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Modeling Inflation in Georgia

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Abstract

The paper explains the behavior of inflation in Georgia in the post-stabilization period. A long-run equation linking prices to money and the exchange rate, as well as a short-run, dynamic equation for inflation are estimated. The inflation equation is stable, points to a dominant role of the exchange rate in the behavior of inflation and shows a low persistence of inflation in Georgia. The equation explains well the behavior of inflation after the Russian crises, when inflation increased sharply but was quickly brought under control, as the National Bank of Georgia kept its monetary policy tight and the exchange rate stable.

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I. Introduction

Georgia has achieved impressive success in stabilizing its economy after a hyperinflationary episode in 1993–1994. Inflation dropped from 15,607 percent in 1994 to 163 percent in 1995 and reached the single-digit level in 1997. Devaluation of the lari after the Russian financial crises raised the price level but did not have any lasting effect on inflation. At the same time, the National Bank of Georgia has faced difficulties in conducting its monetary policy: the economy has been highly dollarized; monetization has been low; and money demand has fluctuated widely. This paper attempts to throw some light on the behavior of inflation in Georgia and to construct a tool for formulation and evaluation of the monetary policy. It tests for the presence of economically interpretable long-run relationships between prices, money, and the exchange rate; estimates a short-run inflation equation; and tests for its robustness and stability.

The model points to a dominant role of the exchange rate in the behavior of inflation and shows a low persistence of inflation in Georgia. Both factors contributed to the observed behavior of inflation after the Russian crises: after the depreciation, inflation increased sharply but was quickly subdued when the authorities managed to maintain the exchange rate at a higher, but stable level.

The model does not attempt to explain the behavior of inflation during the hyperinflation and stabilization periods. For an analytical and empirical analysis of these episodes, the reader is referred to Wang (1999). Jarocinski and Jirny (1998) discuss and model the behavior of money demand in Georgia following the stabilization.

The rest of the paper is organized as follows. Section II describes developments in monetary and exchange rate policy in the post-stabilization period. Section III lays down theoretical background for the model, describes statistical properties of the data, and presents estimates of the long- and short-run models. The last section offers policy conclusions.

II. Macroeconomic Developments in Georgia

Georgia experienced one of the highest inflation rates among the BRO countries after the creation of a national currency—the *coupon*—in April 1993.[2] A stabilization program in mid-1994 brought an end to hyperinflation, and introduction in October 1995 of a new currency (the *lari*) replacing the coupon boosted demand for money. Since then, the National Bank of Georgia (NBG) has conducted a prudent monetary policy, focusing on maintaining price stability. The lari was pegged de facto to the U.S. dollar between October 1995 and December 1998 and price stability helped to remonetize the economy somewhat, although monetization has remained low and dollarization high (Table 1).

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[2] The BRO group includes the Baltics, Russia, and other former Soviet Union countries.

Table 1. Georgia: Selected Macroeconomic Indicators, 1995–2002

	1995	1996	1997	1998	1999	2000	2001	2002
				(Annual percent change)				
Real sector								
GDP volume	2.6	10.5	10.6	2.9	3.0	1.9	4.7	5.6
Consumer prices								
Period average	162.7	39.4	7.0	3.6	19.1	4.0	4.7	5.6
End-of-period	57.4	13.7	7.2	10.7	10.9	4.6	3.4	5.4
				(Percent of GDP)				
Government finances								
Revenue and grants	10.6	14.1	14.4	15.6	15.4	15.2	16.3	15.8
Of which: revenue	7.7	12.2	14.1	14.7	14.6	14.9	15.6	15.6
Expenditure and net lending	18.7	21.5	21.2	21.8	22.1	19.2	18.3	17.8
Balance (commitments)	-8.1	-7.4	-6.8	-6.1	-6.7	-4.0	-2.0	-2.0
Balance (cash)	-7.0	-7.2	-6.1	-4.9	-5.0	-2.6	-1.6	-1.9
				(Percent change, end of period)				
Money and credit 1/								
Net domestic assets of the NBG	156.5	158.5	82.2	69.9	15.3	6.9	-3.9	8.8
Credit to the rest of the economy	40.0	-14.0	63.4	40.3	34.3	30.9	10.8	24.7
Broad money								
Including foreign currency deposits	135.2	41.9	45.5	-1.2	20.7	39.0	18.5	17.9
Excluding foreign currency deposits	319.7	38.2	35.4	-11.5	9.6	33.5	5.7	14.5
				(In millions of U.S. dollars)				
External Sector								
Exports (goods)	362.6	417.0	493.5	478.3	477.0	527.7	473.0	468.6
Imports (goods)	-700.1	-767.9	-1,052.4	-1,163.7	-1,013.0	-937.0	-934.8	-944.1
Trade balance	-337.4	-350.9	-558.9	-685.4	-536.0	-409.2	-461.8	-475.6
Current account (including transfers)	-404.8	-415.4	-364.1	-370.3	-217.5	-175.6	-179.2	-202.5
Official reserves, end-of-period								
(In millions of U.S. dollars)	156.7	158.0	173.3	118.4	132.4	109.4	161.1	197.7
(In months of imports)	2.7	2.5	1.5	1.0	1.3	1.0	1.4	1.8
Memorandum items:								
GDP, current prices (in millions of lari)	2,432	3,768	4,638	5,040	5,665	6,013	6,638	7,457
Exchange rate, lari/U.S. dollar								
Period average	1.29	1.26	1.30	1.39	2.02	1.98	2.07	2.20
End-of-period	1.23	1.27	1.30	1.79	1.96	1.98	2.06	2.09

