples allow for the inclusion of exchange rate volatility into the reaction function and for checking the robustness of results.

The general specification of the continuous reaction function of the NBG net intervention I_t at day t (the amount of USD sold minus purchased) is

$$\begin{aligned} I_t = \beta_0 + \beta_1(e_t - e_{t-1}) + \beta_2(e_t - e_{t-20}) + \beta_3(e_t - e_t^T) + \\ + \beta_4(\Delta e_{t-1})^2 + \beta_5 I_{t-1} + \beta_6 d1 + \beta_7 d2 + \beta_8 d3 + \varepsilon_t. \end{aligned} \tag{1.1}$$

First, the NBG may decide on the amount of intervention based on exchange rate movements: leaning with/against the wind. This can be the same day's (absolute) change[19] $(e_t - e_{t-1})$,[20] and/or an accumulated change in a longer period, such as a month[21] (20 business days).

Second, the NBG may intervene if the lagged spot exchange rate deviates from

[19] The percentage measure of the change in the exchange rate leads to similar results.

[20] The NBG decides on the volume of intervention at the day t based on local commercial banks' preliminary bids.

[21] The one-month period follows Ito (2003). The results are robust in periods up to 3 months.

its target e_t^T, which is allowed to be time-dependent and is set as a 10-day backward moving average.[22] The volatility that can trigger the decision on the intervention's amount is measured as squared changes in the exchange rate as in Hillebrand and Schnabl (2006). The variable I_{t-1} is the previous day's intervention that is expected to influence the current intervention amount.

Finally, three dummies are included to capture the effect of the detected structural breaks in intercepts of $(e_t - e_{t-1})$ and I_t. Dummy variables are a common way of solving the issue of structural breaks, as they do not involve splitting the data.

$$d1 = \left\{ \begin{array}{c} 1, t < 27/11/06 \\ 0, t \geq 27/11/06 \end{array} \right\}, d2 = \left\{ \begin{array}{c} 1, t < 16/03/99 \\ 0, t \geq 16/03/99 \end{array} \right\},$$
$$d3 = \left\{ \begin{array}{c} 1, t < 27/12/01 \\ 0, t \geq 27/12/01 \end{array} \right\}. \tag{1.2}$$

The specifications of the reaction functions estimated over three periods are imbedded in (1.1). They differ in the inclusion of the exchange rate volatility and dummies. Namely, the volatility measure is not included into the regression ($\beta_4 = 0$) for the whole sample.[23] The second reaction function is estimated over the period 07/12/1998 - 14/09/2004 when the NBG was only purchasing USD. Exchange rate volatility is introduced, and $\beta_6 = 0$. Finally, the third reaction function is estimated over the lari appreciation period 26/02/2002 - 19/04/2007, where $\beta_7 = \beta_8 = 0$ and $\beta_4 \neq 0$.

First, these reaction functions are estimated by OLS over three periods with current values of the exchange rate replaced with lagged values. Then, the lagged and current values are used as instruments for the first three variables in period t.[24] As to volatility, it is not assumed to be exogenous, but is believed to be to some extent dependent on

[22] The targeted level of the exchange rate is usually set to the moving average of the spot exchange rate or to the purchasing power parity equilibrium level (Gersl, 2006; Ito, 2003; Akinci et al., 2005).

[23] In fact, the volatility coefficient turns out to be insignificant in the regression estimated over the whole sample.

[24] The AB approach for the reaction function does not give significant results.

the intervention activity. Thus, the lagged volatility is included.[25]

Table 4. Continuous reaction functions for the whole period 01/01/1996-19/04/2007

Estimation method:OLS		Estimation method:IV	
		IVs:$\Delta e_{t-1}, \Delta_{20} e_{t-1}, \Delta_T e_{t-1}$	
$Const$	-2322.12	$Const$	-3311.68***
Δe_{t-1}	-1777.66	Δe_t	3336.05**
$\Delta_{20} e_{t-1}$	2028.04***	$\Delta_{20} e_t$	572.14***
$\Delta_T e_{t-1}$	1447.15***	$\Delta_T e_t$	1596.24**
I_{t-1}	0.16*	I_{t-1}	0.12
$d1$	2015.75***	$d1$	3225.65***
$d2$	758.83**	$d2$	-60.81***
$d3$	-285.72***	$d3$	-153.84***
$R^2 = 0.07$	$DW = 2$	$R^2 = 0.1$	$DW = 1.99$
$BGLM$	0.49	$BGLM$	0.67
$ARCHLM$	0.15	$ARCHLM$	0.27

Notes: Δ, Δ_{20}, Δ_T are one-period change, twenty-period change, and one-period change from the target, respectively.*=significance at 10%; **=significance at 5%;***=significance at 1%; $BGLM$ is the Breusch-Godfrey serial correlation LM test; $ARCHLM$ is the ARCH LM test.

The results of OLS and IV estimation and specification tests are given in Tables 4 and 5. Overall, the structural break intercept dummy variables are significant. The detected structural breaks change the regression intercept. The most important structural break is associated with the increase in the NBG intervention operations.

There is the evidence of leaning against the wind in response to one-month accumulated changes in the exchange rate over the whole sample. The NBG leans against the wind based on the changes in the spot exchange rate but not on the previous day's changes in the exchange rate.

The NBG clearly leans against the wind in the sub-sample of USD purchases. It buys less USD when the lari depreciates and more USD when the lari appreciates. In the sub-sample when the lari continuously appreciates, the previous day's leaning-against-the-wind motive is only marginally significant. The immediate and one-month accumulated motives are significant in the IV estimation results.

The exchange rate volatility in the sub-sample of USD purchases is a significant determinant of intervention at only the 10% level. Note that its sign is not clearly interpretable as the lari first depreciated and then appreciated. In the lari appreciation sub-sample, the NBG clearly attempts to decrease volatility.[26]

[25] The instrumented current volatility with its lags leads to roughly similar results.

[26] Estimation over the lari depreciation period also indicates smoothing volatility as the NBG intervention motive.

The results give clear evidence that the NBG is expected to intervene if the spot exchange rate deviates from the target exchange rate in the full sample and in the appreciation sub-samples. However, there is no targeting motive during the USD-purchases period.

Table 5. Continuous reaction functions for sub-samples

Sub-sample of USD purchases: 07/12/98-14/09/04				Sub-sample of GEL appreciation: 26/02/02-19/04/07			
Estimation method:OLS		Estimation method:IV IVs:$\Delta e_{t-1}, \Delta_{20} e_{t-1}, \Delta_T e_{t-1}$		Estimation method:OLS		Estimation method:IV IVs:$\Delta e_{t-1}, \Delta_{20} e_{t-1}, \Delta_T e_{t-1}$	
$Const$	-2304.97***	$Const$	4784.35	$Const$	-4519.03***	$Const$	-315.42***
Δe_{t-1}	1083.74***	Δe_t	2687.43***	Δe_{t-1}	4778.02*	Δe_t	5358.73***
$\Delta_{20} e_{t-1}$	271.06**	$\Delta_{20} e_t$	5183.80**	$\Delta_{20} e_{t-1}$	4273.76	$\Delta_{20} e_t$	870.82***
$\Delta_T e_{t-1}$	-1029.24***	$\Delta_T e_t$	344.669	$\Delta_T e_{t-1}$	515.23**	$\Delta_T e_t$	174.40***
I_{t-1}	0.55***	I_{t-1}	0.61***	I_{t-1}	0.10	I_{t-1}	0.25***
$d2$	156.12**	$d2$	108.278	$d1$	3168.91***	$d1$	-37.15
$d3$	-191.71***	$d3$	-69.46***	$(\Delta e_{t-1})^2$	-75033.50***	$(\Delta e_{t-1})^2$	-24628.55**
$(\Delta e_{t-1})^2$	5062.99*	$(\Delta e_{t-1})^2$	7113.63*				
$R^2 = 0.44$	$DW = 2.12$	$R^2 = 0.43$	$DW = 2.18$	$R^2 = 0.09$	$DW = 1.99$	$R^2 = 0.14$	$DW = 1.99$
$BGLM$	0	$BGLM$	0	$BGLM$	0.99	$BGLM$	0.37
$ARCHLM$	0	$ARCHLM$	0	$ARCHLM$	0.56	$ARCHLM$	0.63

Notes: Δ, Δ_{20}, Δ_T are one-period change, twenty-period change, and one-period change from the target, respectively. *=significance at 10%; **=significance at 5%;***=significance at 1%; in the case of detected autocorrelation and/or heteroscedasticity, the robust White or Newey-West standard errors are calculated.

Table 6 presents the estimation results of the binary reaction function. First, a Logit model[27] is estimated over the whole sample with dependent variable D_t that equals one if intervention took place and zero otherwise. The probability to intervene is estimated via the maximum likelihood from the model

$$P(D_t = 1 \mid x_t) = F(\beta x_t), \tag{1.3}$$

where F is a logistic cumulative distribution function. The vector of explanatory variables x_t includes the (lagged) short-term and medium-term change in the exchange rate, the deviation of exchange rate from the targeted level, and the previous day's intervention amount. Second, the model is estimated separately for the period of lari appreciation, adding the lagged and the exchange rate volatility to the list of explanatory variables.

[27] The Probit estimation gives similar results.

Table 6. Binary reaction functions

Sample: 01/01/1996-19/04/2007		Sub-sample of GEL appreciation: 26/02/02-19/04/07	
$Const$	8.53***	$Const$	-3.37***
Δe_{t-1}	5.80**	Δe_{t-1}	31.20***
$\Delta_{20} e_{t-1}$	5.95***	$\Delta_{20} e_{t-1}$	1.19
$\Delta_T e_{t-1}$	4.00***	$\Delta_T e_{t-1}$	41.96***
I_{t-1}	$-2.42\times10^{-4***}$	D_{t-1}	-1.69***
$d1$	0.62**	$d1$	1.16***
$d2$	-1.63***	$(\Delta e_{t-1})^2$	519.02***
$d3$	0.21**		
$McFR^2 = 0.27$	$\%CP = 71.29$	$McFR^2 = 0.31$	$\%CP = 73.37$

Notes: Δ, Δ_{20}, Δ_T are one-period, twenty-period changes, and a one-period change from the target respectively. Estimation method: ML - Binary Logit (Newton-Raphson); *=significance at 10%;**=significance at 5%;***=significance at 1%.

In the regression estimated over the whole sample, first, the results give evidence that the NBG intervenes when the exchange rate deviates from a targeted value (scale factor 0.247). Second, the negative value of the lagged intervention coefficient implies that an increase in the previous day's amount of USD sold decreases the probability of the response. The probability to intervene increases with the short- and medium-run depreciation rate. In the sample of the lari appreciation (scale factor 0.243), both the previous period's deviation from the target and the short-run exchange rate change increase the probability to intervene. The volatility is also a significant determinant of the decision to intervene. In line with the continuous reaction function evidence, the structural break (in intercept) dummy variables change the regression intercept.

1.5.3 Evidence on the Effectiveness of Intervention

1.5.3.1 *Impact on the Exchange Rate Level*

Immediate (one day) and short-run (two to four days) impacts of the intervention on the changes in the exchange rate level over one-, two-, and three-day periods are estimated.

$$\Delta e_t = \beta_1 + \sum_{i=0}^{4} \alpha_i I_{t-i} + \beta_2 dir_{t-1} + \beta_3 \Delta e_{t-1}^{RUR} + \beta_4 d1 + \beta_5 d2 + \beta_6 d3 + \beta_7 d4 + \varepsilon_t. \quad (1.4)$$

The dummies are defined as in (1.2) and the dummy variable for the GEL/RUR structural break is

$$d4 = \left\{ \begin{array}{l} 1, t < 09/09/98 \\ 0, t \geq 09/09/98 \end{array} \right\}. \tag{1.5}$$

The change in the exchange rate is expected to be dependent on the volume of the current and lagged NBG intervention. The (lagged) changes in the US interest rate on deposits (dir_{t-1}) and the GEL/RUR exchange rate (Δe_{t-1}^{RUR}) are included as other explanatory variables. Intuitively, if the foreign interest rate goes up, domestic certificates of deposits are substituted with foreign ones, resulting in depreciation pressure on the local currency. On the other hand, when the lari depreciates towards any important substitute currency (the ruble), then an investor wants to switch away from the lari to any other strong currency (the USD). This is likely to have an impact on changes in the GEL/USD exchange rate. Russia was the main trade partner of Georgia during the period 1996-2007 (76% of Georgian foreign trade in 2006).

Intervention depends on the current and one-month accumulated change in the exchange rate as suggested by the estimated reaction function (1.1). In order to avoid bias in α_0 in (1.4) the following procedure is applied. First, the daily reaction function (1.1) is re-estimated over the period 1996-2007 by IV with only significant variables left and the predicted values are obtained. Second, (1.4) is estimated using the predicted values from the reaction function as instruments for the intervention.

Table 7 shows the estimation results of three regressions over the period 01/01/1996-19/04/2007.[28] The structural break dummy variables are insignificant and are not reported. Changes in the exchange rate regime, in the direction of exchange rate movements, and in the size of intervention do not influence the effectiveness-in-mean of intervention.

[28] The results are all robust to the lari-appreciation and the USD-purchases sub-samples.

Table 7. Daily impact of intervention on the GEL/USD exchange rate level

Variable	Regression I: Δe_t	Regression II: $e_t - e_{t-2}$	Regression III: $e_t - e_{t-3}$
		IVs: $\widehat{I_{t-1}}, \widehat{I_{t-2}}, \widehat{I_{t-3}}, \widehat{I_{t-4}}, \widehat{I_{t-5}}$	
$Const$	0.02***	2.22E-03***	3.81E-03***
I_t	8.13E-06**	0.01**	1.23E-03***
I_{t-1}	-1.00E-06	-4.36E-07	-1.29E-06
I_{t-2}	-9.75E-09	-2.73E-08	2.30E-07
I_{t-3}	-7.34E-07*	-6.29E-07*	-8.19E-07*
I_{t-4}	-6.09E-07*	-5.87E-07*	-1.06E-06*
dir_{t-1}	1.82E-03	-3.87E-04	8.50E-04
Δe_{t-1}^{RUR}	2.11***	2.19***	2.63***
R^2	0.28	0.14	0.11

Notes: $\widehat{I_i}$ are predicted values from the reaction function with only 5%-significant variables; sample: 01/01/1996-19/04/2007; estimation method: IV; *=significance at 10%; **=significance at 5%;***=significance at 1%; In regressions I, II and IV, the F-test indicates that all intervention variables are significant at the 1% level.

There is no desired impact of intervention on the changes in the exchange rate level before three days. The immediate effect of intervention on the exchange rate changes is opposite to what is intended. It is shown that the NBG decides on the amount of intervention based on the USD demand-supply ratio from preliminary bids from commercial banks. The amount of the intervention does influence the actual exchange rate change, pushing it further in its trend. This could be explained by imperfect information, or other factors might push the exchange rate in the opposite direction. However, this unintended effect lasts only one day. Already after two days, the NBG pushes the exchange rate in the desired direction (leans against the wind). The third and fourth day's interventions are effective at the 10% significance level.

The insignificant coefficient of the change in the US interest rate on deposits suggests that substitution from domestic to foreign deposits does not create significant depreciation pressure on the lari. This coefficient has the expected positive sign in two specifications. For robustness the check, the spread between American and Georgian interest rates was used. Due to the lack of Georgian data, this robustness check was performed using monthly frequency data. The coefficient β_2 remains insignificant when the same specification is used.

The coefficient β_3 on the changes in GEL/RUR is significantly positive. When the lari depreciates towards the ruble, then an investor wants to switch away from the lari to the USD, which is a strong substitute currency in the investor's portfolio. Thus, the demand for the US dollar increases, and the lari also depreciates towards the USD.

1.5.3.2 *Impact on the Exchange Rate Level and Volatility*

In this sub-section the effects of intervention on the level of the GEL/USD exchange rate and on the conditional volatility are analyzed within the GARCH-M framework. This specification allows analyzing the effectiveness of intervention by introducing conditional variance into the mean equation. The GARCH-M model is specified as follows:

$$\Delta e_t = \beta_0 + \beta_1 I_{t-1} + \beta_2 \ln v_t + \beta_3 dir_{t-1} + \beta_3 \Delta e_{t-1}^{RUR} + \tag{1.6}$$
$$+\beta_5 d1 + \beta_6 d2 + \beta_7 d3 + \beta_8 d4 + \varepsilon_t,$$
$$\varepsilon_t \mid \Omega_{t-1} \sim GED,$$
$$v_t = \delta_0 + \delta_1 \varepsilon_{t-1}^2 + \delta_2 v_{t-1} + \delta_3 |I_{t-1}| + \delta_4 dir_{t-1} +$$
$$+\delta_5 \Delta e_{t-1}^{RUR} + \delta_6 d1 + \delta_7 d2 + \delta_8 d3 + \delta_9 d4 + u_t.$$

In this specification, the level change in the GEL/USD exchange rate level (Δe_t) and the conditional volatility (v_t) depend on the lagged values of intervention (I_{t-1}) to control for simultaneity bias.[29] The second explanatory variable in the mean equation ($\ln v_t$) allows for the possibility that changes in the logarithm of variance influence the conditional mean. The (lagged) change in the US interest rate on deposits (dir_{t-1}) and the GEL/RUR exchange rate (Δe_{t-1}^{RUR}) are included as other explanatory variables similar to (1.4). In the conditional variance equation, the intervention variable is included in the absolute value form as in Dominguez (1998).

Table 8 shows the results of the GARCH-M estimation over the period 01/01/1996-19/04/2007[30] and of the diagnostic tests. The first three explanatory variables included in the conditional variance equation are highly significant, indicating that the parame-

[29] The IV estimation using the fitted values from the reaction function leads to similar results.

[30] The results are all robust to the lari-appreciation and the USD-purchases sub-samples.

ters have explanatory power in the daily model. The ARCH term, which reflects the impact of surprises from previous periods on the volatility, is significant and positive. The magnitude of the coefficient on the lagged conditional variance, δ_2, is about 0.6 and highly significant, indicating that the variance effect is highly persistent. The restrictions for the stability and non-negativity of variance are satisfied.

Table 8. Impact of intervention on the GEL/USD exchange rate level and volatility

Mean equation	
$Const$	-0.01***
$\ln v_t$	-9.05E-04***
I_{t-1}	-6.72E-08***
Δe_{t-1}^{RUR}	1.97***
dir_{t-1}	1.08E-03**
$d1$	2.88E-03***
$d2$	-0.01***
$d3$	-8.53E-04**
$d4$	0.01***
Variance equation	
$Const$	1.38E-05***
$Arch(1)$	0.18***
$Garch(1)$	0.61***
$\lvert I_{t-1}\rvert$	3.76E-10***
Δe_{t-1}^{RUR}	2.71E-04***
dir_{t-1}	-5.78E-06***
$d1$	2.15E-05***
$d2$	-8.23E-05***
$d3$	8.94E-06***
$d4$	1.05E-04***
$R^2 = 0.07$	DW =1.90
Arch LM test	Not reject H_0
BDS independence test	Not reject H_0
The Kočenda test	Reject H_0

Notes: The BDS test is performed for m=2,3,4,5 and different values of ϵ; the critical values for 2500 observations are used (source: Kanzler, 1999). The Kočenda test is performed for m=2,3,4,5 and the optimal range of ε; the critical values for 2500 observations are used (source: Kočenda and Briatka, 2005). Sample: 01/01/1996-19/04/2007; estimation method: ML - ARCH (Marquardt) – Generalized error distribution; Q-tests indicate no remaining serial autocorrelation in residuals; *=significance at 10%;**=significance at 5%;***=significance at 1%.

The conditional distribution of errors is GED. The regression's diagnostics indicate that there is no remaining GARCH in errors. Standardized residuals are iid according to the BDS test. However, they are not iid by Kočenda's test. This provides additional support for using GED in the model.

The structural break dummy variables are significant in both mean and variance equations. The structural breaks of 1998-1999 in the GEL/USD and GEL/RUR exchange rates strongly contribute to the intercept change in the mean equation. The smallest (in absolute value) impact on the mean-equation's regression intercept is from the non-institutional break in the GEL/USD exchange rate of 2001. In the variance equation, the impacts of all four structural break dummy variables are significant and smaller than in the mean equation.

