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## Exchange Rate, Money, And Wages: What Is Driving Prices In Armenia?

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## IMF Working Paper

Middle East and Central Asia Department

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#### Abstract

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This paper is the first attempt to look at inflation dynamics and monetary transmission mechanisms in Armenia in the context of a full information model containing three interrelated markets: foreign exchange, money, and labor. Using the vector error correction model (VECM) approach, we find that the exchange rate pass-through to prices is very strong relative to credit, wage, and interest rate channels. The analysis suggests a relatively fast adjustment of prices to long-run disequilibria in the exchange rate market, albeit with initial overshooting of the price level. In addition, we find no evidence of prices responding to changes in money and wages in a statistically significant manner.

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## I. INTRODUCTION

During the last decade, monetary policy implementation in transition economies (including Armenia) became an important area of research for economists. Despite a wide array of tools available for economic and, specifically, monetary policymakers in developed and emerging markets, the transition process has shown a number of peculiarities not readily solvable based on the experience of developed economies. At the beginning of transition, a combination of sizable monetary overhang, falling tax base, and rapidly deteriorating external accounts proved challenging in conjunction with building institutional and legal foundations for properly functioning market economies.

Armenia offers an interesting case study. The economy experienced one of the most dramatic output collapses among transition countries in the early 1990s. This was accompanied by the hyperinflation of 1993-94 and a blockade by Turkey and Azerbaijan, which led to heavy reliance on the transit route through Georgia and, subsequently, large trade deficits. The pattern changed dramatically when the economy began recording strong growth, low inflation, and a relatively stable exchange rate. Macroeconomic policies implemented since then have allowed Armenia to mitigate the impact of the Russian crisis (1998) and other shocks of lesser magnitude. Authorities created the basic legal framework for the financial sector and liberalized the current and capital accounts. After a decade of reforms, however, Armenia still experiences a myriad of problems that include small and unsophisticated financial markets, weak fiscal performance, and vulnerable current account. On the credit side, the banking system remains small and faces significant challenges related to an underdeveloped business environment, absence of proper collateral-related enforcement mechanisms, and inefficient bankruptcy procedures, which manifest themselves in high lending margins and little intermediation.<sup>2</sup> Insufficient depth of monetary aggregates is further exacerbated by the virtual absence of non-bank financial institutions.

Some of these factors that prevailed in the early years of transition significantly hampered the efficiency of monetary policy. The lack of policy instruments was accompanied by high dollarization (see Figure 1), which narrowed the scope of the monetary transmission channels and the significance of their impact. Despite certain improvements in these areas—and the fact that the officially announced exchange rate regime is a free float—interventions by the Central Bank of Armenia (CBA) in the foreign exchange market has remained a major policy tool. The control over price movements remains one of the major challenges for the CBA, and better understanding of monetary transmission channels and interrelationships between key indicators would likely improve policy efficiency.

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<sup>2</sup> See Grigorian (2003) for an overview of problems facing the sector. The results of factor analysis of the interest rate presented in Poghosyan and Khachatryan (2001) suggest that a large portion of the interest rate spread is due to a high level of nonperforming loans, followed by excessive overheads.

Nevertheless, Armenia is one of a few transition economies of Central and Eastern Europe with a solid price stability record since the mid-1990s. By 1995, the CBA managed to bring inflation down to double-digits from about 5,000 percent in 1994, and the economy has performed in a low single-digit inflation environment since 1998. This is a significant achievement, given that only after the collapse of the Soviet Union in 1991, was Armenia able to establish a central bank and introduce a national currency (the dram), which set the stage for its own independent (initially, only from the policies in the ruble zone) monetary policy.

This paper intends to take stock of monetary policy and resulting price developments in Armenia. It builds a three-market, simple macroeconomic model of Armenia and analyzes the determinants of inflation by using cointegration and a vector error correction model (VECM). Although the approach used here is a simple one and the quality of data leaves much to be desired, the model offers a reasonably good approximation of money, price, and wage dynamics in post-stabilization Armenia, and, therefore, could be used for policy analysis.

The paper is structured in the following way. Section II discusses the developments in the monetary policy since the 1990s and offers a look at the policy challenges facing monetary authorities in Armenia. Section III introduces the model and discusses basic regression results, and Section IV concludes the discussion.