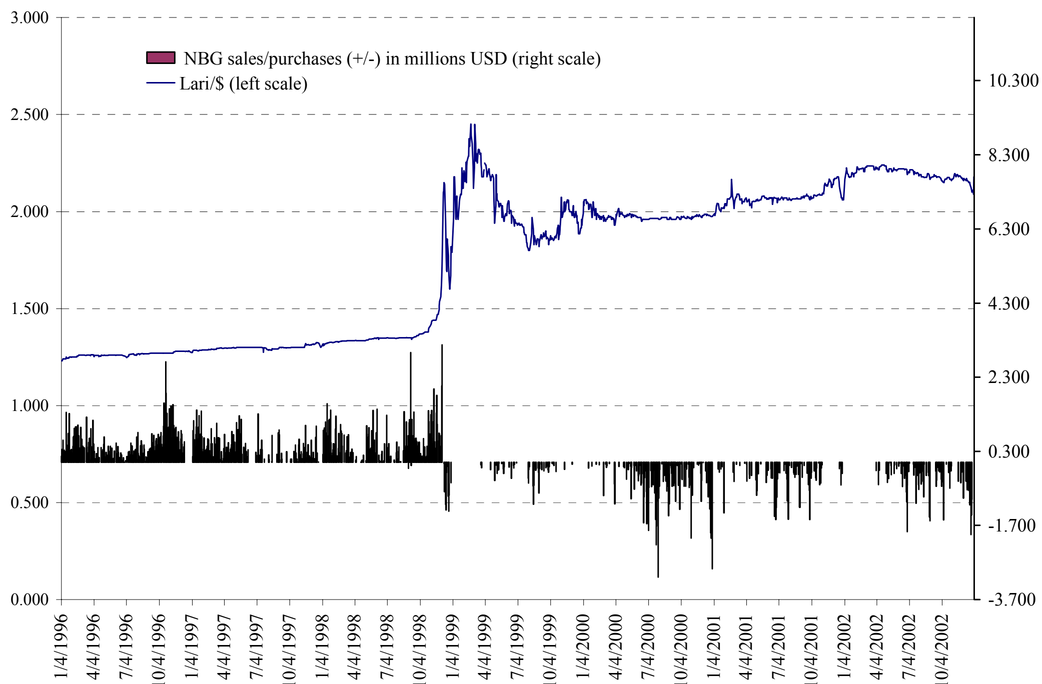
Sources: Georgian authorities; and IMF staff estimates.

1/ Valued at end-of-period actual exchange rates.

To keep the exchange rate stable, the NBG intervened in the foreign exchange market, sterilizing the impact of direct central bank credit to the government on liquidity. Other monetary policy instruments included interventions in interbank credit auctions. At the end of 1996—in an attempt to lower interest rates—the NBG started providing liquidity to the banking sector through the auctions, but the strategy had an adverse effect on NBG foreign reserves targets and was abandoned in the second half of 1997.

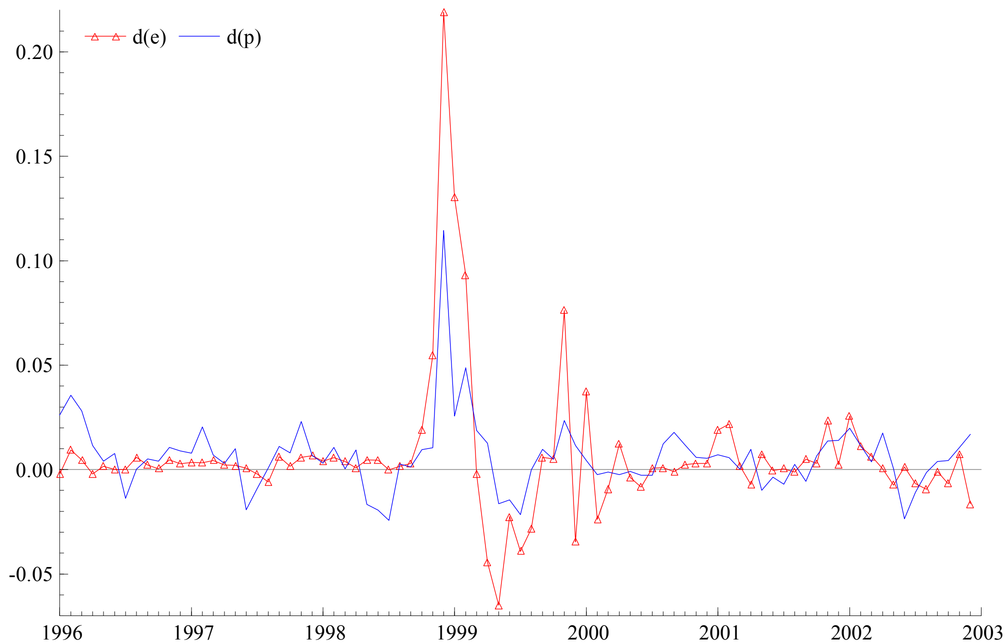
In the final months of 1998, the onset of the Russian crisis and widespread public concern regarding domestic budgetary problems led to a sharp decline in the demand for lari (broad money declined by 25 percent in nominal terms from August to November) and growing pressure on the pegged exchange rate. To defend the lari, the NBG intervened heavily in the foreign exchange market (Figure 1), increased banks' reserve requirements, withdrew liquidity through interbank auctions, and suspended automatic intra-month budget financing. The attempt was unsuccessful, and after running foreign reserves down to the equivalent of three weeks of imports, the NBG allowed the lari to float on December 7, 1998. The lari/dollar exchange rate immediately dropped by 20 percent and monthly inflation soared to 12 percent (Figure 2).

Figure 1. Lari/U.S. Dollar Exchange Rate and National Bank of Georgia's Interventions at the TICEX Market



Source: Georgian authorities.

Figure 2. Inflation and Percentage Changes in Lari/U.S. Dollar Exchange Rate



Source: Georgian authorities.

After the depreciation, the NBG further tightened monetary policy by limiting credit to the government, but the continued weakness of the fiscal position forced an increase in direct financing in the last months of 1999 and in the first half of 2000. This once again exerted downward pressure on the currency. As the fiscal position improved in the second part of 2000, the NBG was able to restrain the growth in net domestic assets. Moreover, it controlled reserve money growth sufficiently to offset a rebuilding of foreign reserves at the end of the year, which was permitted by favorable balance of payments developments. When the exchange rate began to appreciate at the end of 2002, the NBG intervened by stepping up foreign exchange purchases. Aside from these episodes, the exchange rate has remained largely stable, inflation low, and monetization has been increasing throughout the post-crisis period. The crisis, however, has permanently raised dollarization of the economy (which increased from 73 percent at the end of 1998 to 86 percent at the end of 1999),[3] indicating that policy credibility has remained low.