The impact of (lagged) intervention on the exchange rate level is consistent with the leaning-against-the-wind-motive. Thus, the NBG is successful in influencing and preventing the exchange rate from moving in one direction via deliberate operations that result in its movement in the opposite direction. This result is in line with the marginal evidence from the IV estimation results. Holding other factors fixed, if conditional variance is 10% higher, the change in the exchange rate level is 0.000095 points lower. That is, the increased riskiness measured by the conditional variance acts to decrease the pace of depreciation, and thus, increases the return on the currency "asset".

The results suggest that the NBG intervention activity increases conditional volatility.[31] Regardless of the direction of the intervention (sales or purchases of USD), the presence of the NBG at the TIFEX market increases the volatility of the exchange rate. The reaction function estimation results indicate that the NBG aims to decrease volatility. The volatility measure is insignificant in the reaction function estimated over the whole period but is significant when estimated over sub-samples of appreciation and depreciation. Equation (1.6) was also estimated over the lari appreciation and depreciation sub-samples. In both cases, intervention activity increases conditional volatility.[32]

In line with the IV estimation results, the change in the GEL/RUR exchange rate is significantly positive related to the change in the GEL/USD exchange rate level. Moreover, conditional volatility increases with an increase in the change in the GEL/RUR exchange rate. The effect on the conditional volatility is much smaller than on the change in the GEL/USD level.

In contrast with the IV estimation results, the coefficient of the changes in the US interest rate is now significant and positive. An increase in the US interest rate on time

[31] This is a common finding in the intervention literature (for example, Dominguez, 1998).

[32] The results of reaction function estimation are robust to the volatility measure.

deposits is associated with the depreciation of the lari. Interestingly, an increase in the US interest rate on deposits leads to a decrease in the conditional volatility. This effect is smaller than on the change of the GEL/USD level. Similarly to IV estimation, a robustness check was performed with monthly data on the short-term interest rate spread between USD and GEL. The coefficients β_3 and δ_4 in (1.6) have the same signs and similar magnitude.

1.6 Conclusion

This paper analyzes partially sterilized foreign exchange intervention in Georgia. The existing evidence on developing countries is scanty, mixed, and complicated by severe data limitations (Disyatat and Galati, 2007). This paper contributes to the literature by presenting evidence on the determinants and effectiveness of National Bank of Georgia interventions using daily data for the period 1996-2007.

Detected structural breaks in the exchange rate and the intervention series have a significant impact on the way the NBG reacts to changes in the exchange rate and volatility. On the other hand, the breaks affect the impact of intervention on the level and the conditional volatility in the GARCH-M, but not in the IV, estimation. The breaks in the exchange rates are a result of the Russian crisis in 1998. The NBG responded to these breaks by changing the exchange rate regime to free floating. Another break in the exchange rate with the US dollar is caused by increased demand for the lari by local commercial banks. This was a preamble to the lari's continuous appreciation.

The demand for US dollars in Georgia is influenced by the exchange rate of the lari towards the Russian ruble and by the US interest rate on deposits. When the lari weakens towards the RUR, the demand for USD increases. When investments become more attractive in the US than in Georgia, the demand for USD increases as well. This increase creates depreciation pressure on the lari.

The NBG leans against the wind and aims to decrease the exchange rate volatility. Overall, the NBG purchases US dollars to limit the appreciation and the volatility of the lari. This aims to contribute to international trade and to attract foreign investment. The central bank leans against the wind according to the changes in the spot and the accumulated exchange rate changes. When the NBG only purchases USD, the Bank also looks at the previous day's changes in the exchange rate. During the periods of the lari's appreciation and depreciation, the NBG intervenes to "calm a disorderly market".

There is a daily-frequency connection between the partially sterilized intervention and the level of the exchange rate. The NBG is generally successful in its leaning-against-the-wind intervention activity. According to the GARCH-M estimation results, the desired effect is observed already the next day after the intervention is conducted. The immediate impact of intervention is opposite to the intention. There is weak evidence of the intervention's effectiveness-in-mean with a two-day lag according to the IV estimation results. The depreciation trend of the exchange rate is clearly supported by the NBG intervention activity until 2002. With strong capital inflows, the NBG only decreases the pace of the exchange rate appreciation.

On the other hand, the NBG is not successful in "calming a disorderly market". The NBG's frequent interventions increase exchange rate volatility. Intervening too often alters the exchange rate float and is costly. Fear of floating disappears over time in Georgia. This calls for less frequent foreign exchange interventions. Intervention is cost effective in the presence of large shocks, as their fixed costs are often lower than the costs of other policies (Lahiri and Vegh, 2001).

Overall, the NBG faces the challenge of choosing between limiting exchange rate appreciation and controlling inflation. During the period considered in this paper, 1996-2007, the focus of the NBG was mainly to limit appreciation and less to control inflation. Due to the high dollarization and remittances, this policy has negative effects on the welfare of the country. The NBG should focus more on inflation using foreign exchange intervention to smooth short-term fluctuations due to large shocks. From May 2009, the NBG committed to an increase in exchange rate flexibility by limiting its foreign exchange intervention (IMF, 2009).

References

Akinci, Ö., Çulha, O., Özlale, Ü., Sahinbeyoglu, G. (2005a). The Effectiveness of Foreign Exchange Interventions for the Turkish Economy: A Post-Crisis Period Analysis. Central Bank of the Republic of Turkey Research Department Working Paper, 6.

Akinci, Ö., Çulha, O., Özlale, Ü., Sahinbeyoglu, G. (2005b). Causes and Effectiveness of Foreign Exchange Interventions for the Turkish Economy. Central Bank of the Republic of Turkey Research Department Working Paper, 5.

Almekinders, G. (1995). Foreign Exchange Intervention: Theory and Evidence. Edward Elgar Publishing.

Arellano, M. & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. Review of Economic Studies, 58, 277-297.

Asian Development Bank. (2007). Georgia: Country Economic Report.

Baker, K., Rahman, A., S. Saadi. (2005). The Day-of-the-Week Effect and Conditional Volatility: Sensitivity of Error Distributional Assumptions. Review of Financial Economics, accepted manuscript.

Baillie, R. & Osterberg, W. (1997). Why do Central Banks Intervene? Journal of International Money and Finance, 16, 909-919.

Billmeier, A. & Bakradze, G. (2007). Inflation Targeting in Georgia: Are We There Yet? IMF Working Papers, 07/193.

Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. Journal of Econometrics, 31, 307-327.

Brooks, C. & Alistair, R. (2002). Testing for a Unit Root in a Process Exhibiting a Structural Break in the Presence of GARCH Errors. Computational Economics, 20, 157-76.

CamBrock, W., Dechert, W., Scheinkman, J., B. LeBaron. (1996). A Test for Independence Based on the Correlation Dimension. Econometric Reviews, 15, 197-235.

Campbell, J. & Perron, P. (1991). Pitfalls and Opportunities: What Macroeconomists Should Know About Unit Roots. NBER Technical Working Paper, 0100.

Canales-Kriljenko, J. (2003). Foreign Exchange Intervention in Developing and Transition Economies: Results of a Survey. IMF Working Paper, 95.

Disyatat, P. & Galati, G. (2007). The Effectiveness of Foreign Exchange Intervention in Emerging Market Countries: Evidence from the Czech Koruna. Journal of International Money and Finance, 26, 383-402.

Domaç, I. & Mendoza, A. (2004). Is There Room for Forex Interventions under Inflation Targeting Framework? Evidence from Mexico and Turkey. World Bank Policy Research Working Paper, 3288.

Dominguez, K. (2006). When do Central Bank Interventions Influence Intra-daily and Longer-term Exchange Rate Movements? Journal of International Money and Finance, 25, 1051-1071.

Dominguez, K. (2003). The Market Microstructure of Central Bank Intervention. Journal of International Economics, 59, 25-45.

Dominguez, K. (1998). Central Bank Intervention and Exchange Rate Volatility. Journal of International Money and Finance, 17, 161-190.

Dominguez, K. (1992). The Informational Role of Official Foreign Exchange Intervention Operations: The Signalling Hypothesis. Exchange Rate Efficiency and the Behavior of International Asset Markets. Garland Publishing Company.

Dominguez, K. & Frankel, J. (1993a). Does Foreign Exchange Intervention Work? Institute for International Economics. Washington Press.

Dominguez, K. & Frankel, J. (1993b). Does Foreign-Exchange Intervention Matter? The Portfolio Effect. American Economic Review, 83, 1356-1369.

Edison, H. (1993). The Effectiveness of Central Bank Intervention: A Survey of the Literature after 1982. Special papers in International Economics, 18.

Egert, B. (2007). Central Bank Intervention, Communication and Interest Rate Policy in Emerging European Economies. Journal of Comparative Economics, 35, 387-413.

Egert, B. & Komárek, L. (2006). Foreign Exchange Interventions and Interest Rate Policy in the Czech Republic: Hand in Glove? Economic Systems, 30, 121-140.

Fatum, R. & Hutchison, M. (2003). Effectiveness of Official Daily Foreign Exchange Market Intervention Operations in Japan. NBER Working Paper, 9648.

Fatum, R. & King, M. (2005). Rules versus Discretion in Foreign Exchange Intervention: Evidence from Official Bank of Canada High-frequency Data. Working Paper of University of Alberta, 04-24.

Galati, G., Melick, W., Micu, M. (2005). Foreign Exchange Market Intervention and Expectations: the Yen/Dollar Exchange Rate. Journal of International Money and Finance, 24, 982-1011.

Geraļ, A. (2006). Testing the Effectiveness of the Czech National Bank's Foreign-Exchange Intervention. Czech Journal of Economics and Finance, 56, 398-415.

Geraļ, A. & Holub, T. (2006). Foreign Exchange Interventions under Inflation Targeting: The Czech Experience. Contemporary Economic Policy, 24, 4, 475–491.

Guimaraes, R. & Karacadag, C. (2004). The Empirics of Foreign Exchange Intervention in Emerging Market Countries: The Cases of Mexico and Turkey. IMF Working Paper, 123.

Hillebrand, E. & Schnabl, G. (2006). A Structural Break in the Effects of Japanese Foreign Exchange Intervention on Yen/Dollar Exchange Rate Volatility. ECB Working Paper Series, 650.

Humpage, O. & Osterberg, W. (1992). Intervention and the Foreign Exchange Risk Premium: an Empirical Investigation of Daily Effects. Global Finance Journal, 3, 23-50.

IMF Country Reports. (2007, 2009). Georgia: Sixth Review Under the Three-Year Arrangement Under the Poverty Reduction and Growth Facility and Request for Waiver of Performance Criteria.

Ito, T. (2003). Is Foreign Exchange Intervention Effective? The Japanese Experiences in the 1990s. Monetary History, Exchange Rates and Financial Markets. Edward Elgar Publishing, 126-153.

Kim, S. (2007). Intraday Evidence of Efficacy of 1991-2004 Yen Interventions by the Bank of Japan. Journal of International Financial Markets, Institutions and Money, 17, 341-360.

Klein, M. & Rosengren, E. (1991). Foreign Exchange Intervention as a Signal of Monetary Policy. New England Economic Review, 5, 39-50.

Kočenda, E. (2005). Beware of Breaks in Exchange Rates: Evidence from European Transition Countries. Economic Systems, 29, 307-324.

Kočenda, E. (2001). An Alternative to the BDS test: Integration Across the Correlation Integral. Econometric Reviews, 20, 337-351.

Kočenda, E. & Briatka, L. (2005). Optimal Range for the iid Test Based on Integration across the Correlation Integral. Econometric Reviews, 24, 265-296.

Lahiri, A. & Vegh, C. (2001). Living with Fear of Floating: An Optimal Policy Perspective. NBER Working Paper, 8391.

Maliszewski, W. (2003). Modeling Inflation in Georgia. IMF Working Papers, 03/212.

National Bank of Georgia. (various years). Inflation Reports.

Nelson, D. (1991). Conditional Heteroskedasticity in Asset Returns: A New Approach. Econometrica, 59, 347-370.

Perron, P. (1989). The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. Econometrica, 57, 1361-1401.

Sarno, L. & Taylor, M. (2001). Official Intervention in the Foreign Exchange Markets: Is it Effective and, if So, How Does it Work? Journal of Economic Literature, 34, 839-868.

Vogelsang, T. (1997). Wald-type Tests for Detecting Breaks in the Trend Function of a Dynamic Time Series. Econometric Theory, 13, 818–849.

Dollarization in Emerging Markets: New Evidence from Georgia

Abstract:

This paper studies dollarization using the implications of three versions of a money-in-utility function model. These versions accentuate the roles of the exchange rate, the interest rates on foreign and domestic currencies time deposits, and domestic and foreign inflation. Monthly Georgian data for the period 1996 - 2007 is employed in the analysis. Findings indicate that the US dollar is a strong substitute for the domestic currency. Moreover, the dollar has a significant share in domestic liquidity services. The historical dollarization is well explained by the exchange rate model, which implies that the exchange rate is the best predictor of dollarization.

Keywords: Dollarization, Georgia, Money-in-utility function
JEL classification: C51, E41, F31

2.1 Introduction

Dollarization or currency substitution[33] is a common feature of emerging markets characterized by a history of macroeconomic instability. Dollarization is a matter of concern for policymakers, as it leads to reducing the effects of domestic monetary and fiscal policies. Currency substitution was a very popular topic in the academic

[33] The paper uses dollarization (currency substitution) to refer to the unofficial process in which the national currency, as a means of circulation and wealth accumulation, is substituted with a more stable foreign currency or several currencies (Calvo & Vegh, 1996).

literature of 1970s and 1980s. Recently, the issue of dollarization in a number of developing economies has again gained increasing attention. However, this issue is still understudied for CIS-7 countries mainly due to the lack of high frequency data.

In the CIS-7 economies, large amounts of US dollars are held by the public. Significant de-dollarization has not yet occurred in these countries despite the recent progress in macroeconomic stabilization. Georgia is one of these economies, in which currency crises along with a history of hyperinflation resulted in dollarization.[34] The current level of dollarization remains high even with moderate inflation and a stable exchange rate. This paper studies the significance of dollarization in Georgia and rationalizes its level for the period 1996-2007.

Money demand in multi-currency economy is specified based on a theoretical model's implications in the literature. The theoretical models of money demand are cash-in-advance (CIA), transaction costs, and *ad hoc* models.[35] This paper specifies a benchmark model with total money (liquidity) holdings in a utility function (MIUF). Total money is a constant elasticity of substitution function of foreign and domestic currencies that households hold. Both foreign and domestic money are useful for reducing transaction costs.

In order to study dollarization from different perspectives, three versions of the benchmark model are formulated in this paper. These models accentuate the role of inflation, exchange rate, and time deposits' interest rate. It is shown that dollarization exhibits behavior that is related to the partial effects of exchange rate depreciation, inflation and interest rate differentials. In addition, the partial effect models are modified to account for exogenous news about dollarization. The exogenous process of news is approximated by accumulated knowledge on dollarization in previous periods. This

[34] In Georgia, the US dollar has the largest share (85-90%) in total foreign currency holdings.

[35] In *ad hoc* models, the demand and substitutability of both currencies are specified *a priori*. The CIA model illustrates what determines currency substitutability but neither currency serves as a store of value. In countries with underdeveloped financial markets money is an important store of value. Dollarization can be empirically analyzed as this value is observable. In a transaction costs model, money facilitates consumption purchases. Money is more liquid than other assets highlighting the role of the store of value (for discussion see Giovanni and Turtelboom, 1992).

aims to capture not just the role of the fundamentals, but all possible factors that influenced the dollarization process in the past.

In the empirically oriented research, currency substitutability is estimated using various categories of model.[36] The most recent category of models deals with the agent's dynamic optimization (Imrohoroglu, 1994; Bufman and Leiderman, 1993; Friedman and Verbetsky, 2001). These empirical models are the closest to an underlying theoretical model. Based on first order optimization conditions, the parameters of consumer preferences are jointly estimated by generalized method of moments (GMM, Hansen, 1982).[37] This paper estimates both the elasticity of substitution between two currencies and the share of each currency in domestic liquidity. The GMM estimation is performed using information sets of observables consistent with each version of the benchmark model.

In order to rationalize the actual dollarization in Georgia, three versions of the benchmark model are compared. The models implied dollarization is calculated using the estimated parameter values. Three versions of a benchmark model imply that domestic and foreign inflation, the exchange rate depreciation, and interest rates on savings in both currencies influence the decision to switch to a foreign currency. In addition to these macroeconomic indicators, the dollarization dynamics can be influenced by the exogenous process of accumulated knowledge on dollarization in previous periods. The evolution of actual dollarization is compared to the dollarization level implied by the inflation, the interest and the exchange rate models as well as by their modified versions. This allows identifying the exchange rate as the best predictor of dollarization.

[36] For example, money demand functions for domestic and foreign currencies are derived from a two-period portfolio balance model (Cuddington, 1983). Another model is a sequential portfolio balance model (Miles, 1978).

[37] Bufman and Leiderman (1993) estimate a model for Israel using a non-expected utility model. Imrohoroglu (1994) estimates currency substitution between the Canadian and the US dollar. Selcuk (1997) applies the same model for the Turkish case. Friedman and Verbetsky (2001) consider dollarization in Russia. Mulligan and Nijsse (2001) examine currency substitution in Bulgaria, Hungary, Poland, and Romania. A study on Bolivia can be found in Cuddington, Garcia, and Westbrook (2002). Selcuk (2003) provides empirical evidence for the Czech Republic, Hungary, Israel, Jordan, Poland, and the Slovak Republic.

The results show that dollarization is of significant importance in Georgia. Monthly Georgian data gives support to the MIUF model specification with transaction costs reducing role of money. The GMM estimates indicate that the demand for US dollars is responsive to the fluctuations in the exchange rate, inflation, and interest rates. The share of US-dollar denominated money in Georgians' total liquidity is significant. The US dollar holdings have a 60% share in total domestic liquidity. The US dollar is a good substitute for the domestic currency in terms of transaction cost reduction. The implied elasticity of substitution between two currencies is greater than unity. When news are introduced, the demand for the dollar becomes less responsive to the fluctuations in the exchange rate due to learning adjustment. Partial effect models with inflation and interest rates predict lower and more volatile dollarization than the actual case in the economy. The actual dollarization is well explained by the exchange rate partial effect model.

The paper is structured as follows. Section 2 presents the economy model. Section 3 describes the data. Empirical findings are presented in Section 4. The dynamics of dollarization is studied in Section 5. Section 6 concludes.

2.2 Benchmark Model

An endowment economy consists of infinitely living identical agents. At the beginning of each period, each agent decides how much to consume $c_t = \frac{C_t}{NP_t}$, how much to hold in the form of domestic real balances $m_t = \frac{M_t}{NP_t}$ and foreign real balances $m_t^* = \frac{M_t^*}{NP_t^*}$ (domestic and foreign personal accounts and demand deposits), and how much to save in certificates of deposits (domestic and foreign term deposits) $cd_t = \frac{CD_t}{NP_t}$ and $cd_t^* = \frac{CD_t^*}{NP_t^*}$ that earn nominal interest rates i_t and i_t^*. Each individual receives an exogenous endowment $\frac{Y_t}{NP_t}$. Variable P_t is the price of the consumption good in terms of the domestic currency, P_t^* is the foreign price, N is the population that is constant over time.

Each household maximizes the discounted utility stream $\sum_{t=0}^{\infty} \beta^t U(c_{t,} m_t, m_t^*)$ with discount factor $\beta < 1$. The utility function is a reduced form of a more complex problem, in which households can shop more efficiently and increase leisure time by holding more money. The money-in-utility-function approach is empirically convenient and allows comparison with other studies that estimate the elasticity of currency substitution and its share in liquidity services in various countries.

The household's budget constraint is given as

$$\frac{C_t}{NP_t}+\frac{M_t}{NP_t}+\frac{M_t^*}{NP_t^*}+\frac{CD_t}{NP_t}+\frac{CD_t^*}{NP_t^*} = \frac{M_{t-1}}{NP_t}+\frac{M_{t-1}^*}{NP_t^*}+(1+i_t)\frac{CD_{t-1}}{NP_t}+(1+i_t^*)\frac{CD_{t-1}^*}{NP_t^*}+\frac{Y_t}{NP_t}.$$

In real per capita terms the budget constraint is

$$c_t+m_t+m_t^*+cd_t+cd_t^* = m_{t-1}\frac{P_{t-1}}{P_t}+m_{t-1}^*\frac{P_{t-1}^*}{P_t^*}+(1+i_t)\frac{P_{t-1}}{P_t}cd_{t-1}+(1+i_t^*)\frac{P_{t-1}^*}{P_t^*}cd_{t-1}^*+y_t.$$

The first order conditions for the problem are

$$U_c(t) = \beta(1+i_{t+1})\frac{P_t}{P_{t+1}}U_c(t+1), \tag{2.7}$$

$$U_c(t) = \beta(1+i_{t+1}^*)\frac{P_t^*}{P_{t+1}^*}U_c(t+1), \tag{2.8}$$

$$U_c(t) = U_m(t)+\beta\frac{P_t}{P_{t+1}}U_c(t+1), \tag{2.9}$$

$$U_c(t) = U_{m^*}(t)+\beta\frac{P_t^*}{P_{t+1}^*}U_c(t+1). \tag{2.10}$$

The term $U_x(t)$ denotes the marginal utility of x at time t. Marginal utilities $U_m(t)$ and $U_{m^*}(t)$ show a transaction cost reducing role of real money balances at period t in domestic and foreign currencies, respectively. In (2.9) and (2.10), the marginal utility of holding one unit of real money balances plus the discounted next period marginal utility afforded by the real balances at time t are balanced by the marginal utility loss at time t.