## **II. MONETARY POLICY AND PRICE DEVELOPMENTS IN ARMENIA—A BACKGROUND**

### **A. General Overview**

The progress with monetary policy implementation and the resulting price developments in Armenia can be divided into three stages.<sup>3</sup> The first stage is associated with a macro environment that could be characterized by a sharp decline in domestic production, deteriorating external and fiscal positions (with monetary financing of the budget deficit), and rapid devaluation of newly introduced currency, which together led to the hyperinflation of 1993–94. The newly established Central Bank of Armenia initiated the implementation of monetary policy without having proper rules nor appropriate instruments with which to function. A relative stability of both prices and exchange rate were initially declared the objectives of monetary policy. Given the lack of confidence in local currency and the absence of money market instruments at early stages, the CBA chose an orthodox stabilization policy with the exchange rate as an anchor. At the same time, a strategy was developed for the creation of the legal framework for monetary policy implementation and banking supervision.

The second stage—between 1995 and 2002—was aimed at further maintaining macroeconomic stability, developing financial markets, monetary policy tools and techniques, and eliminating administrative barriers. Here, the CBA was faced with certain choices related to monetary

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<sup>3</sup> An appendix to this paper contains a chronology of key events in the monetary and financial sectors in Armenia.

policy objectives and intermediate targets, sequencing of money market and current/capital account liberalizations. The CBA approached those choices first by clarifying the objective of monetary policy, which defined price stability as the main objective and reduced the emphasis on the exchange rate control. Then it developed new institutional tools and mechanisms for the conduct of monetary policy and the support of its credibility. This also included the development of market instruments in foreign exchange and money markets to be used for the management of the monetary base (the operational target) and broad money (the intermediate target). Consistent with its new approach of reducing the emphasis on exchange rate stability, and in an attempt to improve the quality of signals received from domestic markets, the authorities liberalized capital account transactions and removed all administrative restrictions in the credit market.

After the implementation of these reforms, the CBA concentrated on research and development of effective monetary transmission mechanisms to improve its grasp on aggregate price fluctuations.<sup>4</sup> This was closely related with the choice of the monetary regime. Here, too, some changes were on the way: even though since the mid-90s the CBA engaged in monetary targeting (since it believed that the change in monetary aggregates gives the most accurate explanation of changes in price level), during 2003 the CBA initiated research on a possible switch to inflation targeting framework. This perhaps signaled the beginning of a third, and advanced stage of monetary policy implementation in Armenia. We discuss the challenges of this stage below.

## **B. Monetary Transmission Channels**

In general, monetary and exchange rates policies affect prices and economic activity through credit, interest rates, and exchange rate channels. Availability of credit boosts nominal aggregate demand by changing volume of liquidity available to banks, which the latter then on-lend. Lower interest rates mean cheaper and, therefore, more credit. Finally, exchange rate depreciation (appreciation) leads to higher (lower) domestic prices due to higher (lower) prices of importables. However, to the extent that prices are slow to adjust in the short-run, monetary policy interventions can have impact on real economic activity, leading to Phillips curve-type

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<sup>4</sup> Throughout recent years, the CBA has made a number of analytical and practical attempts to develop more sophisticated policy channels. As more data become available with the years, the CBA has tried to refine its estimates of the transmission mechanism and the impact of monetary policy on aggregate demand and prices. Since 1996, the CBA expanded its own financial programming framework, which has significantly improved the quality of estimates. Since 1997, the policy implementation has been widely tested through the practical implications of monetary impulse functions. With signs of development in the secondary market for treasury bills and interbank markets, the CBA started looking into the possibility of estimating monetary policy impact through the use of the Monetary Condition Index (Poghosyan, Mkrtchyan, and Khachatryan, 2001).

trade-offs. In the long-run, agents adjust their expectations of changes in monetary policy, which then leads only to equivalent changes in the price level without any change in real economic activity.<sup>5</sup>

Recent research suggests that the monetary policy transmission mechanisms in transition economies generally, and in Armenia particularly, have peculiar patterns.<sup>6</sup> Thus, the impact of *interest rate* on aggregate demand is generally weak due to the lower elasticity of bank credit with respect to interest rates, higher creditor risk, and dependence on heavy external concessional financing, among other factors. Instead, the impact of underdeveloped financial markets and low financial intermediation are the major obstacles to efficient functioning of the *credit channel*. Finally, regardless of the exchange rate regime, the impact of the *exchange rate* on current, as well as expected price fluctuations, is much stronger than in developed economies.