[3] Measured as a ratio of foreign to total deposits.

III. Model of Inflation

A. Model Specification

This section provides theoretical underpinnings for the long-term (cointegrating) relationship estimated in the empirical part of the paper. Long-term price level (P) behavior is assumed to be governed by the balance between aggregate demand (Y^D) and supply (Y^S) of goods and services. The aggregate demand for goods and services is a function of real money supply (M/P) and the real exchange rate (E/P). In log-linear form (denoted by lower-case letters), the aggregate demand is written as:

$$y^D = \alpha_1 (m - p) + \alpha_2 (e - p) \tag{1}$$

The aggregate supply is exogenously given and in equilibrium is equal to aggregate demand and real income (Y):

$$y = y^S = y^D \tag{2}$$

It is assumed that the goods market is always in equilibrium and therefore equation (2) always holds.

Flow demand for foreign exchange (current account deficit) is assumed to be a function of real exchange rate and real income. Real income is fixed at the level of aggregate supply, the available foreign financing is exogenously given, and the real exchange rate tends to equilibrate the foreign currency market. Money demand is assumed to be a function of real income. Similarly, since real income—the only variable entering the real money demand function—is exogenous, real money balances tend to equilibrate the money market. If the foreign exchange and the money market are in equilibrium, the goods market described by equation (1) is also in equilibrium by application of the Walras law.

If the markets are in equilibrium, the simple model determines two real variables (m-p and e-p), leaving one degree of freedom for determination of nominal variables (m, e and p). Fixing one of the nominal variables determines the other two, providing a nominal anchor for the system. Empirically, if the markets are on average in equilibrium, it is likely that two unique long-run cointegrating vectors emerge between non-stationary nominal variables in equation (1) (treating y as exogenous). The two cointegrating vectors describe equilibrium in any two of the three markets and equilibrium in the omitted market is described by a linear combination of the two unique cointegrating vectors, again by application of the Walras law.

It is also possible that the money and foreign exchange markets are persistently out of equilibrium (adjustments towards equilibrium may be very slow or non-linear) and that only the goods market is—by assumption—always in equilibrium. In this situation, fixing one of the nominal variables no longer provides nominal anchor for the system, but fixing any two still determines a third one by equation (1). Empirically, if the two markets are out of equilibrium, only one cointegrating vector can be found in the data, corresponding to the equilibrium described by equation (1). The persistent pressure on exchange rate before the Russian crisis—discussed in Section I above—may be an example of a disequilibrium of this type in one of the markets. The disequilibrium in the foreign exchange market in this period would imply that the money market was also out of equilibrium. The shift in real money holdings during the crisis gives some support to this hypothesis. While equilibrium in the foreign exchange and money markets had been ultimately restored, the persistence of disequilibrium and a possibly non-linear adjustment process may preclude finding two cointegrating vectors among the series.[4]

Assuming that only goods market is in equilibrium, substituting (2) into (1) and solving for p gives the equilibrium price level:

$$p = \alpha_1/(\alpha_1 + \alpha_2)\, m + \alpha_2/(\alpha_1 + \alpha_2)\, e - 1/(\alpha_1 + \alpha_2)\, y \qquad (3)$$

Equation (3), similar to the price equation developed by Bruno (1993), describes a long-term relationship between prices, exchange rate, money and real income, suitable for estimation and testing in the cointegration framework even if money and foreign exchange markets are persistently out of equilibrium. The equation exhibits a neo-classical dichotomy: y^S is fixed and equi-proportional changes in nominal variables leave the two real variables (m-p and e-p) unaltered. Testing for the neo-classical dichotomy is equivalent to testing that coefficients of money and exchange rate sum up to one.

The equilibrium real money demand discussed above is a function of real income only. A standard money demand formulation for high-inflation economies incorporates expected inflation ($E(p-p_{-1})$) or expected exchange rate depreciation ($E(e-e_{-1})$) into the function. If inflation or exchange rate depreciation series contain a unit root, and if one is interested in estimating a cointegrating relationship describing money demand or behavior of prices, it is necessary to incorporate these variables into the long-run equation (see Budina et al., 2002 or Choudhry, 1998). Visual inspection suggests that time series properties of prices and exchange rate in Georgia changed after eradication of hyperinflation and introduction of the lari. Tests for stationarity of the series—discussed below—suggest that after 1996 inflation and exchange rate depreciation became integrated of order zero, while real money balances remained integrated of order one. This result leaves only the real income as a potential argument in the cointegrating relationship describing the real money demand.

Short-run dynamics of prices and real money demand is modeled as an error-correction mechanism. The exact form of the short run relationship (lag structure) is determined by application of the general-to-specific methodology as discussed below.

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[4] Another implication is that, even if it is possible to successfully find one cointegrating vector corresponding to equation (1), it does not imply that a stable money demand function can be estimated from the data.