The utility function follows Kydland and Prescott (1982) and is non-separable in consumption and total money services:

$$U(c_{t,}\Psi_t) = \frac{(c^{\gamma}\Psi_t^{1-\gamma})^{1-\sigma} - 1}{1-\sigma}.$$

This function is a constant relative risk aversion in the consumption and money services function. The parameter $\sigma > 0$ is the coefficient of relative risk aversion and $\frac{1}{\sigma}$ is the elasticity of intertemporal substitution. The parameter γ reflects the transaction requirement of total money in a broad sense. This form of the utility function reflects the motive for holding money: to reduce transaction costs in implementing efficient consumption plans. It highlights the link between the total liquidity services and efficient consumption. The additive in consumption and the money services utility function, in contrast, would break this linkage.

The total liquidity services function is the following CES function similar to the one used in Imrohoroglu (1994):

$$\Psi_t(m_t, m_t^*) = \left[(1-\varphi)m_t^{-\rho} + \varphi(m_t^*)^{-\rho}\right]^{-\frac{1}{\rho}}.$$

In this specification, $\varphi \in (0,1)$, $\rho \in (-1,\infty)$, and $\rho \neq 0$. This functional form allows identifying the role of foreign money in total liquidity in two ways. First, the constant elasticity of substitution between domestic and foreign currencies can be calculated as $\frac{1}{1+\rho}$. Second, the distribution parameter φ is the share of foreign currency in the production of total domestic liquidity services.

With these functional forms the marginal utilities are

$$\begin{aligned}
U_c &= \gamma c_t^{a-1}\left[(1-\varphi)m_t^{-\rho} + \varphi(m_t^*)^{-\rho}\right]^{b}, \\
U_m &= (1-\varphi)(1-\gamma)c_t^{a}\left[(1-\varphi)m_t^{-\rho} + \varphi(m_t^*)^{-\rho}\right]^{b-1} m_t^{-\rho-1}, \\
U_{m^*} &= \varphi(1-\gamma)c_t^{a}\left[(1-\varphi)m_t^{-\rho} + \varphi(m_t^*)^{-\rho}\right]^{b-1} (m_t^*)^{-\rho-1},
\end{aligned}$$

where $a = \gamma(1-\sigma)$,and $b = \frac{(1-\gamma)(1-\sigma)}{-\rho}$.

2.2.1 Three Model Specifications

Three partial effects of observables on the degree of dollarization are studied in this paper. First is the partial effect of foreign and domestic inflations on the domestic to foreign money ratio. Second is the partial effect of the changes in the exchange rate on dollarization. Third, the partial effect of the foreign and domestic currency time deposit interest rates on dollarization is considered. These three different model specifications allow us to look at dollarization from different prospectives under alternative assumptions.

The first partial effect model's first version will be referred to as the inflation model, version one - model 1.1. In this model, there are no saving opportunities and inflation is defined as $\pi_t = \dfrac{P_t - P_{t-1}}{P_{t-1}}$ and $\pi_t^* = \dfrac{P_t^* - P_{t-1}^*}{P_{t-1}^*}$. The first order conditions (2.9) and (2.10) become

$$\gamma c_t^{a-1}\left[(1-\varphi)m_t^{-\rho}+\varphi m_t^{*-\rho}\right]^b = (1-\varphi)(1-\gamma)c_t^a\left[(1-\varphi)m_t^{-\rho}+\varphi m_t^{*-\rho}\right]^{b-1}m_t^{-\rho-1}+ \\ +\beta\gamma\frac{1}{(1+\pi_{t+1})}c_{t+1}^{a-1}\left[(1-\varphi)m_{t+1}^{-\rho}+\varphi m_{t+1}^{*}{}^{-\rho}\right]^b,$$

$$\gamma c_t^{a-1}\left[(1-\varphi)m_t^{-\rho}+\varphi m_t^{*-\rho}\right]^b = \varphi(1-\gamma)c_t^a\left[(1-\varphi_t)m_t^{-\rho}+\varphi_t m_t^{*-\rho}\right]^{b-1}m_t^{*-\rho-1}+ \\ +\beta\gamma\frac{1}{(1+\pi_{t+1}^*)}c_{t+1}^{a-1}\left[(1-\varphi)m_{t+1}^{-\rho}+\varphi m_{t+1}^{*}{}^{-\rho}\right]^b.$$

These equations are rearranged in such a way that the variables enter the modified equations as ratios ("one minus growth rate" form) indicating the lack of significant trends. This stationarity issue is important for estimation.

$$\beta\gamma\frac{1}{(1+\pi_{t+1})}(\frac{c_{t+1}}{c_t})^{a-1}[\frac{(1-\varphi)(\frac{m_{t+1}}{m_{t+1}^*})^{-\rho}+\varphi}{(1-\varphi)(\frac{m_t}{m_t^*})^{-\rho}+\varphi}]^b(\frac{m_{t+1}^*}{m_t^*})^{-\rho b} = \\ = \gamma-(1-\varphi)(1-\gamma)(\frac{m_t}{m_t^*})^{-\rho}[(1-\varphi)(\frac{m_t}{m_t^*})^{-\rho}+\varphi]^{-1}\frac{c_t}{m_t},$$

$$\beta\gamma\frac{1}{(1+\pi^*_{t+1})}(\frac{c_{t+1}}{c_t})^{a-1}[\frac{(1-\varphi)(\frac{m_{t+1}}{m^*_{t+1}})^{-\rho}+\varphi}{(1-\varphi)(\frac{m_t}{m^*_t})^{-\rho}+\varphi}]^b(\frac{m^*_{t+1}}{m^*_t})^{-\rho b}=$$
$$=\gamma-\varphi(1-\gamma)[(1-\varphi)(\frac{m_t}{m^*_t})^{-\rho}+\varphi]^{-1}\frac{c_t}{m^*_t}.$$

The optimality condition that will be used in GMM estimation[38] for this inflation model 1.1 with the foreign currency share parameter φ and substitution parameter ρ is

$$(\pi^*_{t+1}-\pi_{t+1})\gamma=(1-\gamma)[(1-\varphi)(\frac{m_t}{m^*_t})^{-\rho}+\varphi]^{-1}\{(1+\pi^*_{t+1})\varphi\frac{c_t}{m^*_t}-(1+\pi_{t+1})(1-\varphi)(\frac{m_t}{m^*_t})^{-\rho}\frac{c_t}{m_t}\}. \tag{2.11}$$

The optimal domestic to foreign money ratio shows the degree of dollarization in the economy at period t that is implied by the inflation model 1.1:

$$\frac{m_t}{m^*_t}=(\frac{\varphi(1-\gamma)\frac{c_t}{m^*_t}-\gamma\varphi(1-\frac{(1+\pi_{t+1})}{(1+\pi^*_{t+1})})}{(1-\varphi)(1-\gamma)\frac{c_t}{m_t}+(1-\varphi)\gamma(1-\frac{(1+\pi_{t+1})}{(1+\pi^*_{t+1})})})^{-1/\rho}. \tag{2.12}$$

The money ratio in period t is a function of the consumption-money ratios $\frac{c_t}{m^*_t}$, $\frac{c_t}{m_t}$, and domestic and foreign inflation in the next period π_{t+1}, π^*_{t+1}. The parameters of interest are the share of foreign currency in the production of domestic liquidity services φ, the transaction requirement of money in broad sense parameter γ, and ρ that implies the elasticity of currency substitution $\frac{1}{1+\rho}$.

The optimality condition for the first version of the second model - exchange rate model 2.1- is derived in a similar way. First order conditions (2.9) and (2.10) are combined with the purchasing power parity condition $P_t=e_tP^*_t$. The resulting optimality condition is

$$\gamma(1-\frac{e_{t+1}}{e_t})=[(1-\varphi)(\frac{m_t}{m^*_t})^{-\rho}+\varphi]^{-1}(1-\gamma)\{\varphi\frac{c_t}{m^*_t}-\frac{e_{t+1}}{e_t}(1-\varphi)(\frac{m_t}{m^*_t})^{-\rho}\frac{c_t}{m_t}\}. \tag{2.13}$$

[38] Joint estimation of the consumer preferences parameters in the system of equations 2.3.1a-2.4.1a gives a similar result as the single-equation estimation of model 1.1.

The optimal domestic to foreign money ratio for the exchange rate model 2.1 at period t is

$$\frac{m_t}{m_t^*} = \left(\frac{\varphi(1-\gamma)\frac{c_t}{m_t^*} - \gamma\varphi(1-\frac{e_{t+1}}{e_t})}{(1-\varphi)(1-\gamma)\frac{c_t}{m_t} + (1-\varphi)\gamma(1-\frac{e_{t+1}}{e_t})}\right)^{-1/\rho}. \tag{2.14}$$

In this case, the money ratio depends on the depreciation rate $\frac{e_{t+1}}{e_t}$ in addition to consumption-money ratios and parameters.

In contrast to the inflation and exchange rate models 1.1 and 2.1, saving opportunities are introduced in interest rate model 3.1. Interest rate model 3.1 divides money into current accounts and demand deposit (more liquid money) m_t and m_t^*, and certificates of deposits (term deposits) cd_t and cd_t^* that earn interest rates. From (2.7) and (2.8),

$$\frac{e_{t+1}}{e_t} = \frac{1+i_{t+1}}{1+i_{t+1}^*}.$$

The optimality condition for interest rate model 3.1 is

$$\gamma(1-\frac{1+i_{t+1}}{1+i_{t+1}^*}) = [(1-\varphi)(\frac{m_t}{m_t^*})^{-\rho}+\varphi]^{-1}(1-\gamma)\{\varphi\frac{c_t}{m_t^*} - \frac{1+i_{t+1}}{1+i_{t+1}^*}(1-\varphi)(\frac{m_t}{m_t^*})^{-\rho}\frac{c_t}{m_t}\}, \tag{2.15}$$

and the optimal money ratio at period t is now a function of consumption-money ratios, parameters, and foreign and domestic next period interest rates i_{t+1} and i_{t+1}^*:

$$\frac{m_t}{m_t^*} = \left(\frac{\varphi(1-\gamma)\frac{c_t}{m_t^*} - \gamma\varphi(1-\frac{1+i_{t+1}}{1+i_{t+1}^*})}{(1-\varphi)(1-\gamma)\frac{c_t}{m_t} + (1-\varphi)\gamma(1-\frac{1+i_{t+1}}{1+i_{t+1}^*})}\right)^{-1/\rho}. \tag{2.16}$$

2.2.2 Modified Versions of the Models

In the first version of each partial-effect model in (2.12), (2.14), and (2.16) derived above, the share of foreign currency in domestic liquidity services is a fixed parameter. In this subsection, two modified versions of each partial effect model are presented. That is, each partial effect model has three versions. The conclusions of this paper are built on the set of three versions of three partial effect models.

In two of the modified versions, the assumption of the fixed parameter φ is relaxed. Now, the share of foreign currency in the production of domestic liquidity services φ changes over time. Agents make decisions over consumption and money holdings knowing the past dollarization share DR_t in the economy. The shortcut for this type of learning is to substitute the share of foreign currency in total money services by an exogenous process of "news" about dollarization. This means that agents update the parameters of their preferences after they "read the news" about dollarization. The process of news can be noisy, which gives an additional source of disturbances in the GMM estimation of the parameters.

In the second version of each partial effect model, the exogenous process of news is $DR_t = \frac{m^*_{t-1}}{m^*_{t-1} + m_{t-1}}$. Agents update the parameters of their preferences after they "read the news" that dollarization is the same as it was in the previous period. This process of news is exogenous. Using the actual data on dollarization shares, DR_t is calculated using dollarization ratios. Version 2 of the inflation model 1 - model 1.2 - is

$$\gamma(1 - \frac{(1+\pi_{t+1})}{(1+\pi^*_{t+1})}) =$$
$$= [(1-DR_t)(\frac{m_t}{m^*_t})^{-\rho} + DR_t]^{-1}(1-\gamma)\{DR_t\frac{c_t}{m^*_t} + \frac{(1+\pi_{t+1})}{(1+\pi^*_{t+1})}(1-DR_t)(\frac{m_t}{m^*_t})^{-\rho}\frac{c_t}{m_t}\}.$$

In the third version, individuals act as econometricians by learning the share of foreign currency in money services using the previous periods' data on dollarization shares. This aims to capture the inertia in the agents' foreign currency holdings. Knowledge is accumulated through the use of foreign currency by domestic agents in previous periods. A proxy for such knowledge at time t is the fitted value of the dollarization ratio obtained by the regression on its lags. The idea behind this proxy is that the knowledge of foreign currency is proportional to the amounts of foreign currency previously used.[39] That is, dollarization in the economy persists because

[39] It is assumed that knowledge accumulates equally from all foreign deposits.

agents constantly utilize the accumulated knowledge on foreign currency use. Each individual runs the regression

$DR_t = \alpha + DR_{t-1}\lambda_1 + .. + DR_{t-p}\lambda_p + \varepsilon_t,$

with p being the number of lags. The one-step-ahead forecast $\widehat{DR}_{t/t-1}$ is obtained by OLS estimation under general assumptions. Fitted values are the share of foreign currency in the money services.

$$\gamma(1 - \frac{(1+\pi_{t+1})}{(1+\pi^*_{t+1})}) =$$
$$= [(1-\widehat{DR}_t)(\frac{m_t}{m^*_t})^{-\rho} + \widehat{DR}_t]^{-1}(1-\gamma)\{\widehat{DR}_t\frac{c_t}{m^*_t} + \frac{(1+\pi_{t+1})}{(1+\pi^*_{t+1})}(1-\widehat{DR}_t)(\frac{m_t}{m^*_t})^{-\rho}\frac{c_t}{m_t}\}.$$

Modified versions for the exchange rate and the interest rate models are expressed in a similar way.

2.3 Data

The sample period is January 1996 - November 2007 with monthly frequency observations. Foreign nominal money balances are measured by the sum of the US dollar-denominated personal accounts and demand deposits held in Georgian banks by nonofficial, non-bank residents. The domestic nominal money balances are measured as the sum of the Georgian currency (lari)-denominated personal accounts and demand deposits in local banks. Adding cash outside the banking system would be an even more accurate measure of liquid money. However, the data on foreign currency holdings outside the banking system is not available for Georgia. This is a common "unobservability" problem in the dollarization literature (Calvo and Vegh, 1992). Various proxies are usually used in the literature depending on the dollarization measure specification. Some studies use estimates of foreign cash holdings (Feige and Dean, 2004; Feige *et al.*, 2000, Feige, 2003). The domestic to foreign money ratio is calculated using observable liquid money on personal accounts from which deposited funds can be withdrawn at any time without any notice or penalty.

As a proxy for monthly consumption seasonally adjusted pure energy consumption is used.[40] Goods and services consumption is highly correlated with electricity consumption quarterly series. The annual growth rates of these two series have similar trends over the sample period. The pure energy consumption series are taken from the Georgian electricity distribution company Telasi's statistics.

Both foreign and domestic money balances and consumption are converted to real per capita terms by dividing by population and domestic prices. The domestic prices are the seasonally adjusted consumer price index. The civilian population is obtained from the World Population record. The GEL/USD exchange rate series is taken from the NBG database. The interest rates are domestic- and foreign currency-denominated term deposit interest rates. All these series are taken from the National Bank of Georgia statistical bulletins. The foreign price index is the US consumer price index obtained from the Federal Reserve Bank of St. Louis.

Figure 1 shows the dollarization share, and inflation and depreciation rates for the Georgian economy for the period 1996-2007. The dollarization share is calculated as the real per capita sum of the foreign currency-denominated personal accounts and demand deposits over the sum of the domestic and foreign currency deposits.

Figure 2 shows the shares of the US dollar and Euro in the total dollarization share in the economy in recent years. These are the main foreign currencies in the total ratio. The shares of other currency deposits (RUB, GBP and CHF) are less than 1%. The US dollar holdings are significantly larger in amount compared to the Euro.

Table 1 provides summary statistics, and the stationarity and structural break tests for the ratios that are used in the models $\frac{e_{t+1}}{e_t}, \frac{1+\pi_t}{1+\pi_t^*}, \frac{1+i_t}{1+i_t^*}, \frac{m_t}{m_t^*}, \frac{m_t^*}{m_t^*+m_t}, \frac{c_t}{m_t}$, and $\frac{c_t}{m_t^*}$.

[40] The data on the monthly consumption of goods and services and the share of electricity consumption by household are not available for Georgia.

Figure 2.1: Dollarization, Depreciation, and Inflation in Georgia, 1996-2007

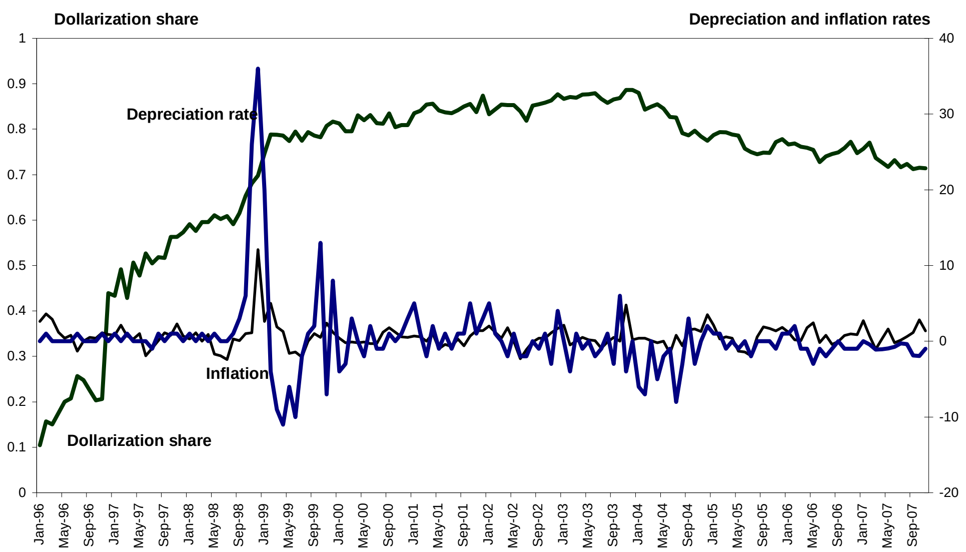


Figure 2.2: USD and EURO Shares in the Dollarization Ratio in Georgia, 2003-2007

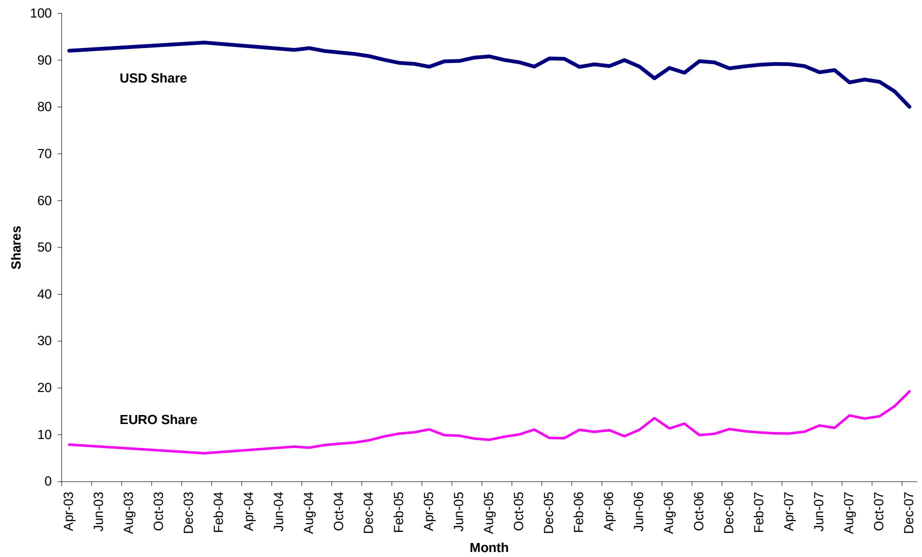


Table 1. Data Statistics

	$\frac{e_{t+1}}{e_t}$	$\frac{1+\pi_t}{1+\pi_t^*}$	$\frac{1+i_t}{1+i_t^*}$	$\frac{c_t}{m_t}$	$\frac{c_t}{m_t^*}$	$\frac{m_t}{m_t^*}$	$\frac{m_t^*}{m_t^*+m_t}$
Obs	142	142	142	142	142	142	142
Mean	0.995	1.505	0.975	0.008	0.009	0.671	0.716
Median	1	1.370	0.986	0.008	0.002	0.275	0.784
Maximum	1.211	13.627	1.053	0.022	0.191	8.579	0.886
Minimum	0.949	-1.247	0.874	0.001	0.000	0.128	0.104
Std. Dev.	0.029	1.716	0.034	0.006	0.023	1.208	0.185
Skewness	4.554	3.662	-0.389	0.319	5.006	3.878	-1.801
Kurtosis	29.100	21.956	-0.245	-1.068	31.032	17.013	2.559
UR/break tests result[a]	broken trend stationary	broken trend stationary	stationary	stationary	stationary	stationary	stationary

[a]The decision is based on the results of ADF, PP, KPSS, Vogelsang and Perron tests at the 5% significance level.