Although largely in line with these findings, Armenia offers a somewhat more extreme case. The research done at the CBA (see footnote 6) has shown that the impact of the exchange rate on macroeconomic indicators, such as prices, growth, and the trade balance is far stronger than the impact of interest rates, credit, or wage pressures. This peculiarity, we believe, could largely be attributed to the following reasons:

- A narrow credit base, low financial intermediation, and underdeveloped financial and debt markets render the interest rate and credit channels weak (see Figure 1).
- Large inflows of external financing (both in the form of budgetary financing and private flows) reduce the demand for CBA reserves, sustain high dollarization, and affect price formation mechanisms. Since a large portion of these flows is driven by external budgetary (and mostly concessional) financing, they (as well as the liquidity generated as a result) are less sensitive to interest rate fluctuations. This also strengthens the need for CBA's foreign exchange interventions and shifts the asset side of the CBA's holdings towards foreign reserves (and away from domestic assets), further limiting the scope for credit- and open market-type operations (see Figure 1).<sup>7</sup>

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<sup>5</sup> This “neutrality” feature of money holds with the exception of cases where excessive money growth can lead to external imbalances (such as capital flights and sharp deteriorations in the current account) and, therefore, have redistributive effects on domestic agents.

<sup>6</sup> For general transition cases see, for example, Calvo and Reinhart (2000), Kuijs (2002), and Billmeier and Bonato (2002). For studies on Armenia, see Vardanyan, Mkrtchyan, and Khachatryan (1998), Poghosyan, Mkrtchyan, and Khachatryan (2001), and Poghosyan and Khachatryan (2001).

<sup>7</sup> To the extent that prices on dram-denominated assets yield higher returns than foreign currency-denominated holdings of the CBA, the latter bears a cost of having to “sterilize” the  
(continued...)

- Dollarization limits the scope for monetary policy implementation and effectiveness (Figure 1). It became pronounced first because of the large stock of dollars held by residents during early transition and subsequent hyperinflation, and was later complemented by inflows of external transfers and workers' remittances.
- A sizable share of imported goods in the domestic consumer market still ensures that the exchange rate pass-through to remain strong.
- The impact of monopolistic and administered prices is becoming increasingly important.

As a result of these factors, the price developments in Armenia largely mimicked the exchange rate dynamics. Since 1995, following the exchange rate stabilization, the prices have leveled off, aided also by restrictive aggregate demand policies. This reduction of inflation was one of the key outcomes of the macroeconomic stabilization package and is largely considered one of the successes of economic policymaking in Armenia. Here, in addition to a tight monetary policy stance, other factors affecting price developments were the administered and foreign prices as well as wages. Overall, price stability provided a major boost to policy credibility in Armenia and had an impact on virtually all key macroeconomic variables, including the levels of investment and financial intermediation.