B. Sources, Transformations, and Statistical Properties of the Data

The model is estimated on monthly data for the post-stabilization period (January 1996–February 2003). Domestic CPI and GDP (a measure of income) are available from the Georgian State Department of Statistics (SDS). The available quarterly GDP series has been interpolated under the assumption that a monthly series follows a unit root process.[5] The exchange rate is measured by average lari/U.S. dollar exchange rate, available from the NBG. Money is measured by M2, but estimation with M3 has also been attempted. Both series are available from the NBG. Fruit and vegetable prices are obtained from disaggregated CPI data and are divided by the total CPI to obtain relative values. Average oil prices are from the IMF's WEO database. All series are in logs and are seasonally adjusted using a version of the X-12 procedure.[6]

Statistical tests confirm that time series properties of the inflation series have changed after macroeconomic stabilization and introduction of the lari. The Augmented Dickey-Fuller (ADF) test conducted on the January 1991–December 1995 sample cannot reject the null hypothesis of non-stationarity. The result is reversed when the test is performed on the post-stabilization sample Jan 1996–February 2003, when logs of CPI, M2, and the lari/U.S. dollar exchange rate are all integrated of order one (Table A-1 in Appendix I).[7] Modeling the regime change is beyond the scope of the paper and the model estimation period starts in January 1996, a few months after introduction of the lari to insulate estimates from the pre-lari regime

C. Testing and Estimation of Cointegrating Vectors

The Johansen (1988) procedure is used to test for the number of cointegrating vectors, estimate their coefficients and test for weak exogeneity of the variables. The weak exogeneity of system variables has important econometric consequences and a clear economic interpretation. From the econometric standpoint, it justifies conditioning on weakly exogenous variables, allowing for simplification of the system. Economically, weak exogeneity implies that there is no feedback from deviations from long-run equilibria to certain variables.

The procedure starts by selecting a set of endogenous and exogenous variables and choosing an appropriate lag structure for the endogenous variables. Prices, the exchange rate and money are modeled as endogenous variables. Real GDP is determined outside the system and restricted to enter only the cointegration space. Allowing output to enter the system endogenously and adding some proxies for potential output—such as deterministic trend—would allow for relaxing the

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[5] The code for the Kalman filter interpolation—written in Ox (Doornik 1999) with the SSFPack package (Koopman et al. 1999)—is available on request from the author.

[6] As implemented in GiveWin.

[7] The log of real GDP is interpolated under the assumption that the series follows a unit root process.

assumptions of output exogeneity and continuous equilibrium in the goods market. The alternative approach is not followed given the small sample size, already a large number of parameters, and difficulties with modeling the supply side of the economy in the midst of structural changes. Two other exogenous variables are added to the list of variables affecting the short-run dynamics of inflation: percentage changes in relative prices of fruits and vegetables, and percentage changes in oil prices. The two variables proxy for supply shocks stemming from agriculture sector and from input prices. The variables are assumed to be exogenous and only their current values enter the short-run equation. In addition, two impulse dummy variables are used: for December 1998, the month of a *de facto* regime change when the lari started floating against the dollar, and for September 1998, the first month after the Russian crises. The VAR is estimated with six lags of each endogenous variable, which is a compromise between an attempt to correctly capture potentially rich dynamics of monthly data and to preserve degrees of freedom.[8] The effective estimation period is June 1996-February 2003.

Results of the tests suggest that there is only one cointegrating vector between prices, money, the exchange rate and output (Table 2). After normalizing the parameter of the log of price level to unity, a hypothesis that coefficients of money and exchange rate sum up to one (homogeneity restriction) is tested, together with exogeneity restrictions (Table 3). The homogeneity restriction, the weak exogeneity of the exchange rate, and the weak exogeneity of money are not rejected at 5 percent significance level. The weak exogeneity of prices is strongly rejected. Testing joint hypotheses leads to the same conclusions about the homogeneity and exogeneity status of the variables. Exogeneity of the exchange rate implies that prices—rather than exchange rate—adjust to bring about changes in the real exchange rate necessary to restore equilibrium in the goods market. This hypothesis is reasonable a priori, given that the nominal exchange rate was heavily managed, even in the post-Russian-crisis period. Similarly, weak exogeneity of money means that prices adjust to generate changes in real money balances necessary to restore equilibrium in the goods market.

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[8] Sequential testing starting from the highest order of six allows for reduction of the lag length to four. Given high uncertainty surrounding the correct lag length, I opt for the over-parameterized model. Monte Carlo studies in Gonzalo (1994) show that efficiency loss from choosing a too long lag structure is small, while a too short lag structure has a severe impact on maximum likelihood estimates. Estimates of cointegrating vector obtained from the four-lag model are almost identical to those obtained from the six-lag specification.

Table 2. Tests for the Number of Cointegrating Vectors Between p, m, e, and y

Rank	λ_{max}		λ_{max} using T - nk		λ_{trace}		λ_{trace} using T - nk	
0	39.25	[0.003]**	28.38	[0.003]**	30.53	[0.041]*	22.07	[0.035]*
1	10.87	[0.223]	9.09	[0.285]	8.46	[0.425]	7.07	[0.489]
2	1.78	[0.182]	1.78	[0.182]	1.38	[0.239]	1.38	[0.239]

Source: IMF staff estimates.

Notes: * and ** denote significance at the 5 percent and 1 percent level, respectively. All results reported in the paper are obtained from PcGive econometric package (Hendry and Doornik 2001).

Table 3. Tests for Weak Exogeneity and Restrictions on Long-Run Coefficients

Homogeneity restriction:
(sum of coefficients of money and exchange rate in the cointegrating vector = 1)

$\chi 2$ (1) = 2.8404 [0.0919]

Weak exogeneity tests: 1/

a. No other restrictions imposed

	e_t^{USD}	m_t	p_t
p_t	$\chi 2$ (2) = 17.868 [0.0001]**	$\chi 2$ (2) = 19.670 [0.0001]**	$\chi 2$ (1) = 17.606 [0.0000]**
m_t	$\chi 2$ (2) = 3.1609 [0.2059]	$\chi 2$ (1) = 3.0294 [0.0818]	
e_t^{USD}	$\chi 2$ (1) = 0.2559 [0.6130]		

b. With homogeneity restriction imposed

	e_t^{USD}	m_t	p_t
p_t	$\chi 2$ (3) = 19.273 [0.0002]**	$\chi 2$ (3) = 24.458 [0.0000]**	$\chi 2$ (2) = 22.616 [0.0000]**
m_t	$\chi 2$ (3) = 6.8798 [0.0758]	$\chi 2$ (2) = 6.7213 [0.0347]*	
e_t^{USD}	$\chi 2$ (2) = 4.3538 [0.1134]		

Source: IMF staff estimates.