2.4 Evidence on Dollarization: Empirical Findings

The estimation results for models 1, 2 and 3 and their three versions are obtained using the GMM procedure. This methodology is robust to conditional heteroscedasticity and autocorrelation. Alternative instrument sets are used to check the sensitivity of the results to the choice of instruments. Instruments are lags of observables that are consistent with each partial-effect model. The results for the following instrument sets[41] are presented:

$$I_{t1} = \left\{1, \frac{1+\pi_{t-1}}{1+\pi_{t-1}^*}, \frac{1+\pi_{t-2}}{1+\pi_{t-2}^*}, \frac{m_{t-1}}{m_{t-1}^*}, \frac{m_{t-2}}{m_{t-2}^*}, \frac{c_{t-1}}{m_{t-1}}, \frac{c_{t-2}}{m_{t-2}}, \frac{c_{t-1}}{m_{t-1}^*}, \frac{c_{t-2}}{m_{t-2}^*}\right\}, \quad (2.17)$$

$$I_{t2} = \left\{1, \frac{e_t}{e_{t-1}}, \frac{e_{t-1}}{e_{t-2}}, \frac{m_{t-1}}{m_{t-1}^*}, \frac{m_{t-2}}{m_{t-2}^*}, \frac{c_{t-1}}{m_{t-1}}, \frac{c_{t-2}}{m_{t-2}}, \frac{c_{t-1}}{m_{t-1}^*}, \frac{c_{t-2}}{m_{t-2}^*}\right\}, \quad (2.18)$$

$$I_{t3} = \left\{1, \frac{1+i_{t-1}}{1+i_{t-1}^*}, \frac{1+i_{t-2}}{1+i_{t-2}^*}, \frac{m_{t-1}}{m_{t-1}^*}, \frac{m_{t-2}}{m_{t-2}^*}, \frac{c_{t-1}}{m_{t-1}}, \frac{c_{t-2}}{m_{t-2}}, \frac{c_{t-1}}{m_{t-1}^*}, \frac{c_{t-2}}{m_{t-2}^*}\right\}. \quad (2.19)$$

The results are given in Tables 2, 3, 4. In each case, the number of orthogonality conditions is greater than the number of parameters. The validity of these overidentifying restrictions is tested using J-statistics. The null hypothesis is that the restrictions are satisfied, and the test statistic is distributed assymthotically as χ^2 with degrees of freedom equal to the number of overidentifying restrictions (Hansen, 1982). The Hansen J-statistics are insignificant for all models, thus their validity is not rejected.

[41]The estimation using different instrument sets (number of lags) gives similar results.

Table 2. Estimation Results for Inflation Model 1

parameter	inflation model 1.1	inflation model 1.2	inflation model 1.3
φ	0.566***(0.099)	-	-
γ	6.41E-04**(3.37E-04)	1.08E-03**(5.61E-04)	2.91E-03***(6.66E-04)
ρ	-0.464**(0.767)	-0.811**(0.382)	-1.618***(0.329)
$1/(1+\rho)$	1.852	5.300	-1.617
J	6.949[0.542]	5.291[0.808]	14.302[0.074]

Sample: 01/01/1996-01/11/2007; estimation method: GMM;
*=significance at 10%;**=significance at 5%;***=significance at 1%.
Standard errors of coefficient estimates are in parentheses. P-values for the J-test are in square brackets.

Table 3. Estimation Results for Exchange Rate Model 2

parameter	exchange rate model 2.1	exchange rate model 2.2	exchange rate model 2.3
φ	0.591***(0.161)	-	-
γ	1.06E-03*(5.74E-04)	0.068***(0.024)	6.58E-04***(1.76E-04)
ρ	-0.909***(0.467)	-0.017**(8.52E-03)	-0.647**(0.833)
$1/(1+\rho)$	10.989	1.017{0.00}[a]	2.833
J	12.293[0.504]	7.322[0.885]	4.929[0.977]

Sample: 01/01/1996-01/11/2007; estimation method: GMM;
*=significance at 10%;**=significance at 5%;***=significance at 1%.
Standard errors of coefficient estimates are in parentheses. P-values for the J-test are in square brackets.
[a] p-values of the equality to unity test are in curly brackets.

Table 4. Estimation Results for Interest Rates Model 3

parameter	interest rates model 3.1	interest rates model 3.2	interest rates model 3.3
φ	0.800***(0.253)	-	-
γ	9.44E-04***(3.26E-04)	1.40E-03***(3.80E-04)	3.68E-03***(8.06E-04)
ρ	-2.49509(2.232)	-0.797*(.531)	-0.426***(0.329)
$1/(1+\rho)$	-	4.926	1.742
J	4.776[0.853]	3.106[0.96]	15.622[0.058]

Sample: 01/01/1996-01/11/2007; estimation method: GMM;
*=significance at 10%;**=significance at 5%;***=significance at 1%.
Standard errors of coefficient estimates are in parentheses. P-values for the J-test are in square brackets.

In all the models, foreign currency holdings have a positively significant share φ in total liquidity services. The parameter estimate is less than one, consistent with the restrictions. The economic significance of the US dollar is large. The share estimates range between 0.57 and 0.8. Thus, more than half of domestic liquidity is provided by the US dollar. The estimate of the transaction cost reducing role of total money is reflected in parameter γ. The estimate of this parameter is positively significant, less than one, and small in magnitude. The data supports the highly significant role of total money services in reducing transaction costs associated with domestic consumption.

The estimates of substitution parameter ρ are, in general, significant and of meaningful magnitude. In the first two versions of the inflation model, the parameter estimates imply the elasticity of currency substitution being 1.9 and 5.3. There is strong substitution between the US dollar and the lari in Georgia. The implicit demand for the US dollar is responsive to relative currency price changes. In the case of the inflation model, an increase in domestic over foreign inflation leads to the substitution of the domestic for the foreign currency.

In model 2 with the exchange rate, the implied elasticity of substitution is between 1.017 and 11. The demand for the US dollar is responsive to the fluctuations in the relative currency price. Keeping φ constant in the first version of the exchange rate model, the substitution parameter estimate is close to -1. The elasticity of currency substitution is smaller in the second and third versions of model 2. The hypothesis $1/(1+\rho) = 1$ is rejected at any significance level in favor of $1/(1+\rho) > 1$ in the second version of exchange rate model 2.

In model 3 with interest rates, the elasticity of substitution between domestic and foreign money is 1.74 and 4.9 for the second and the third versions, respectively. The US dollar holdings are strong substitutes for the lari when money are used to reduce transaction costs in buying consumption goods and services. However, the substitution parameter estimate is not significant in the first version of the interest rate model 3.

To summarize, monthly Georgian data gives support to the models' overidentifying restrictions. The data supports the money-in-the-utility-function model specification with the transactions cost-reducing role for money. Total liquidity services provide significant cost-reducing services for transactions. Overall, the implied elasticity of currency substitution is greater than one. The elasticity ranges between 1.017 and 11, depending on the partial effect model specification and version. The US dollar is a good substitute for the lari when the motive for holding money is to reduce transaction costs in purchasing consumption goods. The implicit demand for the US dollar in Georgia is responsive to the changes in the relative values of the currencies. The estimate of the share parameter for foreign currency in total money services is significant. The US dollar accounts for a more than 50% share of total liquidity.

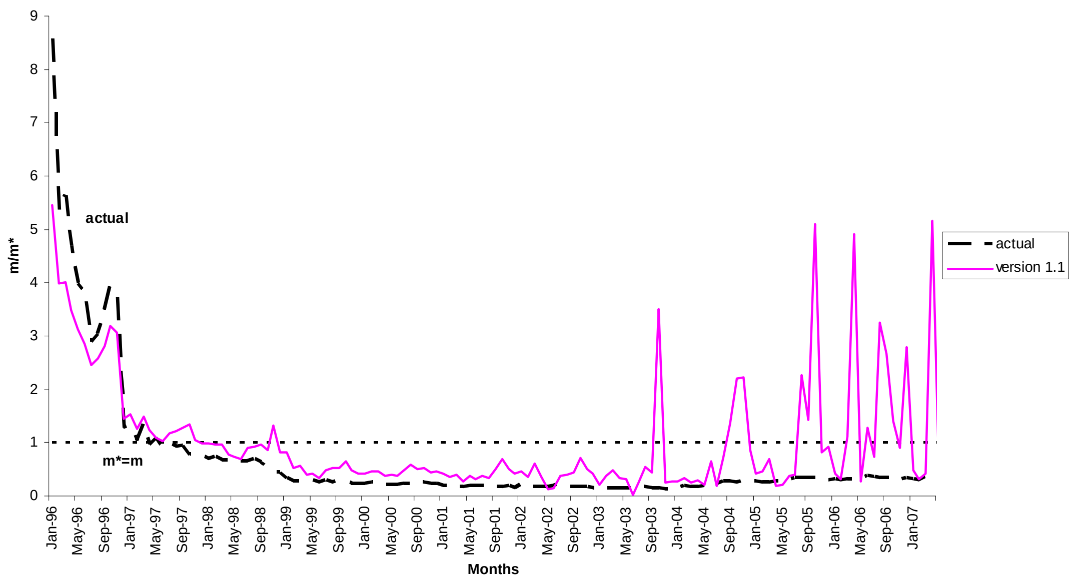
2.5 Dynamics of Dollarization

The optimality conditions of the three versions of the three models are used to calculate the implied domestic to foreign money ratios by the models. The optimal money ratio in the economy at period t is a function of the economy parameters and consumption-money ratios. In model 1, the money ratio is also a function of domestic and foreign inflation. In the second and third models, the ratio depends on the changes in the exchange rate and interest rates, respectively. In two more versions of partial effect models, the assumption of the fixed parameter φ is relaxed. The actual historical values of the dollarization ratio are compared to the models' implied ones. The latter values are calculated using the estimated parameter values for Georgia. For each partial effect model, the results of the versions with the dollarization ratio closest to the actual one are presented.

Figure 3 shows the actual and the calculated from the inflation model dollarization dynamics. For the first version of the inflation model, the optimal money ratios capture the major movements in the actual data in two-thirds of the sample. Before 1997, the model implies a lower dollarization ratio. In the first half of 1997, the dynamics of the ratios is roughly the same. The model's implied dollarization is only slightly lower than in the actual data during the period 1998-2003. The model implies greater volatility than in the actual data. The increased volatility according to the inflation after 2003 mainly results from a decrease in the domestic consumption-money ratio over time. The model predicts lower dollarization and even de-dollarization after 2003.

The exchange rate models imply a dollarization ratio that is very close to its actual values (Figure 4). For the period 1996-1997, model 2.1 underestimates the dollarization ratio in Georgia as opposed to model 2.3. The exchange rate model with inertia 2.3 performs better during the period 1997- 1999. The agents in the economy accumulate knowledge through the use of foreign currency in the previous periods. From 1999 on, both models result in dollarization close to the actual. The partial effect model

Figure 2.3: Money Ratio: Actual and the Inflaion Model 1



that accentuates the role of the exchange rate is suitable to rationalize dollarization in Georgia for the period 1996- 2007.

The interest rate models 3.1-3.3, on average, predict that agents hold equal amounts of domestic and foreign currencies, which is not the case in the actual data.[42] The modified interest rate models predict the actual values better in the period 1997-1999. The poor performance of the interest rate models indicates that the interest rate parity condition is not likely to hold in Georgia.

Dollarization is persistent in Georgia along with recent improvements in macroeconomic fundamentals. According to the conditional dynamic implications of the models, the simple basic model is able to capture this pattern. Clearly, the main factor that influences the decision on foreign currency holdings is the exchange rate. The exchange rate model implies dollarization very close to the actual. Inertia in the agents' behav-

[42]When habit persistance is introduced the predicted dollarization is less volatile in some periods. The utility function depends on the quasi-difference of consumption $c_t - \alpha c_{t-1}$ rather than only on consumption at period t. Parameter α is the intensity of habit formation between zero and one. Modest (0.2) and strong (0.6) intensities of habit formation were considered. However, on average, the models still predict the same level of dollarization.

Figure 2.4: Money Ratio: Actual and the Exchange Rate Model 2

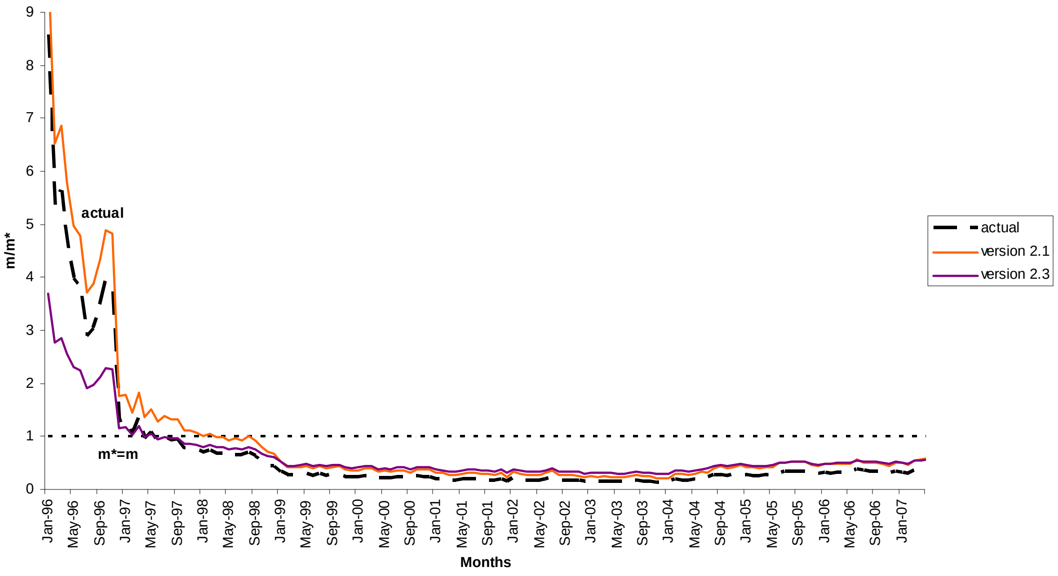
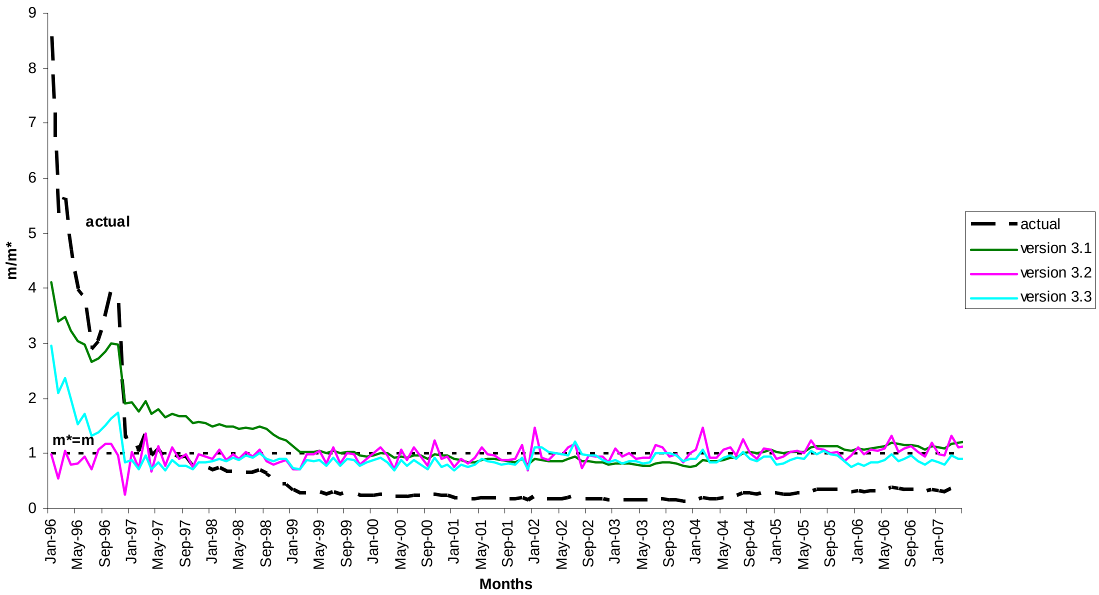


Figure 2.5: Money Ratio: Actual and the Interest Rates Model 3



ior explains high dollarization in the period from 1997 to 1999. Inflation is the second factor that influences foreign currency holdings. However, the inflation model predicts that the dollarization ratio should be more volatile as a response to the changes in domestic inflation. The interest rate differential between domestic and foreign currency deposits should provide incentives to significantly reduce US dollar holdings according to the interest rate model.

2.6 Conclusion

This paper studies dollarization in the Georgian economy based on three versions of the money-in-utility-function model. These partial effect models stress the roles of inflation, the exchange rate and the interest rate. First, the economic and statistical significance of dollarization is studied based on the implications of three versions of the model. The elasticity of substitution between the US dollar and the lari, and their shares in money services, are estimated using the GMM procedure. The impact of learning behavior on the elasticity of currency substitution is studied. Secondly, the paper compares the model's implied and actual dynamics of dollarization. This is done to rationalize the actual dollarization.

The main empirical findings reveal that dollarization is of first-order importance in Georgia. Monthly data supports the role of total liquidity (personal accounts and demand deposits) to reduce transaction costs in consumption purchases. The US dollar provides a good substitute for the lari. Overall, the implied elasticity of currency substitution is significantly greater than one. When behavioral aspects are introduced, the demand for the foreign currency becomes less responsive to the fluctuations in the exchange rate due to learning adjustment. Moreover, the US dollar has a significant 60% share in the total agents' liquidity services.

The empirical results of this paper can be compared with findings for other countries based on the implications of similar dynamic models. Bufman and Leiderman (1991) get an elasticity of currency substitution for Israel greater than one. The share of foreign currency in total liquidity is less than 50%. Selcuk (2003) finds that elasticity in the Czech Republic is 1.72, in Israel 1.78, in Poland 5, in the Slovak Republic 1.28, and in Turkey 1.4. Foreign balances have a significant share in liquidity services: in Turkey 53%, in Poland 50%, in the Czech Republic 42% and in Israel 39%. Fiedman and Verbetsky (2001) report the elasticity of currency substitution in Russia between 2 and 3, and estimate of a share of the US dollar in liquidity services below 50%. In a low inflation economy like Canada the US dollar is not a good substitute of domestic currency and, moreover, the share of foreign currency in domestic liquidity services is very small (Imrohorouglu, 1994). Dollarization plays a significant role in transition economies like Russia, the Czech and Slovak Republics, Poland, and Georgia but is insignificant in developed economies like Canada. Moreover, the share of the US dollar in liquidity services is higher in Georgia than in other developing and developed countries.

The dollarization ratio calculated from the three partial effect models is compared to the actual ratio. The exchange rate model predicts dollarization closest to the actual values among the partial effect models. The inflation and interest rate models predict lower and more volatile dollarization than the actual case. According to the exchange rate and interest rate models, inertia in foreign currency holdings takes place until 1999. Agents are looking at the previous period's dollarization in the economy when deciding how much of each currency to hold. Once agents switched to the US dollar in response to macroeconomic instability, hedging against future uncertainty took place. Among the macroeconomic indicators, the best predictor of dollarization in the Georgian economy is the exchange rate.