### **C. Toward a More Advanced Monetary Policy Framework**

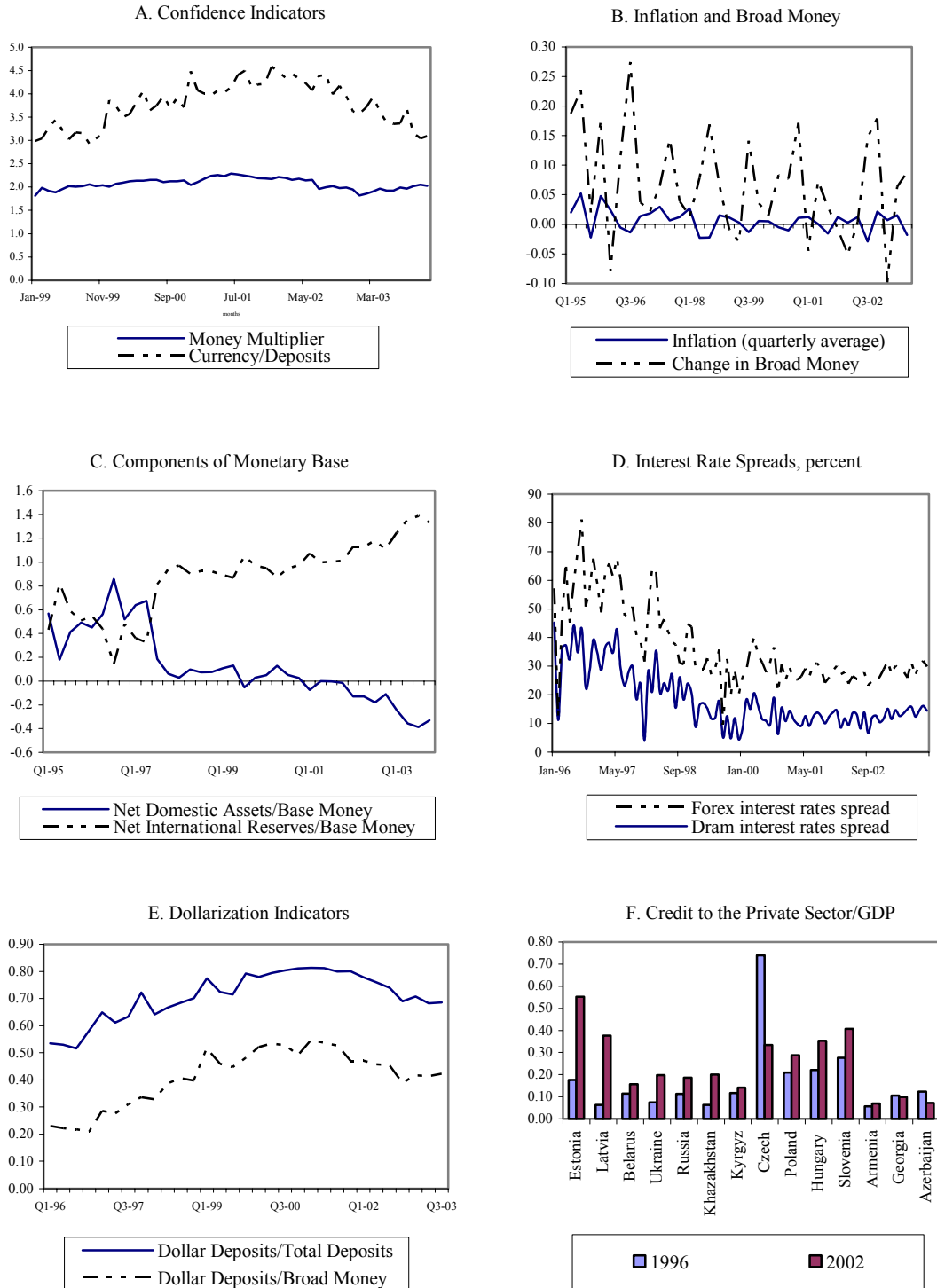
To develop more responsive credit and interest rate channels, in addition to implementing the first-stage reforms described above, better coordination between monetary and fiscal policies in the short and long run is required. The key issue in this regard was the discontinuation of the CBA's direct financing of the budget. This took place in 1998 when the CBA and the government agreed on the securitization of the government debt to the CBA, after which (since 1999) the CBA discontinued its practice of direct lending to the government. Although the issue was formally resolved, the quality of the solution still needed significant improvements. The initial idea was to develop a treasury bill market that would, in the long run, become a reliable domestic source of fiscal financing. Although the short-run costs of domestic financing were viewed as potentially high, policy makers realized that the long-run benefits of building a liquid treasury bill market could outweigh the costs. They saw that this would also assist the efficient functioning of money markets and instruments and create a reasonable yield curve through the formation of market expectations. Finally, this would provide the CBA with extra leverage in terms of the interest rate channel of monetary transmission. With this in mind, from the beginning of 1999, the CBA and the government undertook the securitization of government external financing, linking the issuance of treasury bills to disbursement of external financing. This allowed the CBA to smooth the impact of budget expenditures on banks and other

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capital inflows described above. These costs can be substantial given the interest rate differential between the dram- and foreign currency-denominated assets.