1/ Numbers along diagonal are test statistics for a simple hypothesis that a variable in a given column (or, likewise, in a row) is weakly exogenous. Numbers outside diagonal are test statistics for a joint hypothesis that variables in a given column and a row are weakly exogenous.

Estimation using M3 yields similar results, but the weak exogeneity of money is harder to reject when this measure of money is used in the model. M2 is easier to control by monetary authorities and there appear to be no feedback policy rule governing the behavior of this aggregate. The weak exogeneity result is therefore to be expected. It is also convenient to exploit, since it is valid to condition on weakly exogenous variables in the model. The behavior of money in Georgia between 1996 and 2002 was volatile, with a break in remonetization coinciding with the Russian crisis. The crisis has also led to a change in the exchange rate regime. Given the breaks, the behavior of money and the exchange rate is difficult to model. Conditioning on these two variables is therefore a convenient strategy in modeling inflation, which is of primary interest. Moreover, although foreign currency deposits may reflect transaction demand for money, they are also one of a very few assets available for savings. The link between M3 and inflation may be therefore more complicated than the simple mechanisms outlined in the theoretical part of the paper, leading to the rejection of the weak exogeneity and rendering the use of this aggregate in the inflation modeling problematic.[9]

The equation with imposed restrictions of homogeneity and weak exogeneity of money (measured by M2) and exchange rate (Table 4) is chosen for further analysis. The exchange rate coefficient is higher than that of money, but they are both close to one-half. Real income coefficient is negative, as predicted by equation (3). Less restricted estimates are also recognizable as the price equation (3), with positive coefficients of money and exchange rate and a negative coefficient of output. Recursive estimates of parameters, plotted on Figure 3, show that coefficients are stable over time. Figure 4 plots the cointegrating vector and components of the long-run relationship. The largest deviation from equilibrium appears after the post-Russian-crisis devaluation. Since prices did not fully adjust to the new exchange rate level, the disequilibrium was exhorting an upward pressure on inflation in this period.

[9] The correlation between log changes in M2 and M3 is nevertheless very high (0.88).

Table 4. Coefficients of Cointegrating Vectors β and Corresponding Adjustment Coefficients α

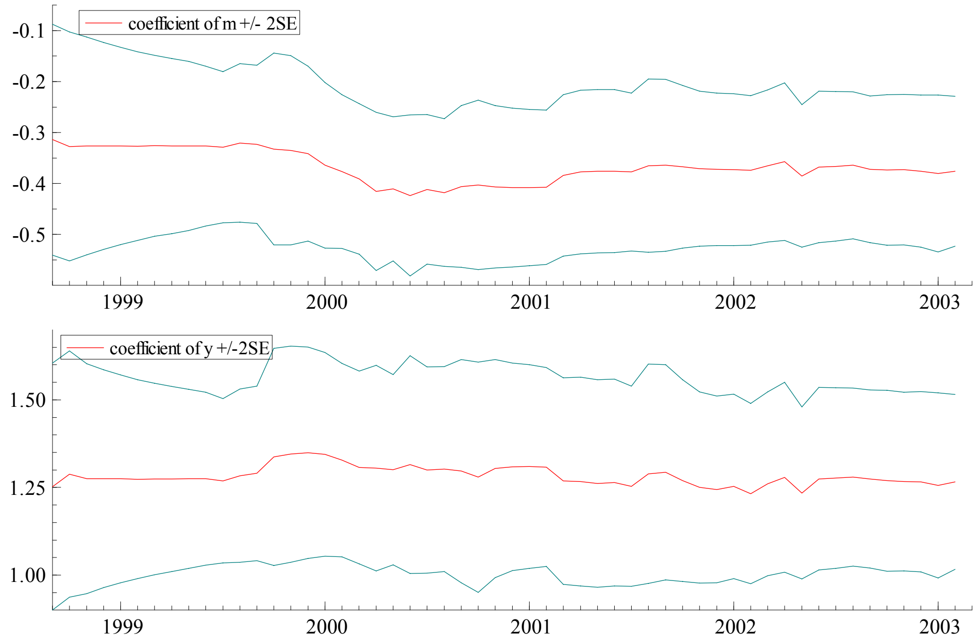
	A	B	C
Restriction	Number of cointegrating vectors = 1		
		Sum of coefficients of money and exchange rate =1	
			Weak exogeneity of money and exchange rate
β:			
p_t	1.0000	1.0000	1.0000
	(0.0000)	(0.0000)	(0.0000)
m_t	-0.2530	-0.4309	-0.3759
	(0.0457)	(0.0650)	(0.0736)
e^{USD}_t	-0.5213	-0.5691	-0.6241
	(0.0314)	(0.0000)	(0.0000)
y_t	0.4418	1.2833	1.2659
	(0.1478)	(0.1101)	(0.1247)
α:			
p_t	-0.1561	-0.0706	-0.0744
	(0.0394)	(0.0190)	(0.0171)
m_t	0.3271	0.1741	
	(0.2015)	(0.0951)	
e^{USD}_t	-0.0451	-0.0487	
	(0.0888)	(0.0418)	

Source: IMF staff estimates.

Notes: The system has a form $\Delta x_t = \sum_{j=1}^{k-1} \Pi_j \Delta x_{t-j} + \alpha\beta' x_{t-1} + \gamma D_t + \varepsilon_t$, where x_t is a vector of endogenous variables and D_t is a vector of exogenous variables. The rank of the αβ' matrix determines the number of cointegrating vectors. The matrix can be decomposed to the matrix of adjustment coefficients α and the matrix of long-run coefficients β. Standard errors reported in parentheses.