References

Adam, C., Goujon, M., Guillaumont Jeanneney, S. (2004). The Transactions Demand for Money in the Presence of Currency Substitution: Evidence from Vietnam. Applied Economics, 36, 1461-1470.

Aslamazishvili, N. & Kakulia, M. (2004). Dollarization in Georgia: Size of the Problem, Factors and the Ways of Solutions. Banki, 3, 13-24.

Brodsky, B. (1997). Dollarization and Monetary Policy in Russia. Review of Economies in Transition, 6, 49–62.

Bufman, G. & Leiderman, L. (1993). Currency Substitution under Non-expected Utility: Some Empirical Evidence. Journal of Money, Credit, and Banking, 25, 320–325.

Calvo, G. & Vegh, C. (1996). From Currency Substitution to Dollarization and Beyond: Analytical and Policy Issues. G. Vegh ed. Money, Exchange Rates and Outputs. Cambridge: MIT Press.

Calvo, G. & Vegh, C. (1992). Currency Substitution in Developing Countries - An Introduction. International Monetary Fund Working Paper, 92/40.

Cuddington, J. (1983) Currency Substitution, Capital Mobility and the Demand for Domestic Money. Journal of International Money and Finance, 2, 111–133.

Cuddington, J., Garcia R-M., Westbrook, D. (2002). A Micro-foundations Model of Dollarization with Network Externalities and Portfolio Choice: The Case of Bolivia (mimeo). Department of Economics of Georgetown University.

Feenstra, R. (1986). Functional Equivalence Between Liquidity Costs and the Utility of Money. Journal of Monetary Economics, 17, 271–91.

Feige, E., Faulend, M., Sonje, V., Sosic, V. (2000). Currency Substitution, Unofficial Dollarization and Estimates of Foreign Currency Held Abroad: The Case of Croatia. Financial Vulnerability and the Exchange Rate Regime, MIT Press.

Feige, E. (2003). The Dynamics of Currency Substitution, Asset Substitution and De facto Dollarization and Euroization in Transition Countries. *Comparative Economic Studies*, 3, 358-383.

Feige, E. & Dean, J. (2004). Dollarization and Euroization in Transition Countries: Currency Substitution, Asset Substitution, Network Externalities, and Irreversibility. Chapter in Monetary Unions and Hard Pegs: Effects on Trade, Financial Development, and Stability. Oxford University Press, 303–319.

Friedman, A. & Verbetsky, A. (2001). Currency Substitution in Russia. Economic Education and Research Consortium Working Paper Series, 01/05.

Giovanni, A. & Turtelboom, B. (1992). Currency Substitution. NBER Working Paper, 4232.

Hansen, L. (1982). Large Sample Properties of Generalized Method of Moments Estimators. Econometrica, 50, 1029–1054.

Hansen, L. & Singleton, K. (1982). Generalized Instrumental Variables of Nonlinear Rational Expectations Models. Econometrica, 50, 1269–1285.

Havrylyshyn, O. & Beddies, C. (2003). Dollarisation in the Former Soviet Union: From Hysteria to Hysteresis. Comparative Economic Studies, 45, 329-357.

Imrohoroglu, S. (1994). GMM Estimates of Currency Substitution between the Canadian Dollar and the U.S. Dollar. Journal of Money, Credit and Banking, 26, 792–807.

Miles, M. (1978). Currency Substitution, Flexible Exchange Rates, and Monetary Independence. American Economic Review, 68, 428–436.

Mongardini, J. & Mueller, J. (1999). Effects in Currency Substitution: An Application to the Kyrgyz Republic. IMF Working Paper, 99/102.

Mulligan, R. & Nijsse, E. (2001). Shortage and Currency Substitution in Transition Economies: Bulgaria, Hungary, Poland and Romania. International Advances in Economic Research, 7, 275–95.

Selcuk, F. (2003). Currency Substitution: New Evidence from Emerging Economies. Economics Letters, 78, 219-224.

Selcuk, F. (1997). GMM Estimation of Currency Substitution in a High-Inflation Economy. Applied Economics Letters, 4, 225-228.

Sidrauski, M. (1967). Rational Choice and Tatters of Growth in a Monetary Economy. American Economic Review, 2, 534-544.

Thomas, L. (1985). Portfolio Theory and Currency Substitution. Journal of Money, Credit and Banking, 17, 347-357.

Uribe, M. (1997). Hysteresis in a Simple Model of Currency Substitution. Journal of Monetary Economics, 40, 1299-1303.

Household Currency Substitution: Evidence from the Czech Republic, Georgia, Croatia, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkey

Abstract:

This paper studies household currency substitution in the Czech Republic, Georgia, Croatia, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkey based on the implications of three versions of a money-in-utility-function model. These versions accentuate the roles of the exchange rate, foreign and domestic currency time deposit interest rates, and domestic and foreign inflation. Structural breaks in the data, which are exogenous from the perspective of the models, are detected and taken into account. The results suggest that households have stronger preferences towards foreign currency in Croatia, Georgia, the Kyrgyz Republic, Tajikistan and Turkey than in the Czech Republic and Kazakhstan. The role of foreign currency in domestic liquidity services decreases over time in Croatia, Georgia, and Turkey. Foreign currency provides a good substitute for the domestic currency in Georgia, Kyrgyzstan and Turkey in several sub-samples.

3.1 Introduction

Following important socioeconomic and political transformations, households often shift part of their money holdings to foreign currencies. This process is known as household currency substitution (dollarization). This paper aims at rationalizing and exploring the significance of household dollarization in a newly compiled data set, which traditionally has not been the focus of the dollarization literature.

Seven countries with a history of macroeconomic instability and different levels of development are considered. They are the graduated developing economy of the Czech Republic, and the emerging and developing economies of Croatia, Turkey, Kazakhstan, Georgia, Kyrgyzstan and Tajikistan.[43] The compiled data set allows focusing on household dollarization separately from firms.[44] The Czech Republic aside, economic and political changes have induced currency substitution in these countries. Recently, the economic and political environment has gradually become more stable. Nevertheless, dollarization remains sizable in some of these countries.

In the recent literature, money demand in a multi-currency economy is derived from the household's maximization problem rather than postulated *ad hoc*. A money-in-utility-function (MIUF) model is a general approach to formalize the micro-foundations for the household's money demand.[45] The parameters of consumer preferences in the model are usually estimated by generalized method of moments (GMM, Hansen, 1982).[46]

This paper adds to the literature by providing evidence on household currency substitution based on the implications of a benchmark MIUF model for the set of countries. Foreign and domestic currencies facilitate consumption purchases in this model. Three versions originate from this benchmark model. Aiming at rationalizing

[43] Classification is according to the International Monetary Fund's World Economic Outlook Report, April 2010.

[44] Due to data constraints, a dollarization measure cannot be constructed for households and firms separately for many emerging markets (Stix, 2010).

[45] In general, both a Baumol-Tobin transaction and simple cash-in-advance models can be approximated by the MIUF model (Feenstra, 1986; Blanchard and Fischer, 1989). The MIUF specification can be also viewed as a derived utility function that includes real balances because agents economize on time spent in transacting (Obstfeld and Rogoff, 1996).

[46] Bufman and Leiderman (1993) estimate a model for Israel using a non-expected utility model. Imrohoroglu (1994) estimates currency substitution between the Canadian and US dollars. Selcuk (1997) applies the same model to the Turkish case. Friedman and Verbetsky (2001) consider dollarization in Russia. Mulligan and Nijsse (2001) examine currency substitution in Bulgaria, Hungary, Poland, and Romania. A study on Bolivia can be found in Cuddington, Garcia, and Westbrook (2002). Selcuk (2003) provides empirical evidence for the Czech Republic, Hungary, Israel, Jordan, Poland, and the Slovak Republic.

dollarization in each country, these models accentuate the role of the exchange rate, foreign and domestic currency time deposit interest rates, and domestic and foreign inflation. Domestic liquidity services are provided by foreign and domestic demand deposits of households. Non-liquid interest-bearing assets are household time deposits. Two specifications of a liquidity function with two currencies are used. These are a log-linear and a constant elasticity of substitution (CES) functions. In the case of log-linear liquidity services, the parameter of interest is the share of foreign currency. The elasticity of the currency substitution parameter is added in the case of CES technology.

A household's optimal choice between foreign and domestic money is derived from the optimality conditions of three versions of the MIUF model. For each version of the MIUF model, corresponding information sets of observables are used in the GMM estimation. The time series properties of variables are explicitly addressed prior to estimation analysis. A search for the most critical structural break (Vogelsang, 1997) and a broken trend stationarity test (Perron, 1989) are performed.[47] The elasticity of currency substitution between the domestic and foreign currencies as well as the preferences toward each currency in domestic money services are then estimated by GMM.

The results of the paper indicate that dollarization is of significant importance in Croatia, Georgia, the Kyrgyz Republic, Tajikistan, and Turkey. There is little currency substitution in the Czech Republic and Kazakhstan. Overidentifying restrictions are not rejected for all the countries in the case of log-liner liquidity services. Structural breaks are detected in most of the macroeconomic series. They are associated with but do not necessarily coincide with country-specific events. All the detected breaks are exogenous from the prospective of the specified models. The instability of the parameters' estimates due to the structural breaks are treated by splitting the sample and by introducing dummy variables. Most of the series are stationary around a

[47] The focus is on the most decisive structural break and not on other less pronounced shifts in the series.

deterministic time trend with an exogenous change.

The GMM estimation results, before and after structural breaks, demonstrate clear differences in the economic significance of the foreign currency in liquidity services. Overall, the share of the foreign currency in domestic liquidity services is significantly positive. In the cases of Croatia, Georgia, and Turkey, the estimated share of foreign currency in liquidity services is lower after a structural break. For the Czech Republic, the sample is not divided, as a structural break is at the beginning of the sample. In the rest of the countries, the estimated share increases. The highest economic significance of a foreign currency is in Croatia (0.91-0.93) during the period 1995-2010. The lowest estimated share, 0.1, is for Kazakhstan in the period 1998-2001 and for the Czech Republic in the period 1997-2010. The estimated elasticity of currency substitution in Georgia, Kyrgyzstan, and Turkey is significantly larger than unity in several subsamples.

The rest of the paper is organized as follows. Section 2 presents the model of currency substitution. Section 3 describes the methodology employed and describes the data used in the analysis to estimate the utility preference parameters. Section 4 presents and discusses empirical results. Section 5 summarizes the results of the analysis.

3.2 Model of Currency Substitution

The optimal allocation of domestic and foreign currencies is derived from a household optimization problem in a model with domestic and foreign money in a utility function. The inclusion of money in the utility function reflects the usefulness of both currencies in reducing transaction costs.

A small endowment economy consists of infinitely living identical agents. At the beginning of each period, each agent decides how much to consume $c_t = \frac{C_t}{NP_t}$, how much to hold in the form of domestic real balances $m_t = \frac{M_t}{NP_t}$ and foreign real balances

$m_t^* = \frac{M_t^*}{NP_t^*}$, and how much to save in deposits $d_t = \frac{D_t}{NP_t}$ and $d_t^* = \frac{D_t^*}{NP_t^*}$ that earn nominal interest rates i_t and i_t^*. Each individual receives an exogenous endowment $\frac{Y_t}{NP_t}$. Variable P_t is the price of the consumption good in terms of the domestic currency, P_t^* is the foreign price, N is the population, which is constant.

The utility function is a reduced form of a more complex problem in which households can shop more efficiently and increase leisure time by holding more money. The household's maximization problem with discount factor $\beta < 1$ is

$$\max \sum_{t=0}^{\infty} \beta^t U(c_t, m_t, m_t^*), \tag{3.20}$$

subject to the household's budget constraint in real per capita terms:

$$c_t + m_t + m_t^* + d_t + d_t^* = m_{t-1}\frac{P_{t-1}}{P_t} + m_{t-1}^*\frac{P_{t-1}^*}{P_t^*} + (1+i_t)\frac{P_{t-1}}{P_t}d_{t-1} + (1+i_t^*)\frac{P_{t-1}^*}{P_t^*}d_{t-1}^* + y_t.$$

The first order conditions for the problem are

$$U_c(t) = \beta(1+i_{t+1})\frac{P_t}{P_{t+1}}U_c(t+1), \tag{3.21}$$

$$U_c(t) = \beta(1+i_{t+1}^*)\frac{P_t^*}{P_{t+1}^*}U_c(t+1), \tag{3.22}$$

$$U_c(t) = U_m(t) + \beta\frac{P_t}{P_{t+1}}U_c(t+1), \tag{3.23}$$

$$U_c(t) = U_{m^*}(t) + \beta\frac{P_t^*}{P_{t+1}^*}U_c(t+1). \tag{3.24}$$

The term $U_x(t)$ denotes the marginal utility of x at time t. Marginal utilities $U_m(t)$ and $U_{m^*}(t)$ show a transaction cost reducing role of the real money balances at period t in domestic and foreign currencies, respectively. In (3.23) and (3.24), the marginal utility of holding one unit of real money balances plus the discounted next period marginal utility afforded by the real balances at time t are balanced by the marginal utility loss at time t.

From the first order conditions, the money demand equations are

$$U_m(t) = U_c(t)\frac{i_{t+1}}{(1+i_{t+1})}, \tag{3.25}$$
$$U_{m^*}(t) = U_c(t)\frac{i^*_{t+1}}{(1+i^*_{t+1})}. \tag{3.26}$$

Substituting (3.25) into (3.26), the optimal allocation of domestic and foreign currencies will be derived from

$$\frac{U_{m^*}(t)}{U_m(t)} = \frac{i^*_{t+1}}{(1+i^*_{t+1})}\frac{(1+i_{t+1})}{i_{t+1}}. \tag{3.27}$$

3.2.0.1 Functional Forms

To parameterize the model, functional forms are chosen for the utility function and its money balance components. The utility function follows Kydland and Prescott (1982) and is non-separable in consumption c_t and domestic money (liquidity) services Ψ_t:

$$U(c_{t,}\Psi_t) = \frac{(c_t^{\gamma}\Psi_t^{1-\gamma})^{1-\sigma} - 1}{1-\sigma}.$$

This function is a constant relative risk aversion in the consumption and money services function. Domestic money or liquidity services are produced using a combination of domestic and foreign currencies. The parameter $\sigma > 0$ is the coefficient of relative risk aversion, and $\frac{1}{\sigma}$ is the elasticity of intertemporal substitution; γ reflects the transaction requirement of money in a broad sense. This form of the utility function reflects the motive for holding money: to reduce transaction costs in implementing efficient consumption plans. It highlights the link between liquidity services and efficient consumption.

Domestic money services Ψ_t is a function of domestic m_t and foreign m^*_t currencies. The liquidity services are well described by a production function. In the applied research, the constant elasticity of substitution (CES) production functions are widely used:

$$\Psi_t(m_t, m_t^*) = \eta\left[(1-\varphi)m_t^{-\rho} + \varphi(m_t^*)^{-\rho}\right]^{-\frac{\mu}{\rho}}.$$

In this specification, φ is the distribution parameter, η is a level parameter that depends on the units in which the output and inputs are measured, and ρ is the substitution parameter, which lies between -1 and ∞. The parameter μ represents the degree of homogeneity: if $\mu = 1$, the function is linear homogeneous. For $\eta = \mu = 1$, the elasticity of currency substitution is $\epsilon = \dfrac{1}{1+\rho}$.[48]

In this paper, two versions - cases a and b - of the model that differ in the liquidity services functional form are specified. In the first case, the liquidity service function is assumed to be additive in domestic and foreign money balances. In the second case, domestic money services are "produced" according to a CES production function with both currencies as inputs.

Case a

The optimal allocation of money holdings is derived from a model with log-linear utility components of real balance (unit elasticity of substitution). The liquidity services function is

$$\Psi_t(m_t, m_t^*) = (1-\varphi)\ln m_t + \varphi \ln m_t^*.$$

This total liquidity is used by households to reduce transaction costs when purchasing consumption goods. The utility preference parameter $\varphi \in (0,1)$ is the share of foreign currency in domestic liquidity services. The value and statistical significance of this parameter show how big are households's preferences for domestic and foreign currencies in total liquidity. This parameter shows how big and significant the evidence of currency substitution is in an economy.

Using the purchasing power parity condition, the first order conditions, and the

[48] With $\rho \to 0$, this is the case of the unit elasticity of substitution $\epsilon = 1$, and the production function is a linear homogeneous Cobb-Douglas function. If $\rho \to \infty$, there is no substitution $\epsilon = 0$, and it is a Leontief production function. Finally, when $\rho \to -1$ and the elasticity of currency substitution $\epsilon \to \infty$ the inputs are perfect substitutes and the production function is additive.

uncovered interest rate parity condition

$$(1+i^*_{t+1}) = (1+i_{t+1})\frac{e_t}{e_{t+1}}, \tag{3.28}$$

$$\frac{e_t}{e_{t+1}} = \frac{1}{1+z_{t+1}}. \tag{3.29}$$

The optimal allocation in terms of interest rate and the depreciation rate z_t is

$$\frac{m^*_t}{m_t} = \frac{\varphi}{(1-\varphi)}\frac{i_{t+1}}{(i_{t+1}-z_{t+1})}. \tag{3.30}$$

Specification (3.30) will be referred to as M1a: case a of exchange rate model 1.

From (3.27), the optimal allocation of two different currencies in a regime of currency substitution is

$$\frac{m^*_t}{m_t} = \frac{\varphi}{(1-\varphi)}\frac{(1+i^*_{t+1})}{i^*_{t+1}}\frac{i_{t+1}}{(1+i_{t+1})}. \tag{3.31}$$

Specification (3.31) will be referred to as M2a: case a of interest rate model 2.

Using definition of inflation

$$(1+i^*_{t+1}) = (1+i_{t+1})\frac{\pi^*_{t+1}+1}{\pi_{t+1}+1},$$

the optimal allocation in terms of inflation is

$$\frac{m^*_t}{m_t} = \frac{\varphi}{(1-\varphi)}\frac{i_{t+1}(\pi^*_{t+1}+1)}{(1+i_{t+1})(\pi^*_{t+1}+1)-\pi_{t+1}-1}. \tag{3.32}$$

Specification (3.32) will be referred to as M3a*:* case a of inflation model 3.

Case b

The liquidity services function is the CES function as in Imrohoroglu (1994)

$$\Psi_t(m_t, m^*_t) = \left[(1-\varphi)m_t^{-\rho} + \varphi(m^*_t)^{-\rho}\right]^{-\frac{1}{\rho}}.$$

This total liquidity is used by households to reduce transaction costs when purchasing consumption goods. The CES functional form allows estimating both the elasticity of currency substitution $\dfrac{1}{1+\rho}$ and the share of foreign currency in domestic liquidity services $\varphi \in (0,1)$. The utility preference parameter $\varphi \in (0,1)$ is the share of foreign currency in domestic liquidity services. The value and statistical significance of this parameter show how big are households' preferences to domestic and foreign currencies in total liquidity. The value and significance of the substitution parameter ρ show how responsive demand for foreign currency is to changes in its relative price in terms of exchange rate, inflation, and interest rates. These two parameters show the evidence of currency substitution in an economy in terms of both households' preferences for foreign currency use for transactions, and the elasticity of substitution between the two currencies.

Using (3.27), the case b for the exchange rate model, the inflation model, and the interest rate model specifications referred to as M1b, M2b, and M3b are:

$$\frac{m_t^*}{m_t} = \left(\frac{\varphi}{(1-\varphi)} \frac{i_{t+1}}{(i_{t+1} - z_{t+1})}\right)^{\frac{1}{1+\rho}}, \tag{3.33}$$

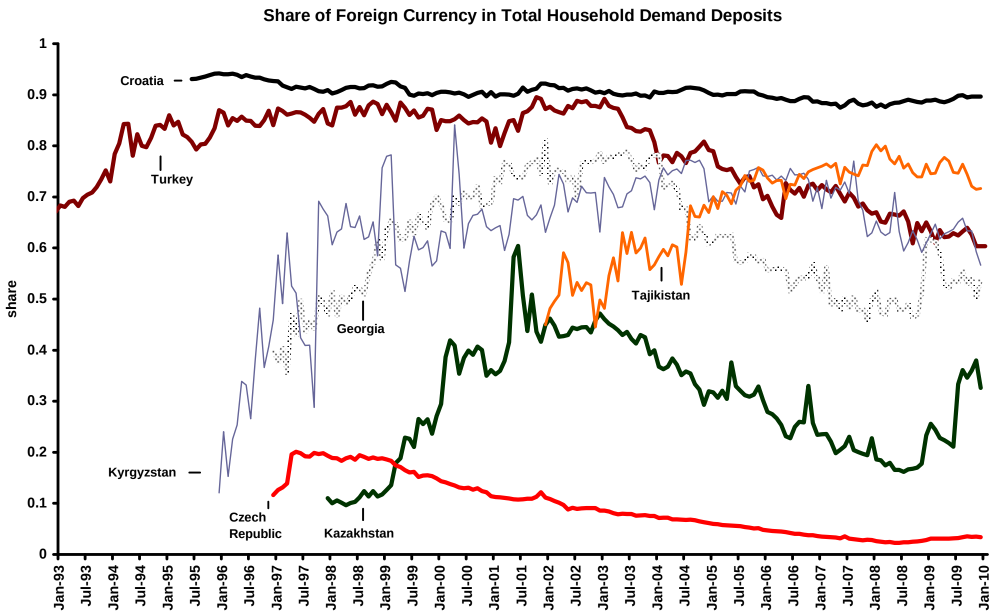
$$\frac{m_t^*}{m_t} = \left(\frac{\varphi}{(1-\varphi)} \frac{(1+i_{t+1}^*)}{i_{t+1}^*} \frac{i_{t+1}}{(1+i_{t+1})}\right)^{\frac{1}{1+\rho}}, \tag{3.34}$$

$$\frac{m_t^*}{m_t} = \left(\frac{\varphi}{(1-\varphi)} \frac{i_{t+1}(\pi_{t+1}^* + 1)}{(1+i_{t+1})(\pi_{t+1}^* + 1) - \pi_{t+1} - 1}\right)^{\frac{1}{1+\rho}}. \tag{3.35}$$

3.3 Data, Tests, and Estimation Procedure

3.3.1 Data

The figure below shows the evolution of the share of foreign currency demand deposits in total demand deposits of households in the set of countries considered in this paper. The Czech Republic is a country that went through political and economic transformations. Unlike other countries in the sample, it does not demonstrate a high level of currency substitution. It is therefore used as a comparison and convergence benchmark.



Georgia, Kazakhstan, Kyrgyzstan, and Tajikistan are former members of the Soviet Union. These economies went through severe political and economic changes after the collapse of the USSR. The instability induced by these changes created an environment for currency substitution. These countries are heavily dependent on remittances.[49] Georgia, Kyrgyzstan, and Tajikistan belong to seven poorest countries of the Commonwealth of Independent States, the CIS-7 group.

Turkey experienced political and economic changes between 1980 and 2000. These changes and crises in governance caused the high level of dollarization the country still experiences today. Croatia also experienced important economic and political changes building itself from the former Yugoslavia. These changes and the general instability of the region for many years led to a high level of currency substitution in this economy.

In Table 1, the data series summary statistics are presented. All the data series are at monthly frequencies. The longest available sample periods are different for

[49] Tajikistan ranks first in the world in terms of the dependency of its economy on remittances: 52 percent of GDP in 2008 (IMF Country Report No. 10/104, 2010).

each country. Several variables are constructed for each country. Depending on the country, the foreign currency is either USD or Euro. The ratio of foreign to domestic money holdings by households $\frac{m_t^*}{m_t}$ is built from households' personal accounts from which deposited funds can be withdrawn at any time without any notice or penalty. This is a measure of foreign and local currencies used by resident households every month to facilitate transaction costs.[50] The data series i_t (for domestic currency) and i_t^* (for foreign currency) are nominal interest rates on households' deposits in banking institutions that cannot be withdrawn for a certain period of time.[51] These data series are extracted from central bank databases. The depreciation rate $z_{t+1} = \frac{e_{t+1}}{e_t} - 1$ is constructed from the nominal exchange rate in units of domestic currency per one unit of foreign currency taken from the International Financial Statistics database. Domestic, Euro area, and US inflations ($\boldsymbol{\pi}_t$,$\boldsymbol{\pi}_t^{euro}$ and $\boldsymbol{\pi}_t^{us}$) are month-to-month changes of CPI obtained from the IFS, the central banks, and the statistical offices.

3.3.2 Testing and Estimation

In order to estimate the parameters φ and ρ in the models M1a, M2a, M3a and M1b, M2b, M3b, the GMM method is used. The GMM estimates of parameters are consistent only when data is a stationary process. Stationarity is important for the sample means to converge as the sample size increases. Existing structural breaks in the data should not be neglected. In this paper, prior to the estimation, the data series are analyzed focusing on structural break and stationarity issues. A detailed description of all the tests and the estimation procedure is provided in Appendix I.

The Vogelsang (1997) test is applied to search for a break point in the time series. The null hypothesis of no break is tested. A trimming parameter is specified for each time series. It represents the portion of the time span that is not allowed to contain

[50] Adding foreign and domestic currency cash would be an even more accurate measure of liquid money. Unfortunately, no data on foreign cash in circulation is avaliable for every country. In the literature, demand deposits are used very often for estimation purposes.

[51] The interest rate differential $(i_t^* - i_t)$ was also used instead of i_t^*. All the estimation results remained roughly the same.

a break. For time series without a structural break detected, the usual stationarity tests are performed. These are Phillips and Perron (1988), (augmented) Dickey-Fuller (1981), and (augmented) Weighted Symmetric tests.

The break detected by the Vogelsang test is used as the expected break in the Perron (1989) test for broken trend stationarity. The null hypothesis is that a series has a unit root with an exogenous structural break that occurs at a given date. The alternative hypothesis is stationarity around a deterministic time trend with an exogenous change. Three alternative specifications are considered that allow for an exogenous change in the intercept, an exogenous change in the linear trend coefficient, and a combination of an exogenous change in intercept and the linear trend coefficient.

Structural breaks determined by the above tests are exogenous from the perspective of the economic models. To assure the stability of the GMM estimated parameters and to bring more flexibility to the estimation, the breaks are treated as follows. When the money ratio in (3.30), (3.31), (3.32) and (3.34), (3.33), (3.35) is a broken trend stationary time series, the sample for the GMM estimation is divided according to the break point. Within each sub-sample the data series is now stationary around the deterministic time trend. The trend is explicitly included in the regression.[52] Structural breaks in other series are captured by structural break dummy variables.

The GMM methodology is used within each sub-sample to estimate the parameters φ and ρ. The GMM procedure is robust to conditional heteroscedasticity and autocorrelation. Two lags of each independent variable and a constant are used as instrumental variables. Alternative instrument sets are used to check the sensitivity of results to the choice of instruments. A J-test is used to test the null hypothesis that the moment conditions hold (the overidentifying restrictions hold). This test provides a convenient method for testing the validity of the model specification.

[52] If no trend is included in the regression, then the right-hand-side variable is likely to be significant just because it is a proxy for a trend.

3.4 Estimation Results

3.4.1 Structural Breaks

Results of the search for a structural break and of tests for (trend) stationarity are presented in this subsection. The time series used in the estimation are tested. They are household's foreign to domestic demand deposit ratio $\frac{m_t^*}{m_t}$, interest rates on foreign and local currency time deposits i_t and i_t^*, depreciation rate z_t, domestic inflation π_t, and external inflations $\pi_t^{euro}$and π_t^{us}.

Table 2 presents the results of the Vogelsang test for a structural break, the Perron test for broken trend stationarity, and the Phillips and Perron (1988), the (augmented) Dickey-Fuller (1981), and the (augmented) Weighted Symmetric tests for series without a structural break.

For the Vogelsang test, the determined structural break date at a 5% significance level is presented together with a trimming parameter λ^*. This result is obtained by testing the null hypothesis of no break versus the alternative of a single break. Critical values tabulated in Vogelsang (1997) are used. The order of a trend polynomial (p=0,1,2) is chosen based on a combination of visual inspection and the Ben-David and Papell algorithm.[53] The number of lags of the dependent variable (to account for serial correlation in errors) is determined by the Campbell-Perron method.

To summarize the results, the Vogelsang test detected structural breaks in most of the time series. Many breaks are associated with the socioeconomic and political transformations of the 1990s and the global financial crisis that started in summer 2007. Others are country-specific events.

In Croatia, the break in the ratio of foreign to domestic household's demand deposits ($\frac{m_t^*}{m_t}$) is detected in June 1997. It was caused by the rehabilitation of banks, injection

[53]Start with p=2 (quadratic trend). If the null hypothesis of no trend break can be rejected the result is reported. In the opposite case, set p = 1 (linear trend). The null hypothesis is tested again. If the null can be rejected then the results are reported. Otherwise, the model with p = 0 (no trend), is estimated and the result is reported.

of cash in the banking system through privatization, and the introduction of insurance on a household's deposit. The January 2008 break in the depreciation rate (z_t) was due to central bank intervention. This intervention led to a decline in the domestic currency's (the kuna) liquidity, strengthening the appreciation pressures. The October 2008 break in the interest rate on the kuna's time deposits (i_t) is due to the central bank policies to stop the withdrawal of deposits from domestic banks. The November 1996 break in the interest rate on foreign currency time deposits (i_t^*) can be explained by the risky behavior of banks in 1996 that provided time deposits (in DEM) with rates that exceeded substantially comparable rates in Germany (Kraft and Galac, 2007). Finally, the inflation break (π_t) in August 2007 was caused by supply side shocks, especially by the increase in food prices.

For the Czech Republic, the November 1997 break in $\frac{m_t^*}{m_t}$ was mainly caused by the central bank's institutional reforms. The March 2009 break in z_t was caused by the increased depreciation that resulted from a contraction of exports. The March 1999 i_t break resulted from a gradual decline in money market rates. Finally, the December 2002 π_t break was caused by various factors affecting both supply and demand.

In Georgia, the March 2003 break in $\frac{m_t^*}{m_t}$ was mostly due to the strengthening of household confidence in the domestic currency. The February 1999 break in z_t was a result of the Russian crisis in 1998. Finally, the June 1997 and March 1998 breaks in i_t and i_t^*, respectively, were both due to an increase in time deposit dollarization in these periods.

For Kazakhstan, the August 2001 break in $\frac{m_t^*}{m_t}$ reflected the capital amnesty that was offered to legalize funds. This caused deposit dollarization to rise sharply as these funds were deposited in US dollars. Since then, dollarization has been decreasing. In 1999, June's z_t and August's π_t breaks were caused by the Russian crisis. In 2009, February's i_t and September's i_t^* breaks were mostly induced by an increase of the deposit volume despite the crisis.

In Kyrgyzstan, the February 2004 break in $\frac{m_t^*}{m_t}$ is a preamble to a gradual partial de-dollarization. December 1996's z_t break marks the end of an exchange rate sharp drop in 1996. The reasons were external assistance to build international reserves and an increase in money growth rates. Both March's i_t and April's i_t^* breaks in 1999 are linked with the banking crisis of 1998-1999. Finally, the July 1999's π_t break is related to a decline in economic activity, the inadequacy of supervision, and large depreciation following the Russian crisis in 1998.

Tajikistan's September 2004 break in $\frac{m_t^*}{m_t}$ marks an increased growth of dollarization in the economy. July 2009's z_t break is caused by the somoni's (the local currency) increased depreciation against the US Dollar. The central bank maintained a conventional peg exchange rate arrangement. In 2009, the central bank committed to a more flexible exchange rate regime (managed float). This policy was aimed at managing the external current account deficit and to support an adjustment to external shocks. Finally, February 2003's π_t break is a preamble of the effects of the central bank's successful policy of stabilizing the reserve money growth to reduce inflation.

In Turkey, the February 2003 break in $\frac{m_t^*}{m_t}$ marks a reversed trend: the decrease of foreign exchange deposits. The reason is that the lira (the Turkish currency) appreciated against the US Dollar in this period mostly due to strong economic development in the country. June 1994's z_t break was due to a currency crisis in Turkey. In the course of the crisis, the lira depeciated by almost 60%, and the economy recorded a negative growth of 6%. The central bank lost \$3 billion of its international reserves, and three banks collapsed.[54] Both March 2001's i_t and June 2001's i_t^* breaks are due to a period of depreciation of the lira toward the US Dollar, severe political and economic instability that led to the collapse of exchange rate system, and an eventual change to floating regime. March 1991's π_t break marks one of the peaks in the period of

[54]The central government's moves in 1992 and 1993 to grant large salary increases to civil servants and to increase transfers to state enterprises enlarged the public-sector borrowing requirement to a record 17 percent of GDP in 1993. These high government spendings sharply boosted domestic demand's rate of growth to 6.4 percent in 1992 and 7.6 percent in 1993. In turn, inflation rates went up, with the annual rate peaking at 73 percent in mid-1993. This resulted in a rise in the real exchange rate, translated into increased imports, and slowed the expansion of exports. The trade deficit rose in 1993 to \$14 billion, while the current account deficit reached \$6.3 billion, or 5.3 percent of GDP.

sustainability of high and persistent inflation. Only since the end of March 2004 has the government succeeded in lowering inflation to single-digit levels.

The global economic downturn in the second half of 2008 had rapidly pushed down commodity prices. Thus, in the Euro zone and the USA, inflation breaks in π_t^{euro} and π_t^{us} indicate disinflation that happened after previously high inflation peaks.

When a break is not detected, Phillips and Perron (1988), (augmented) Dickey-Fuller (1981), and (augmented) Weighted Symmetric tests are performed. In Table 2, p-values of the tests are presented for the most suitable model (trend, constant, augmented, etc.). The inflation in Georgia and the interest rates in Tajikistan are stationary according the tests results.

For the Perron test, the break detected by the Vogelsang test is used as the expected break. The test statistics for testing the null hypothesis $\alpha = 1$, the significance level in its rejection, and the estimated pre-break fraction λ are reported in Table 2. The model specification is selected according to the significance of other coefficients in the hypothesis. The results of the test show that all the series containing a break (in level, trend, or both) are broken trend stationary, i.e. stationary around a deterministic time trend with an exogenous change in the trend function at the break time.

All the breaks are exogenous from the perspective of the economic models specified in Section 2. Estimated parameters in M1a, M2a, M3a, M1b, M2b, and M3b, but not the specification of the process itself, are likely to change due to the detected breaks in data. Thus, the estimation is done over sub-samples without major breaks in the ratio of foreign to domestic household demand deposits. Structural break dummy variables are included to capture the breaks in the depreciation rate, interest rate, and inflation.

3.4.2 GMM Estimation

The GMM is applied as the method of moments estimation on a set of orthogonality conditions being the products of equations and instruments.[55] Initial conditions for estimation are obtained by three-stage least squares. The estimation allows for potential heteroscedasticity and cross-equation correlation. The instrumental variables are two lags of the independent variables. The GMM model selection criteria are the J-statistic for testing over-identifying restrictions, goodness of fit, and coefficient significance.

In order to account for detected breaks in the money ratio $\frac{m_t^*}{m_t}$, the sample is divided according to the break point. Structural breaks in other series are captured by adding a structural break dummy variable dB_t. This dummy variable captures a break in level, intercept, or level and intercept depending on the series. A trend polynomial is added to the equations as most of the series are broken trend stationarity.

For each model, the equations below are estimated over the sub-samples where $\frac{m_t^*}{m_t}$ is trend stationary, i.e. before and after the detected break.

$$\frac{m_t^*}{m_t} = \left(\frac{\varphi}{(1-\varphi)} \frac{i_{t+1}}{(i_{t+1} - z_{t+1})}\right)^{\frac{1}{1+\rho}} + \sum_{p=0}^{3} \beta_p t^p + b * dB_t + \epsilon_t, \tag{3.36}$$

$$\frac{m_t^*}{m_t} = \left(\frac{\varphi}{(1-\varphi)} \frac{(1+i_{t+1}^*)}{i_{t+1}^*} \frac{i_{t+1}}{(1+i_{t+1})}\right)^{\frac{1}{1+\rho}} + \sum_{p=0}^{3} \beta_p t^p + b * dB_t + \epsilon_t, \tag{3.37}$$

$$\frac{m_t^*}{m_t} = \left(\frac{\varphi}{(1-\varphi)} \frac{i_{t+1}(\pi_{t+1}^* + 1)}{(1+i_{t+1})(\pi_{t+1}^* + 1) - \pi_{t+1} - 1}\right)^{\frac{1}{1+\rho}} + \sum_{p=0}^{3} \beta_p t^p + b * dB_t + \epsilon_t. \tag{3.38}$$

The first set of models consists of M1a, M2a, and M3a, the case of additive liquidity

[55] The advantages of GMM over IV are the following. If heteroskedasticity is present, the GMM estimator is more efficient than the simple IV estimator. If heteroscedasticity is not present, the GMM estimator is no worse asymptotically than the IV estimator.

service function ($\rho \to 0$). In this case, the elasticity of substitution between domestic and foreign currencies is unity. The estimated parameter φ shows a household's preferences to use the local currency in their total liquidity. Models M1b, M2b, and M3b contain both parameters φ and ρ.

The GMM estimation results for models M1a, M2a, and M3a are reported in Table 3. Overall, the models' overidentifying restrictions cannot be rejected at standard significance levels.

In Croatia, the sample is divided into two parts before and after June 1997's break in the ratio $\frac{m_t^*}{m_t}$. The highly significant estimate of the share of foreign currency in liquidity services changes from 0.93 to 0.92 after the break. The economic and statistical significance of dollarization in the country is very high. The trend significance and direction are in line with the dynamics of dollarization. The breaks in the right-hand-side variables, i_t and π_t^{euro}, are significant in M2a and M3a.

For the Czech Republic, the sample starts in November 1997, after the structural break in $\frac{m_t^*}{m_t}$. Model one is estimated with p=2 (quadratic trend). A structural break dummy variable for July 2009 in z_t is included. The estimate of the share of foreign currency in domestic liquidity services is highly significant. However, it is small in magnitude being 0.22. This indicates a significantly positive role of foreign currency in total liquidity services. The economic significance is, however, small given its magnitude. The structural break dummy is positively significant, and is very small in magnitude. In the model with inflation (M3a), the estimate of the share of foreign currency in domestic liquidity services indicates only 0.13 of economic significance. The linear trend is significant only at the 10% level, and the quadratic trend is negative and highly significant.

In Georgia, the economic significance of dollarization changes from 0.87 before 2004 to 0.44 after in the model with exchange rate. The linear trend is significant and has the expected sign. The structural break dummy in the depreciation rate is significantly positive. In model 2 with interest rates, both samples indicate a 0.62 share of foreign currency in domestic liquidity services. Both the linear and quadratic trend are significant. The structural break dummy for the interest rate is insignificant. In model 3 with inflation, the estimated share is lower. It is 0.36 in the first sub-sample and decreases to 0.27 after 2004. A negatively significant quadratic trend is present only in the second sub-sample.

The estimate of the share of foreign currency is only 0.1 - 0.2 in Kazakhstan before the structural break in 2001. In the second sub-sample, the estimated share increases to 0.46 in the first two models and to 0.48 in the third one. An upward trend in the first sub-sample is reflected in a positively significant quadratic trend in models 1 and 2, and in a positively significant linear trend in model 2. The structural break dummy variables are significant in all the models (only at the 10% level in the first model).

In the Kyrgyz Republic, for the first sub-sample prior to 2004, the estimate of the share of foreign currency is 0.30 for model 1, 0.42 for model 2, and 0.44 for model 3. An upward dollarization trend is reflected in a positively significant linear trend. In the second sub-sample, the estimates of the share are 0.76 in the first two models and 0.74 in the third one. The linear trend is significantly negative. Dummy variables for breaks in RHS are significant in all the models.

In Tajikistan, the estimated shares over the first sub-sample are 0.49, 0.50, and 0.48 in models 1, 2 and 3, respectively. The linear trend coefficients are significantly positive with small magnitude. In the second sub-sample, the estimate of the share of foreign currency is significantly higher, 0.91, 0.79, and 0.64 in the models 1, 2, and 3. The upward trend is larger in magnitude and the quadratic trend becomes significant. The dummy variable is significant only in the third model. In the first model, the break resulted in non-stationary coefficients, and the results excluding the break are reported. The right-hand-side ratio $\frac{i_{t+1}}{(i_{t+1}-z_{t+1})}$ is a stationary process without a structural break.