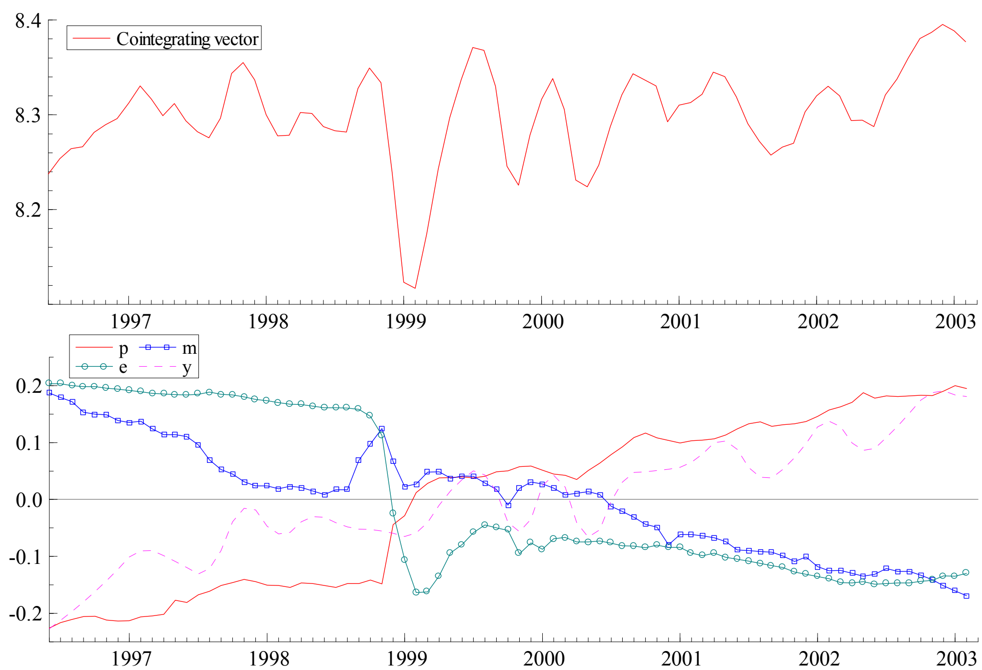
Since the weak exogeneity of the exchange rate and money is not rejected, the next section estimates the error-correction model for inflation conditioning on these two variables.. In order to check for the robustness of this specification, the model is also estimated by instrumental variables method, using past changes in money and exchange rate as instruments.

Figure 3. Recursive Estimates of Long-Run Coefficients of the Price Equation



Source: IMF staff estimates.

Figure 4. Cointegrating Vector and Components of the Long-Run Relations



Source: IMF staff estimates.

D. Error-Correction Model for Inflation

The "general-to-specific" methodology is followed in searching for the final form of the short-run dynamic inflation equation. The specification search begins from estimation of a relatively unrestricted model. The unrestricted inflation equation includes five lags of inflation; five lagged and current values of changes in the log of money and in the log of the exchange rate; the lagged error-correction term from the long-run price equation; changes in oil prices and in relative prices of fruits and vegetables; and the dummy variables discussed above. The search is guided by information criteria and the imposed restrictions are tested against unrestricted alternatives.[10]

Restrictions imposed on the general specification leading to the final equation reported in Table 5 cannot be statistically rejected and improve information criteria. Figure 5 shows actual and fitted values, together with residuals. The equation shows that inflation is strongly affected by exchange rate changes and that the pass-through is fast.[11] Changes in money also have a significant impact on inflation, but this effect takes longer to work its way through the economy than exchange rate changes. The adjustment of prices is also affected by the error-correction term, which is highly significant. This suggests that the price level adjusts to its long-run equilibrium, which is a function of the levels of money, exchange rate and output. Lagged inflation terms do not appear in the final specification of the short-run dynamics, indicating that—conditioning on the behavior of exchange rate, money, and relative prices—inflation persistence is very low. Supply shocks originating in agriculture have a high and significant short-term impact on inflation. Changes in oil import prices have a smaller, but also significant impact.

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[10] F-tests have been used to test the restrictions. Akaike, Schwarz, Hannan-Quinn, and the Final Prediction Error criteria have been used for judging adequacy of the reductions.

[11] The same conclusion is reached by Gigineishvili (2002), who estimates a similar inflation model using different assumptions about equilibrium in the goods market and different econometric techniques.

Table 5. Parsimonious Error-Correction Equations for Inflation and Money Demand

$$\Delta p_t = \underset{(0.1078)}{0.4633} + \underset{(0.0274)}{0.0935}\,\Delta e^{USD}_t + \underset{(0.0253)}{0.0973}\,\tfrac{1}{3}(\Delta m_t + \Delta m_{t-1} + \Delta m_{t-2}) + \underset{(0.0137)}{0.0589}\,ECM_{t-1}$$

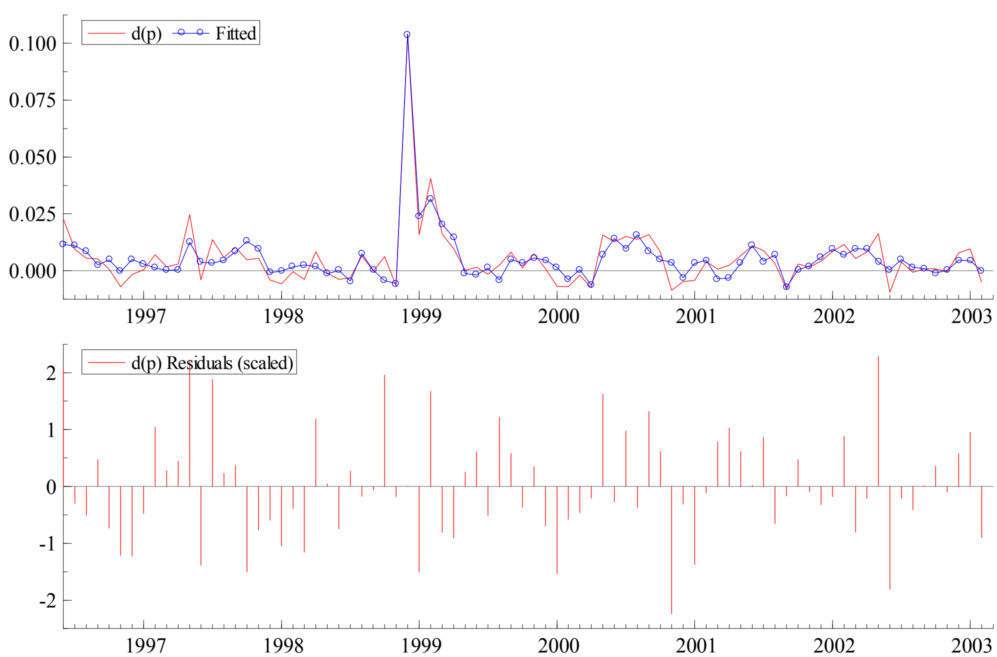
$$+ \underset{(0.0225)}{0.1322}\,\Delta(p_t^{food} - p_t) + \underset{(0.0076)}{0.0287}\,\Delta p_t^{oil} + \underset{(0.0081)}{0.0872}\,D1298$$