The estimated share parameter for Turkey over the first sub-sample is 0.93 for model 1, 0.81 for model 2, and 0.91 for model 3. The linear trend is positively significant and the quadratic trend is negative and very small in magnitude. In the second sub-sample, the estimated share is a bit lower: 0.86, 0.82, and 0.85. The linear trend is significantly negative indicating decreasing dollarization in the economy. The dummy variable for structural break is significant only in the third model.

For each country, the estimation results for the models with two parameters φ and ρ are reported in Table 4. The starting values supplied for the parameters are $\rho \to 0$ and $\widehat{\varphi}$, the estimated coefficient from the model with unit elasticity of substitution. Starting guesses were obtained in the same way as for the previous models. One hundred other initial starting values were used to check the robustness of the parameter estimates. Several models have convergence problems with most starting values. The results of these models are not robust and stable. Their results are not reported but marked as NC (not converged).

The specifications of the models, the order of the trend, the right-hand-side break dummy variables, and instrumental variables are exactly the same as in M1a, M2a, and M3a. The models are estimated over the same sub-samples. The coefficients of the trend and dummies for break variables are roughly the same in magnitude and sign. The model's overidentifying restriction cannot be rejected in all the models with three exceptions. These are M2b in the first sub-sample for Georgia, and M1b and M2b in the second sub-sample for Tajikistan.

For Croatia, the estimated share of foreign currency is in the same range as in M1a, M2a, and M3a. The coefficient is significant in three cases: both sub-samples for M2b, and in M3b over the first sub-sample. The economic significance of currency substitution is again very high: 0.94 and 0.98. The estimated coefficient ρ is insignificant in all the models.

For the Czech Republic, the estimates of the coefficients ρ and φ are both insignificant at all significance levels in model M1b. The signs and magnitudes of the trend and break coefficients are the same as in model M1a.

The estimated shares of foreign currency in Georgia usually have similar magnitude as in the first set of models in all the models. The exception is M2b over the first sub-sample (moreover, this model's specification is rejected according to the J-test). Both estimated coefficients ρ and φ are significant in M1b and M2b over the second sub-samples, and model M3b over the first sub-sample. The implied elasticities $\dfrac{1}{1+\rho}$ are equal to 19.2, 4.065, and 3.096. Hence, the results suggest that the US dollar is a strong substitute for the lari when the motive for holding money is to reduce transaction costs. The highest elasticity of substitution is in model 1, suggesting that the demand for the US dollar is more responsive to the fluctuations in the exchange rate than to the changes in the interest rate on time deposits or inflation. The economic significance of currency substitution is more than 0.5 in the first two models and only 0.26 in the third one.

For Kazakhstan, the estimated share parameter of the foreign currency is highly significant in the second and third models over the second sub-samples. The economic significance of the currency substitution is moderate at 0.46 and 0.48. The models indicate that the implied elasticity of the currency substitution is not significant or less than unity (0.56) in the model with inflation.

The estimation results for the Kyrgyz Republic indicate that the economic significance of currency substitution is roughly that same as in the first set of models. It changes from 0.43 and 0.48 in the period 1996-2004 to 0.6 and 0.9 in the period 2004-2010. In the second model, the elasticity of currency substitution falls from 6.9 in the first sub-sample to 2.6 in the second. In model three, the elasticity is insignificant in the first sub-sample, and is 0.7 in the second. In the models with exchange rate, both coefficients are insignificant.

For Tajikistan, the estimated coefficients ρ and φ are not significant in any of the models Moreover, the overidentifying restrictions are rejected in two cases. These results might be caused by the small sample size or the lack of cash estimates in $\dfrac{m_t^*}{m_t}$.

The results from the Turkish data indicate that in the second model the economic significance of dollarization changes from 0.45 to 0.91 between the sub-samples. The elasticity of currency substitution is very high in the first sub-sample but is insignificant in the second. In model 3, the estimated share of the foreign currency parameter is 0.65, and the elasticity is 2.1.

To summarize, foreign currency plays a significant role in the total liquidity that is used to reduce transaction costs in purchasing goods in each country. The estimated magnitude of the preferences differ with the countries and sub-samples. The highest estimated preferences, 0.93, are in Croatia for the period 1995-1997. This parameter drops to 0.91 after 1997, and the money ratio has a significant negative trend. In the Czech Republic, the preferences for foreign currency are low, 0.1 and 0.2. The substitution parameters are insignificant in both Croatia and the Czech Republic.

In Georgia and Turkey, the values of the estimated share parameters are big. According to the interest rate model, the estimated parameters are the same before and after the break in both countries. Other models suggest that the estimated preference parameter drops significantly after 2003 in Turkey, and after 2004 in Georgia. The money ratio, in general, has a significant negative trend after the break. The implied elasticity of substitution between domestic and foreign currencies is very significant and high in Georgia after 2004 in the exchange rate and interest rate models, and before 2004 in the inflation model. In Turkey, the implied elasticity is larger than unity for the period 1990-2003 in the second and third models.

The estimated preference share increases after 2001 in Kazakhstan (from 0.1 to 0.4), and after 2004 in the Kyrgyz Republic (from 0.4 to 0.7) and in Tajikistan (from 0.5 to 0.8). In Kazakhstan and the Kyrgyz Republic, the money ratio has a negatively significant trend during these periods. In contrast, this trend is significantly positive in Tajikistan. In Kazakhstan, the implied elasticity of substitution is less than unity in the third model during the period 2001-2010. According to the second model, the demand for foreign currency is responsive to changes in the relative prices of currencies in the Kyrgyz Republic. During the period 2004-2010, the elasticity is less than unity according to the third model. The substitution coefficients are not significant in Tajikistan.

3.5 Conclusion

This paper rationalizes and studies the significance of household dollarization. A newly compiled data set is used to explore the significance of dollarization based on three versions of a money-in-utility-function (MIUF) model's implications. The data set includes countries with a history of important economic and political transformations: the Czech Republic, Croatia, Turkey, Kazakhstan, Georgia, Kyrgyzstan, and Tajikistan.

This paper contributes to the literature by providing evidence on household currency substitution based on the micro-foundations of the individual's demand for money in the set of countries. Three versions of a MIUF model are specified to rationalize household dollarization. The models focus on the observables that individuals typically base their decision to hold foreign currency on: exchange rate, foreign and domestic time deposit interest rates, and inflation at home and abroad. Structural breaks in the data that are exogenous from the perspective of the models are detected and added to the estimation. The main finding is that currency substitution is most significant in Croatia, Georgia, the Kyrgyz Republic, Tajikistan and Turkey, while it is not significant in the Czech Republic and Kazakhstan.

The model is specified with foreign and domestic money in the utility function, reflecting the usefulness of both currencies to reduce transaction costs. Dollarization is empirically analyzed using observable money holdings that represent a store of value: household deposits. The liquidity services are provided by the household's foreign and domestic demand deposits. Non-liquid interest-bearing assets are the household's time deposits.

A household's optimal choice between foreign and domestic money is derived from the optimality conditions of the three versions of the MIUF model. Two cases are considered for each model: log-linear and the CES technologies to produce liquidity services. In the case of log-linear liquidity services, the parameter of interest is the share of foreign currency in money services. The magnitude of this parameter measures the economic significance of dollarization in an economy. The elasticity of the currency substitution parameter is added in the case of the CES technology. It shows the responsiveness of the demand for foreign currency to fluctuations in the exchange rate, domestic and foreign inflation, and interest rates in domestic and foreign currency deposits.

An endogenous search for critical structural breaks in the data is performed prior to the GMM estimation. Structural breaks, detected in most of the series, are often associated with country-specific events that are exogenous for specified MIUF models. The estimation sample is divided according to the break in the ratio of foreign to domestic demand deposits. This corrects for the instability of parameter estimates due to the structural breaks in the data. Breaks in independent variables are captured by structural break dummies. The trend is included into the estimation as most series are stationary around a deterministic trend. The conditions for the optimal choice between foreign and domestic money are estimated using the GMM method. The instrumental variables are two lags of the independent variables in each version of the model. In general, the data gives support to models' overidentifying restrictions.

Overall, the estimation results show that the share of foreign currency in total domestic liquidity services is positively significant in each country. The economic significance of dollarization is different in sub-samples before and after detected structural breaks. It decreased over time in Croatia, Georgia, and Turkey, and increased in Tajikistan, Kyrgyzstan and Kazakhstan. The share of foreign currency in total liquidity is economically small in the Czech Republic (0.1-0.22) and in Kazakhstan (0.15-0.48). The share of foreign currency in domestic liquidity is the highest in Croatia ranging from 0.91 to 0.93. In general, foreign currency accounts for more than half of total domestic liquidity in Georgia, Tajikistan, and Turkey. The minimum and maximum estimates of the share are 0.3 and 0.9 for Georgia, 0.48 and 0.91 for Tajikistan, and 0.6 and 0.93 for Turkey. When the CES functional form is used, the magnitude of the estimate of the share of foreign currency in liquidity services is roughly similar for all countries. According to the implied elasticity of currency substitution, the US dollar is a strong substitute for the local currency in Georgia, Kyrgyzstan and Turkey. In Kazakhstan, it is less than one in the inflation model.

References

Adam, C., Goujon, M., Guillaumont Jeanneney, S. (2004). The Transactions Demand for Money in the Presence of Currency Substitution: Evidence from Vietnam. Applied Economics, 36, 1461-1470.

Aslamazishvili, N. & Kakulia, M. (2004). Dollarization in Georgia: Size of the Problem, Factors and the Ways of Solutions. Banki, 3, 13-24.

Blanchard, O. & Fischer, S. (1989). Lectures on Macroeconomics. MIT Press.

Brodsky, B. (1997). Dollarization and Monetary Policy in Russia. Review of Economies in Transition, 6, 49–62.

Bufman, G. & Leiderman, L. (1993). Currency Substitution under Non-expected Utility: Some Empirical Evidence. Journal of Money, Credit, and Banking, 25, 320–325.

Calvo, G. & Vegh, C. (1996). From Currency Substitution to Dollarization and Beyond: Analytical and Policy Issues. G. Vegh ed. Money, Exchange Rates and Outputs. Cambridge: MIT Press.

Cuddington, J. (1983) Currency Substitution, Capital Mobility and the Demand for Domestic Money. Journal of International Money and Finance, 2, 111–133.

Cuddington, J., Garcia R-M., Westbrook, D. (2002). A Micro-foundations Model of Dollarization with Network Externalities and Portfolio Choice: The Case of Bolivia (mimeo). Department of Economics of Georgetown University.

Dickey, D. & Fuller, W. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, 49, 1057-1072.

Egert, B., Jiménez-Rodríguez, R., Kočenda, E., Morales-Zumaquero, A. (2006). Structural Changes in Central and Eastern European Economies: Breaking News or Breaking the Ice? Economic Change and Restructuring, 39, 85-103.

Feenstra, R. (1986). Functional Equivalence Between Liquidity Costs and the Utility of Money. Journal of Monetary Economics, 17, 271–91.

Feige, E. & Dean, J. (2004). Dollarization and Euroization in Transition Countries: Currency Substitution, Asset Substitution, Network Externalities, and Irreversibility. Chapter in Monetary Unions and Hard Pegs: Effects on Trade, Financial Development, and Stability. Oxford University Press, 303–319.

Friedman, A. & Verbetsky, A. (2001). Currency Substitution in Russia. Economic Education and Research Consortium Working Paper Series, 01/05.

Garg, A., Barajas A., Chami R., Fullenkamp, C. (2010). The Global Financial Crisis and Workers' Remittances to Africa: What's the Damage. IMF Working Papers, 10/24.

Giovanni, A. & Turtelboom, B. (1992). Currency Substitution. NBER Working Paper, 4232.

Hansen, L. (1982). Large Sample Properties of Generalized Method of Moments Estimators. Econometrica, 50, 1029–1054.

Hansen, L. & Singleton, K. (1982). Generalized Instrumental Variables of Nonlinear Rational Expectations Models. Econometrica, 50, 1269–1285.

Havrylyshyn, O., Beddies, C. (2003). Dollarisation in the Former Soviet Union: From Hysteria to Hysteresis. Comparative Economic Studies, 45, 329-357.

IMF. (April 2010). World Economic Outlook Database.

Imrohoroglu, S. (1994). GMM Estimates of Currency Substitution between the Canadian Dollar and the U.S. Dollar. Journal of Money, Credit and Banking, 26, 792–807.

Kočenda, E. (2005). Beware of Breaks in Exchange Rates: Evidence from European Transition Countries. Economic Systems, 29, 307-324.

Kraft, E. & Galac, T. (2007). Deposit Interest Rates, Asset Risk and Bank Failure in Croatia. Journal of Financial Stability, 2, 312-336.

Kydland, F. & Prescott, E. (1982). Time to Build and Aggregate Fluctuations. Econometrica, 50, 1345-70.

Miles, M. (1978). Currency Substitution, Flexible Exchange Rates, and Monetary Independence. American Economic Review, 68, 428–436.

Mongardini, J. & Mueller, J. (1999). Effects in Currency Substitution: An Application to the Kyrgyz Republic. IMF Working Paper, 99/102.

Mulligan, R. & Nijsse, E. (2001). Shortage and Currency Substitution in Transition Economies: Bulgaria, Hungary, Poland and Romania. International Advances in Economic Research, 7, 275–95.

Nelson, C. & Plosser, C. (1982). Trends and Random Walks in Macroeconmic Time Series : Some Evidence and Implications. Journal of Monetary Economics, 10, 139-162.

Obstfeld, M. & Rogoff, K. (1996). Foundations of International Macroeconomics. MIT Press.

Perron, P. (1989). The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. Econometrica, 57, 1361-1401.

Phillips, P. & Perron, P. (1988) Testing for a Unit Root in Time Series Regression. Biometrika 75, 335-346.

Selcuk, F. (2003). Currency Substitution: New Evidence from Emerging Economies. Economics Letters, 78, 219-224.

Selcuk, F. (1997). GMM Estimation of Currency Substitution in a High-Inflation Economy. Applied Economics Letters, 4, 225-228.

Sidrauski, M. (1967). Rational Choice and Tatters of Growth in a Monetary Economy. American Economic Review, 2, 534-544.

Stix, H. (2010). Euroization: What Factors drive its Persistence? Household Data Evidence for Croatia, Slovenia and Slovakia. Forthcoming in Applied Economics.

Thomas, L. (1985). Portfolio Theory and Currency Substitution. Journal of Money. Credit and Banking, 17, 347-357.

Uribe, M. (1997). Hysteresis in a Simple Model of Currency Substitution. Journal of Monetary Economics, 40, 1299-1303.

Vogelsang, T. (1997). Wald-type Tests for Detecting Breaks in the Trend Function of a Dynamic Time Series. Econometric Theory, 13, 818–849.

Appendix I: Methodology

Vogelsang and Perron Tests

The test proposed by Vogelsang (1997) endogenously searches for a single break point in a series. The specification of this test is robust to the unit-root dynamics of the series, does not impose restrictions on the nature of the data and the distribution of errors, and can be applied to a general polynomial function of time. The null hypothesis of no break is tested for a data generating process. To perform the Vogelsang test for a time series $\{y_t\}_{t=1}^{T}$, a re-parametrisation for the data generating process is used and then the following equation is estimated by the OLS:

$$\Delta y_t = \beta_0 + \sum_{t=1}^{p} \beta_i t^i + \delta_0 DU_t + \sum_{t=1}^{p} \delta_i (DT_t)^i + \pi y_{t-1} + \sum_{t=1}^{K} \rho_i \Delta y_{t-i} + \varepsilon_t. \tag{3.39}$$

The dummy variables for the structural break are: $DU_t = 1$ for $t > T_B^C$ and zero otherwise, and $DT_t = t - T_B^C$ for $t > T_B^C$ and zero otherwise with T_B^C being the unknown time of the break. This specification allows for a shift in level and trend at the break point. The serial correlation in errors is addressed by including lags of a dependent variable. The appropriate number of lags is usually determined using the method proposed by Campbell and Perron (1991): by setting the upper bound to eight and reducing it until the estimate of the coefficient at the highest lag is significant at the 10% level.

The OLS estimation of 3.39 is done for all possible break dates $T_B^C = \lambda T, \lambda \in [\lambda^*, 1-\lambda]$, where λ^* is a trimming parameter that represents the portion of the time span that is not allowed to contain a break, and T is the number of observations. There are two possible values of the parameter λ^*: 0.01 and 0.15. The parameter's choice depends on the expectations of where the break appears. If the break is likely to appear in the beginning or at the end of the sample, the trimming parameter is set to 0.01. In the case of a break in the middle, $\lambda^* = 0.15$. For each of the estimated equations that differ in the potential break date, the hypothesis $\delta_i = 0$ is tested computing the usual F-test. Finally, the statistic SupF is calculated as the maximum over all F-statistics. The null hypothesis of no break is rejected if this statistic is greater than the appropriate critical value in absolute value.

The break detected by the Vogelsang test is used as the expected break in the Perron test for broken trend stationarity. The test considers three alternative specifications: exogenous change in the intercept (A), exogenous change in the linear trend coefficient (B), and a combination of an exogenous change in intercept and the linear trend coefficient (C).

$$ModelA \;:\; y_t = \mu + \beta t + d(DT_B)_t + \theta DU_t + \alpha y_{t-1} + \sum_{t=1}^{K} \rho_i \Delta y_{t-i} + \varepsilon_t, \tag{3.40}$$

$$ModelB \;:\; y_t = \mu + \beta t + \gamma(DT)_t + \alpha y_{t-1} + \sum_{t=1}^{K} \rho_i \Delta y_{t-i} + \varepsilon_t, \tag{3.41}$$

$$ModelC \;:\; y_t = \mu + \beta t + d(DT_B)_t + \theta DU_t + \gamma(DT)_t + \alpha y_{t-1} + \sum_{t=1}^{K} \rho_i \Delta y_{t-i} + \varepsilon_t \tag{3.42}$$

In these specifications, T_B is the predetermined break date. The dummies are $D(T_B)_t - 1$ for $t = T_B + 1$ and zero otherwise, $DU_t - 1$ for $t > T_B$ and zero otherwise, and $DT_t = t - T_B$ for $t > T_B$ and zero otherwise.

Perron's null hypothesis is that a series has a unit root with an exogenous structural break that occurs at a given date. The alternative hypothesis is stationarity around deterministic time trend with an exogenous change. The series are broken trend stationary only if the remaining coefficients satisfy all the requirements on other coefficient estimates for the general specification of the alternative hypothesis.

$$ModelA \;:\; H_0 : \alpha = 1, \beta = 0, \theta = 0, d \neq 0; H_A : \alpha < 1, \beta \neq 0, \theta \neq 0, d = 0, \tag{3.43}$$

$$ModelB \;:\; H_0 : \alpha = 1, \beta = 0, \gamma = 0; H_A : \alpha < 1, \beta \neq 0, \gamma \neq 0, \tag{3.44}$$

$$ModelC \;:\; H_0 : \alpha = 1, \beta = 0, \gamma = 0, \theta \neq 0, d \neq 0; H_A : \alpha < 1, \beta \neq 0, \gamma \neq 0, \theta \neq 0, d = 0 \tag{3.45}$$

The test critical values differ with the pre-break fraction $\lambda = T_B/T$. This fraction accounts for the break timing with respect to the whole time span. If the calculated t-statistic is lower than the appropriate critical value, the H_0 of UR with a break is rejected in favor of broken trend stationarity.

Generalized Method of Moments

As the name suggests, GMM estimates the unknown parameters by the method of moments (MOM). Moreover, it allows for more orthogonality conditions than parameters. Provided the data is a stationary and ergodic process, the GMM estimates are typically consistent and normally distributed, even if the series in the moment conditions are serially correlated and heteroskedastic. Most traditional methods (OLS, IV, MLE, etc.) are special cases of GMM.

Formally, denote a stationary and ergodic data vector $(h \times 1)$ by z_t, and a $(Th \times 1)$ vector $[z_1...z_T]$ by Z_T. Let β be a $(a \times 1)$ vector of coefficients with the true value β_0. The residual from the model is a $(r \times 1)$ vector-valued function $h(z_t, \beta)$. The orthogonality (moment) conditions are

$$E(h(z_t, \beta_0)) = 0.$$

Its sample equivalent evaluated at some value of β is given by

$$g(\beta, Z_t) = \frac{1}{T}\sum_{t=1}^{T} h(z_t, \beta).$$

If the system is exactly identified (the number of equations is equal to the number of unknown parameters, $a = r$), $g(\beta, Z_t)$ can be set equal to zero by solving for the parameters in β. When the system is overidentified ($a < r$), the parameters can no longer be solved for by inverting the functions. Instead, a criterion function of the moment equations is minimized. To derive the GMM estimator of β, the sample moment $g(\beta, Z_t)$ is put as close as possible to the population moment of zero. The GMM estimator minimizes the quadratic form of a weighted criterion function with positive definite weighting matrices W_T :

$$\min\{g(\beta, Z_t)' \times W_T \times g(\beta, Z_t)\}.$$

The a first order conditions for minimizing the GMM loss function with respect to a parameters are that the partial derivatives with respect to β equal zero at estimate $\widehat{\beta}$. The system can be solved for the GMM estimator $\widehat{\beta}$ by numerical methods:

$$(\frac{d(g(\widehat{\beta}, Z_t))}{d(\beta^{'})})' \times W \times g(\widehat{\beta}, Z_t) = 0.$$

The inverse of the covariance matrix of the moment conditions S_0 evaluated at the true parameters gives the asymptotically most efficient estimator for a given set of orthogonality conditions.

$$W_T = S_0^{-1} S_0 = Cov[\sqrt{T} g(\beta_0, Z_t)] = \sum_{s=-\infty}^{\infty} Eh(z_t, \beta_0) h(z_{t-s}, \beta_0)^{'}.$$

If the vector process $h(z_t, \beta)$ is serially uncorrelated, then the matrix S_0 can be heteroskedasiticity-consistently estimated by $S_0 = \frac{1}{T} \sum h(z_t, \beta_0) h(z_t, \beta_0)^{'}$. This estimator can be modified to take into account serial correlation by using the Newey-West estimator.

When the system is overidentified ($a < r$), the statistic $J_T = Tg(\widehat{\beta}, Z_t)^{'} \times S_0^{-1} \times g(\widehat{\beta}, Z_t)$ can be shown to be asymptotically χ^2-distributed with $(r - a)$ degrees of freedom when $W_T = S_0^{-1}$ is used. This is a test for overidentifying restrictions (J-test). This test provides a convenient method for testing the validity of the model specification. If the test statistic is significant, the model specification under consideration can be rejected.

Appendix II: Data and Estimation Results

Table 1. Data Series Univariate Statistics

Statistic	$\frac{m_t^*}{m_t}$	z_t	i_t	i_t^*	π_t	$\frac{m_t^*}{m_t}$	z_t	i_t	i_t^*	π_t	$\frac{m_t^*}{m_t}$	z_t	i_t	i_t^*	π_t	$\frac{m_t^*}{m_t}$	z_t	i_t	i_t^*	π_t
	Croatia					**Czech Republic**					**Georgia**					**Kazakhstan**				
Sample	**1995:7-2009:12**					**1997:1-2010:1**					**1996:2-2010:1**					**1998:1-2010:1**				
Mean	9.870	0.000	6.680	4.431	0.287	0.106	0.018	3.015		0.295	1.705	0.002	11.325	13.433	0.604	0.474	0.005	11.821	7.213	0.704
Maximum	16.144	0.028	15.288	7.770	2.311	0.251	0.261	9.060		4.025	4.286	0.213	32.345	33.366	12.167	1.527	0.309	25.600	9.700	4.723
Minimum	7.003	-0.029	2.493	2.520	-1.299	0.023	-0.079	1.180		-0.810	0.015	-0.050	4.633	8.197	-3.356	0.106	-0.038	2.800	5.200	-1.026
Std. Dev.	2.037	0.009	3.126	1.418	0.545	0.072	0.049	2.520		0.659	0.985	0.029	4.991	5.528	1.563	0.258	0.036	3.109	1.198	0.786
Skewness	1.345	0.183	0.806	0.653	0.220	0.674	1.730	1.421		2.656	0.516	4.322	1.813	1.648	2.524	0.883	6.424	1.102	0.322	2.648
Kurtosis	1.598	0.458	0.011	-0.701	1.015	-0.824	6.558	0.597		10.528	-0.575	26.462	4.431	1.988	17.558	1.432	48.131	2.598	-1.004	11.514

Statistic	$\frac{m_t^*}{m_t}$	z_t	i_t	i_t^*	π_t	$\frac{m_t^*}{m_t}$	z_t	i_t	i_t^*	π_t	$\frac{m_t^*}{m_t}$	z_t	i_t	i_t^*	π_t	π_t^{euro}	π_t^{us}
	Kyrgyzstan					**Tajikistan**					**Turkey**					**External Inflation**	
Sample	**1996:1-2010:1**					**2002:1-2010:1**					**1990:3-2010:1**					**1995:7-2009:12**	**1990:3-2009:12**
Mean	2.025	0.009	22.224	12.229	0.982	2.355	0.006	17.002	14.595	0.885	4.071	0.028	16.009	6.437	3.344	0.157	0.221
Maximum	5.284	0.254	53.862	31.792	8.938	4.057	0.077	24.212	21.540	6.300	8.547	0.544	47.488	16.320	100.000	0.942	1.193
Minimum	0.137	-0.055	10.101	6.228	-2.901	0.802	-0.020	11.230	2.260	-0.800	1.005	-0.079	10.000	3.850	-0.751	-0.834	-1.894
Std. Dev.	0.799	0.037	13.412	5.832	1.792	0.870	0.014	2.345	2.829	1.069	2.089	0.057	9.167	2.329	8.155	0.275	0.339
Skewness	0.085	3.168	0.647	1.422	1.522	-0.250	2.626	0.146	-1.753	1.978	0.224	3.780	1.714	1.326	8.345	-0.419	-1.276
Kurtosis	1.005	15.233	-1.236	0.886	4.325	-1.178	9.578	0.508	4.906	6.585	-1.315	28.678	2.491	1.771	88.513	1.243	7.283

Table 2. Structural Breaks and Stationarity Tests.

Test	$\frac{\mathbf{m}_t^*}{\mathbf{m}_t}$	$\mathbf{z}_t$	$\mathbf{i}_t$	$\mathbf{i}_t^*$	$\boldsymbol{\pi}_t$
			Croatia		
Vogelsang break	$T_B^C = 06.1997$ $\lambda^* = 0.01$	$T_B^C = 01.2008$ $\lambda^* = 0.01$	$T_B^C = 10.2008$ $\lambda^* = 0.01$	$T_B^C = 11.1996$ $\lambda^* = 0.01$	$T_B^C = 08.2007$ $\lambda^* = 0.01$
Perron test	$t = -6.03^{***}$ $\lambda = 0.19$	$t = -8.19^{***}$ $\lambda = 0.94$	$t = -6.53^{***}$ $\lambda = 0.92$	$t = -7.44^{***}$ $\lambda = 0.16$	$t = -6.61^{***}$ $\lambda = 0.84$
Decision	BS	BS	BS	BS	BS
			Czech Republic		
Vogelsang break	$T_B^C = 11.1997$ $\lambda^* = 0.01$	$T_B^C = 03.2009$ $\lambda^* = 0.01$	$T_B^C = 03.1999$ $\lambda^* = 0.01$	N/A	$T_B^C = 12.2002$ $\lambda^* = 0.15$
Perron test	$t = -6.11^{***}$ $\lambda = 0.06$	$t = -7.58^{***}$ $\lambda = 0.94$	$t = -5.68^{***}$ $\lambda = 0.17$	N/A	$t = -4.36^{***}$ $\lambda = 0.45$
Decision	BS	BS	BS	N/A	BS
			Georgia		
DF	–	–	–	–	0.00
PP	–	–	–	–	0.00
WS	–	–	–	–	0.00
Vogelsang break	$T_B^C = 03.2004$ $\lambda^* = 0.15$	$T_B^C = 02.1999$ $\lambda^* = 0.01$	$T_B^C = 05.1997$ $\lambda^* = 0.01$	$T_B^C = 03.1998$ $\lambda^* = 0.01$	*no*
Perron test	$t = -3.81^{***}$ $\lambda = 0.56$	$t = -6.24^{***}$ $\lambda = 0.21$	$t = -9.19^{***}$ $\lambda = 0.08$	$t = -10.93^{***}$ $\lambda = 0.15$	–
Decision	BS	BS	BS	BS	S
			Kazakhstan		
Vogelsang break	$T_B^C = 08.2001$ $\lambda = 0.15, 0.01$	$T_B^C = 05.1999$ $\lambda = 0.01$	$T_B^C = 09.2009$ $\lambda = 0.01$	$T_B^C = 02.2009$ $\lambda = 0.01$	$T_B^C = 08.1999$ $\lambda = 0.01$
Perron test	$t = -7.27^{***}$ $\lambda = 0.30$	$t = -7.37^{***}$ $\lambda = 0.11$	$t = -8.72^{***}$ $\lambda = 0.15$	$t = -9.54^{***}$ $\lambda = 0.92$	$t = -6.20^{***}$ $\lambda = 0.13$
Decision	BS	BS	BS	BS	BS
			Kyrgyzstan		
Vogelsang break	$T_B^C = 02.2004$ $\lambda^* = 0.15$	$T_B^C = 12.1996$ $\lambda^* = 0.01$	$T_B^C = 03.1999$ $\lambda^* = 0.01$	$T_B^C = 04.1999$ $\lambda^* = 0.15$	$T_B^C = 07.1999$ $\lambda^* = 0.15$
Perron test	-6.49^{***} $\lambda = 0.58$	-11.42^{***} $\lambda = 0.07$	-4.20^{***} $\lambda = 0.22$	-9.04^{***} $\lambda = 0.23$	-8.14^{***} $\lambda = 0.26$
Decision	BS	BS	BS	BS	S
			Tajikistan		
DF	–	–	0.01	0.01	–
PP	–	–	0.00	0.00	–
WS	–	–	0.01	0.00	–
Vogelsang break	$T_B^C = 09.2004$ $\lambda^* = 0.01$	$T_B^C = 07.2009$ $\lambda^* = 0.01$	*no*	*no*	$T_B^C = 02.2003$ $\lambda^* = 0.01$
Perron test	$t = -5.35^{***}$ $\lambda = 0.33$	$t = -6.37^{***}$ $\lambda = 0.94$	–	–	$t = -7.04^{***}$ $\lambda = 0.14$
Decision	BS	BS	S	S	BS
			Turkey		
Vogelsang break	$T_B^C = 02.2003$ $\lambda^* = 0.15$	$T_B^C = 05.1994$ $\lambda^* = 0.01$	$T_B^C = 03.2001$ $\lambda^* = 0.15$	$T_B^C = 05.2001$ $\lambda^* = 0.15$	$T_B^C = 03.1991$ $\lambda^* = 0.01$
Perron test	$t = -3.81^{***}$ $\lambda = 0.65$	$t = -7.88^{***}$ $\lambda = 0.2$	$t = -6.35^{***}$ $\lambda = 0.65$	$t = -4.56^{***}$ $\lambda = 0.57$	$t = -9.01^{***}$ $\lambda = 0.05$
Decision	BS	BS	BS	BS	BS

External Inflation		
Test	$\boldsymbol{\pi}_t^{euro}$	$\boldsymbol{\pi}_t^{us}$
Vogelsang break	$T_B^C = 11.2008$ $\lambda^* = 0.01$	$T_B^C = 10.2008$ $\lambda^* = 0.01$
Perron test	$t = -6.66^{***}$ $\lambda = 0.92$	$t = -8.47^{***}$ $\lambda = 0.94$
Decision	BS	BS

Vogelsang test: H_0: no break; H_A: a break in at least one of the trend polynomials or in the intercept; λ^* is a trimming parameter;T_B^C is the estimated break time; order of trend polynomial p=0,1,2; K is determined by the Campbell-Perron method; 5% critical values are used (source: Vogelsang, 1997). Perron test: H_0: unit root with exogenous break in trend and/or intercept, H_A: broken trend stationarity; K is determined by the Campbell-Perron method; predetermined break date is T_B^C ; λ is the pre-break fraction; critical values source: Perron (1989). For Weighted Symmetric (WS,tau) , Dickey-Fuller (DF,tau), Phillips-Perron (PP,z) tests p-values are for optimal number of lags.

Table 3. GMM Estimation Results: Case a

Model	M1a		M2a		M3a	
			Croatia			
Smpl	1995:7 - 1997:06	1997:06 - 2009:12	1995:7 - 1997:06	1997:06 - 2009:12	1995:7 - 1997:06	1997:06 - 2009:12
φ	0.93***	0.917***	0.93***	0.91***	0.932***	0.912***
b		0.024		-0.08***		-0.08***
t	0.494***	-0.02***	0.39***	-0.017***	0.360***	-0.016***
t^2	-0.28***		-0.03***		-0.022***	
J	1.17[0.76]	3.70[0.593]	3.71[0.29]	7.60[0.18]	4.130 [0.941]	7.596 [0.180]
			Czech Republic			
Smpl	1997:11 - 2010:1		N/A		1997:11 - 2010:1	
φ	0.22***				0.132***	
b	0.0060**				-0.11***	
t	-0.0035***				0.001*	
t^2	0.000011***				-0.00001***	
J	2.09[0.84]				11.31 [0.185]	
			Georgia			
Smpl	1996:2 - 2004:3	2004:4 - 2010:1	1996:2 - 2004:3	2004:4 - 2010:1	1999:2 - 2004:3	2004:3 - 2010:1
φ	0.87***	0.44***	0.62***	0.62***	0.358***	0.269**
b	0.48***		0.139			
t	0.032***	-0.015***	0.062***	-0.011***	0.040***	0.077***
t^2			-0.002***			-0.001***
J	7.42 [0.11]	1.63 [0.80]	1.28[0.87]	6.27 [0.281]	9.0723 [.336]	5.998 [.647]
			Kazakhstan			
Smpl	1998:1 - 2001:7	2001:8-2010:1	1998:1 - 2001:7	2001:8-2010:1	1998:1 - 2001:7	2001:8-2010:1
φ	0.15**	0.46***	0.08***	0.46***	0.105***	0.475***
b	0.12*			0.80***	0.048**	
t	-0.01	-0.02***	0.0005***	-0.009***	-0.004	-0.015***
t^2	0.0007***	0.00009***			0.001***	0.000***
J	4.43[0.49]	4.12[0.53]	0.72[0.98]	5.95[0.20]	4.257 [.935]	8.568 [.285]
			Kyrgyz Republic			
Smpl	1996:1 - 2004:1	2004:2 - 2010:1	1996:1 - 2004:1	2004:2 - 2010:1	1996:1 - 2004:1	2004:2 - 2010:1
φ	0.30***	0.760***	0.415***	0.759***	0.443***	0.738***
b	0.68***		-0.609**		-0.460**	
t	0.015***	-0.022***	0.027***	-0.023***	0.025***	-0.023***
t^2						
J	4.79 [0.442]	4.818 [.438]	7.435 [.190]	6.104 [.296]	6.653 [.758]	7.597 [.369]
			Tajikistan			
Smpl	2002:1 - 2004:9	2004:10 - 2010:1	2002:1 - 2004:9	2004:10 - 2010:1	2002:1 - 2004:9	2004:10 - 2010:1
φ	0.49***	0.91***	0.50***	0.79***	0.480***	0.642***
b				0.04	0.229***	
t	0.02***	0.12***	0.01***	0.10***	0.011***	0.066***
t^2		-0.008***		-0.006***		-0.001***
J	5.71[0.33]	5.94[0.43]	2.58[0.76]	2.29[0.51]	4.678 [.699]	7.714 [.358]
			Turkey			
Smpl	1990:3 - 2003:1	2003:1 - 2009:12	1990:3 - 2003:1	2003:1 - 2009:12	1990:3 - 2003:1	2003:1 - 2009:12
φ	0.93**	0.86***	0.810***	0.819***	0.91***	0.849***
b					0.006***	
t	0.10***	-0.14***	0.100***	-0.095***	0.040***	-0.124***
t^2	0.0004***	0.001***	-0.0004***	0.0007***	-0.0001***	0.001
J	1.46[0.83]	1.85[0.87]	0.73[0.69]	4.82[0.58]	4.11 [0.66]	8.694 [.275]

Table 4. GMM Estimation Results: Case b

Model	M1b		M2b		M3b	
			Croatia			
Smpl	1995:7 - 1997:06	1997:06 - 2009:12	1995:7 - 1997:06	1997:06 - 2009:12	1995:7 - 1997:06	1997:06 - 2009:12
φ	0.916	0.934	0.942***	0.972***	0.983***	
b		0.024		-0.694***		
t	0.332***	-0.020***	0.357**	-0.018***	0.328***	NC
t^2	-0.022***		-0.022***		-0.021***	
ρ	-0.102	0.098	0.075	0.509	0.527	
J	2.260 [0.520]	3.817 [0.431]	3.785 [0.151]	6.097 [0.192]	4.172 [.900]	
$\frac{1}{1+\rho}$	-	-	-	-	-	
			Czech Republic			
Smpl	1997:11 - 2010:1		N/A		1997:11 - 2010:1	
φ	0.175					
b	0.006**					
t	-0.003***				NC	
t^2	0.000***					
ρ	0.249					
J	2.612 [0.625]					
$\frac{1}{1+\rho}$	-					
			Georgia			
Smpl	1996:2 - 2004:3	2004:4 - 2010:1	1996:2 - 2004:3	2004:4 - 2010:1	1999:2 - 2004:3	2004:3 - 2010:1
φ	0.998	0.506***	0.180	0.555***	0.256*	
b	0.497***		0.127			
t	0.031***	-0.012***	0.066***	-0.071****	0.039***	NC
t^2			0.000*	0.001***		
ρ	-0.428	-0.948***	-0.985	-0.754***	-0.677**	
J	7.450 [0.114]	3.051 [0.802]	14.437 [0.002]	5.127[0.275]	9.928 [0.270]	
$\frac{1}{1+\rho}$	-	19.231	-	4.065	3.096	
			Kazakhstan			
Smpl	1998:1 - 2001:7	2001:8-2010:1	1998:1 - 2001:7	2001:8-2010:1	1998:1 - 2001:7	2001:8-2010:1
φ	0.101	0.225	0.095	0.464***	0.007	0.475***
b	0.116**			0.804**	0.043**	
t	-0.013	-0.024***	0.000***	-0.009***	-0.003	-0.015***
t^2	0.001***	0.000***			0.000***	0.000***
ρ	0.276	0.673	-0.072	-0.092	1.250	0.800***
J	5.810 [0.214]	4.57[0.334]	0.767 [0.943]	5.514 [0.138]	4.370 [0.885]	4.8 [0.99]
$\frac{1}{1+\rho}$	-	-	-	-	-	0.556
			Kyrgyz Republic			
Smpl	1996:1 - 2004:1	2004:2 - 2010:1	1996:1 - 2004:1	2004:2 - 2010:1	1996:1 - 2004:1	2004:2 - 2010:1
φ	0.242	0.862	0.478***	0.604***	0.428***	0.896***
b	0.679***		-0.690**		-0.474**	
t	0.015***	-0.022***	0.028***	-0.022***	0.025***	-0.019***
t^2						
ρ	0.345	0.583	-0.854***	-0.615**	0.281	0.402**
J	4.853 [0.303]	4.657 [0.324]	5.663[0.226]	5.055 [0.282]	6.527 [0.686]	7.736 [0.561]
$\frac{1}{1+\rho}$	-	-	6.849	2.597	-	0.713
			Tajikistan			
Smpl	2002:1 - 2004:9	2004:10 - 2010:1	2002:1 - 2004:9	2004:10 - 2010:1	2002:1 - 2004:9	2004:10 - 2010:1
φ	0.366	0.999***	0.100	0.332	0.100	
b				0.040	0.115	
t	0.019***	0.118	0.017**	0.103***	0.012**	
t^2		-0.001		-0.001***		NC
ρ	0.964	-4.539	-0.363	-0.982	0.630	
J	5.683 [0.224]	15.523 [0.017]	2.555 [0.635]	15.586 [0.004]	5.035 [0.539]	
$\frac{1}{1+\rho}$	-	-	-	-	-	
			Turkey			
Smpl	1990:3 - 2003:1	2003:1 - 2009:12	1990:3 - 2003:1	2003:1 - 2009:12	1990:3 - 2003:1	2003:1 - 2009:12
φ	0.706	0.896	0.45***	0.91***	0.653***	
b						
t	0.102***	-0.136***	0.098***	-0.116***	0.037**	NC
t^2	0.000***	0.001***	-0.0003	0.0008***	0.000	
ρ	-0.045	0.167	-0.979***	0.45	-0.554**	
J	4.840 [0.304]	1.799 [0.773]	6.204 [0.184]	4.205 [0.379]	4.118 [0.661]	
$\frac{1}{1+\rho}$	-	-	47.619	-	2.242	