$R^2 = 0.8583$	Sample: 1996.6 – 2003.2
Equation standard error: 0.0054	Number of observations: 81
DW = 2.18	

Source: IMF staff estimates.

Notes: Δ indicates first difference. D0998 is one for September 1998, zero otherwise, and D1298 is one for December 1998, zero otherwise. Standard errors reported in parentheses.

Figure 5. Δp: Actual Values (SA), Fitted Values, and Residuals from the Error-Correction Model



Source: IMF staff estimates.

The final inflation equation easily passes all specification tests (Table 6). One-step ahead residuals are within a 2 standard deviations band, indicating that the estimated parameters are stable (Figure 6). One-step ahead and break-point Chow tests do not reject stability of the parameters at 1 percent level (Figure 6). Since the behavior of inflation is visibly different in the period immediately preceding the exchange rate devaluation of December 1998 than in the rest of the sample, the model is re-estimated on the shorter sample from June 1999 to February 2003 as a further check for stability of the coefficients (column B in Table 7). The results are remarkably close to the full sample estimates.[12]

The assumption that conditioning on contemporaneous changes in exchange rate and money is valid is checked by estimating the equation by the instrumental variables (IV) method. The results of IV estimation, using lagged changes of exchange rate and lagged moving average of money changes as instruments, are reported in column C of Table 7. The estimates are close to the OLS results, although coefficient of the moving average of changes in money is lower than the OLS counterpart.

Table 6. Diagnostic Statistics for the Single-Equation Inflation Model

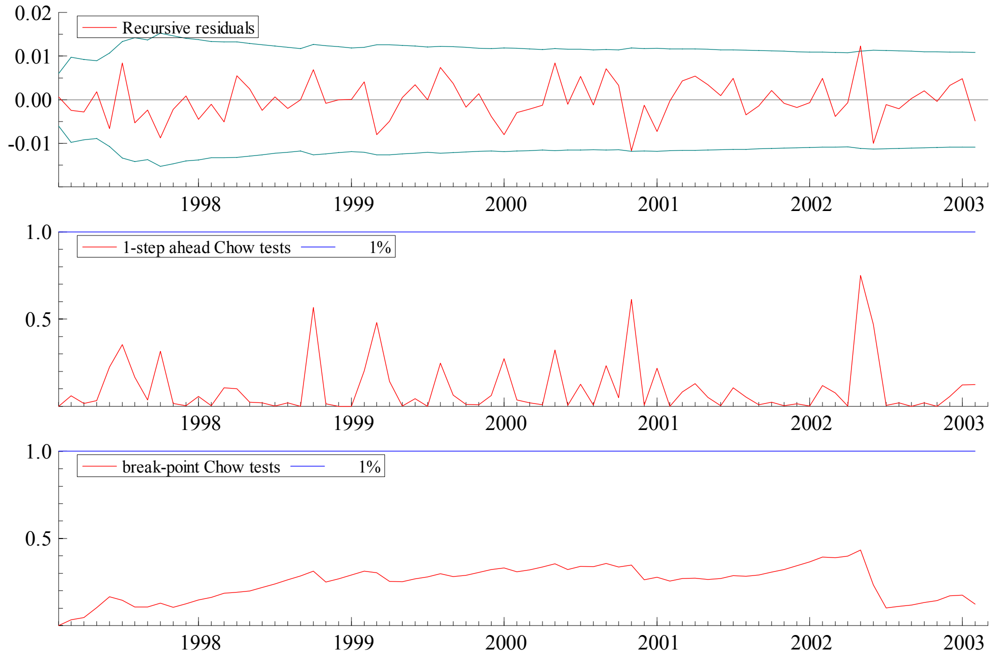
AR 1-5 test:	F(5,69)	=	1.5659 [0.1813]
ARCH 1-5 test:	F(5,64)	=	0.17575 [0.9707]
Normality test:	$\chi 2$ (2)	=	1.6839 [0.4309]
hetero test:	F(11,62)	=	0.77122 [0.6668]
hetero-X test:	F(21,52)	=	0.57618 [0.9165]
RESET test:	F(1,73)	=	0.93119 [0.3377]

Source: IMF staff estimates.

Notes: *AR 1-n* tests for autocorrelation up to *n*th lag, performed through an auxiliary regression of residuals on original variables and lagged residuals. *Normality test* has a null hypothesis that distribution of residuals has skewness and kurtosis corresponding to the normal distribution. *ARCH 1-n* tests for autoregressive conditional heteroscedasticity up to *n*th lag in the residuals through auxiliary regression of squared residuals on a constant and lagged squared residuals. See Hendry and Doornik (2001) for a description of the tests. Probabilities are reported in parentheses and * and ** denote significance at the 5 percent and 1 percent level, respectively.

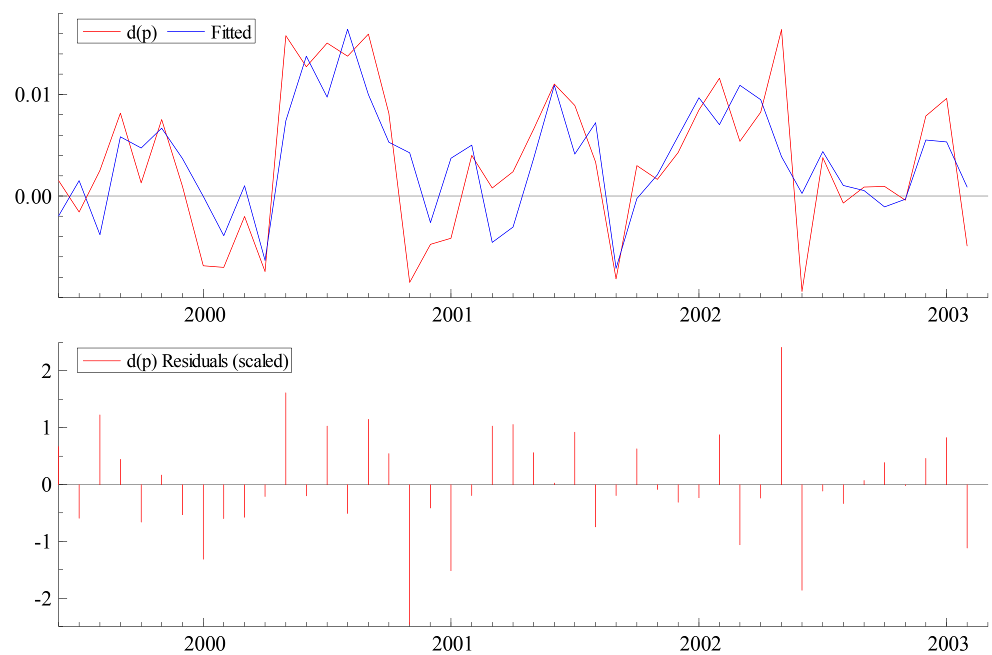
[12] Standard errors of some coefficients are higher, but this is not surprising, given that the new estimates are based on a shorter and therefore less informative sample.

Figure 6. Δp: Recursive Residuals, 1-Step-Ahead Chow Tests, and Break-Point Chow Tests



Source: IMF staff estimates.

Figure 7. Δp: Actual Values (SA), Fitted Values, and Residuals from the Error-Correction Model



Source: IMF staff estimates.

Table 7. Robustness Check for the Single-Equation Inflation Model

	Dependent variable: Δp_t		
	A	B	C
Estimation method:	*OLS*	*OLS*	*IV*
Sample:	*96.6 – 03.02*	*99.6 – 03.02*	*96.6 – 03.02*
Constant	0.4633	0.4569	0.5024
	(0.0935)	(0.1785)	(0.1123)
Δe^{USD}_t	0.0935	0.0991	0.0685
	(0.0274)	(0.0558)	(0.0410)
$1/3\ (\Delta m_t+\Delta m_{t-1}+\Delta m_{t-2})$	0.0973	0.1352	0.0632
	(0.0253)	(0.0626)	(0.0358)
ECM_{t-1}	-0.0589	-0.0581	-0.0638
	(0.0137)	(0.0229)	(0.0143)
$\Delta(p_t^{food} - p_t)$	0.1322	0.1256	0.1324
	(0.0225)	(0.0293)	(0.0232)
Δp_t^{oil}	0.0287	0.0325	0.0271
	(0.0076)	(0.0095)	(0.0079)
D1298	0.0872		0.0922
	(0.0081)		(0.0105)

Source: IMF staff estimates.

Notes: Standard errors reported in parentheses.

IV. Conclusions

The econometric results show that it is feasible to estimate robust price and inflation equations for Georgia. The long-run price equation expresses prices as a function of money, the exchange rate, and real income, and may be interpreted as portraying equilibrium in the goods market. Short-run dynamics of inflation are strongly affected by current exchange rate changes, money growth, and changes in relative prices of foodstuffs and in oil prices. The estimated long- and short-run relationships are stable and may be useful as a tool for policy formulation and evaluation. Inflation in Georgia exhibits very low persistence, possibly owing in part to the use of relatively short-term nominal wage contracts (a legacy of the hyperinflationary period), which may prevent inflation from becoming entrenched after a shock.

The results suggest that the NBG faces serious challenges when conducting monetary policy. Public memory of hyperinflation is still fresh, and any external or internal shock quickly exerts strong pressure on the exchange rate. Because its stock of foreign exchange reserves remains small, the NBG has no scope for leaning against downward pressure on the lari, especially when budget-financing needs complicate monetary tightening. Yet even when faced with these challenges, the NBG has enjoyed substantial success in keeping inflation low and relatively stable. Looking ahead, further accumulation of foreign reserves and development of indirect monetary control instruments, which would be facilitated by a deeper treasury bill market, would increase the capacity of the NBG to respond to shocks.

I. Tests for Stationarity

Table A-1. Unit Root Augmented Dickey-Fuller Test Statistics, January 1996-February 2003

	Level		First Difference	
	Lag	Test statistic	Lag	Test statistic
	Seasonally Adjusted Series			
p	2	-2.951	1	-3.873**
m	1	-3.180	1	-6.250**
e^{USD}	3	-1.628	2	-5.172**
	Unadjusted Series			
p	2	-2.732	4	-4.344**
m	1	-3.181	1	-6.596**
e^{USD}	3	-1.750	2	-4.854**

Source: IMF staff estimates.

Notes: The null hypothesis is that a series contains a unit root against a stationary alternative. For each variable the augmented Dickey-Fuller test statistic and the number of lags used in the test are reported. The number of lags was chosen based on F-tests for a joint significance of lags and Akaike information criterion, starting from six lags for each equation. Equations for levels of unadjusted series are estimated with a constant, seasonals and a linear trend. Equations for levels of seasonally adjusted series are estimated with a constant and a linear trend. Since first differences do not appear to be trended, the trend is not included in estimated equations for first differences of the series. Inclusion of trend into these equations does not change the results. * and ** denote significance at the 5 percent and 1 percent level, respectively.

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