Figure 1. Armenia: Money and Credit Indicators, 1995-2003



Source: Central Bank of Armenia; International Financial Statistics, IMF; and authors' calculations.

segments of financial markets, and facilitated an understanding of the response of interest rates to movements in the banks' liquidity.<sup>8</sup>

Simultaneously, the CBA instituted new roles for the monetary policy instruments, in which the deposit and Lombard facilities would be in a stand-by mode, while the repurchase (i.e., repo) transactions would be the main policy tool signaling policy changes. It also reserved the use of open market operations for long-run liquidity adjustment purposes. These changes, together with macroeconomic stability and improved confidence, have resulted in a significant decline of interest rates since the end of 1999; the annualized treasury bill yields declined from an average of 50 percent to around 20 percent in 2000 alone and, subsequently, to approximately 12 percent in 2003. However, the government continued to rely heavily on external concessional financing, mainly in the form of low-rate credits and grants, and even reduced the issuance of treasury bills to ease the pressure on interest rates and reduce interest payments. The market remained narrow and non-liquid. As a result, the CBA lost a significant portion of its treasury bills portfolio, which, as mentioned above, has narrowed the scope of use of money market instruments and left foreign exchange sales as the main tool for CBA interventions.

### **III. THE MODEL**

#### **A. Overall Setup**

The modeling approach used in the paper to estimate the relative strength of the monetary transmission channels described above assumes that inflation could be caused by: (i) excessive money growth not accommodated by growth in money demand, (ii) imported inflation (i.e., inflation in trading partner countries), and (iii) wage pressures in excess of labor productivity increases. The paper investigates the presence and relative strengths of these channels by building a three-market macro model of Armenia. This allows one to condition the dynamics in variables of interest by a larger set of economic indicators and, therefore, offer a more complete picture of linkages between markets and economic indicators. We specify and test the full system by imposing certain identifying restrictions suggested by the economic theory on the Johansen procedure (Johansen, 1992). These restrictions are then tested to our satisfaction, leading to parsimonious and explainable individual long-run equations. The paper presents the results of a cointegration analysis of all three equations and discusses the consistency of estimated coefficients with those suggested by the theory. The specifics of short- and long-term structures of key markets are discussed, along with potential policy implications.

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<sup>8</sup> This exercise was accompanied by the introduction of the monetary base corridor, which was aimed at smoothing the fluctuations in the operational target and increasing the efficiency of its impact on price management. Should the monetary base leave the corridor in either direction, the CBA would intervene in money and foreign exchange markets to bring the monetary base back into the band.

We specify a variable autoregressive model followed by the variables in the system as follows:

$$Z_t = \sum_{i=1}^k \Gamma_i Z_{t-i} + \Phi D + c + \varepsilon_t \quad (1)$$

where  $Z$  is the vector of all variables in the model,  $D$  is the matrix of seasonal dummy variables,  $\Gamma$  and  $\Phi$  are matrixes of coefficients, and  $\varepsilon$  is the error term. This equation could be transformed into a reduced error correction model by taking the first differences in the following way:

$$\Delta Z_t = \sum_{i=1}^{k-1} \Omega_i \Delta Z_{t-i} + \Theta Z_{t-1} + \Phi D + c + \omega_t \quad (2)$$

where the relationship between coefficient matrixes is:

$$\Omega_i = - \sum_{j=i+1}^k \Gamma_j \quad \text{and} \quad \Theta = \sum_{i=1}^k \Gamma_i - I$$

Note that in the differenced specification (i.e., Equation 2) the matrix  $Z_{t-1}$  appears in levels and plays the role of error correction to be dealt with below. Estimates of this equation would produce short-run relationships in all three markets discussed above, with the estimates of coefficients on error correction terms providing inferences about the adjustment of the variables in question to long-run disequilibria in the markets.

## B. Data Properties

Before turning to the specifics of the estimation, let us discuss the statistical properties of the data series.<sup>9</sup> The data used for the analysis covers the period from January 1996 to June 2003, and covers the entire post-stabilization period in Armenia. It is publicly available through the CBA and/or the International Monetary Fund's International Financial Statistics database. The following notation is used throughout the paper:

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<sup>9</sup> It is important to note at this stage the data limitations in Armenian (and more generally, in transition economies') context. These are largely due to less-than-perfect methodologies of data collection and aggregation, and structural changes that took place within the decade of transition. Even though in recent years the quality of monetary statistics in Armenia has improved dramatically, there remain considerable problems in the external and real sector coverage. Although Armenia recently joined the IMF's Special Data Dissemination Standard (SDDS), the timeliness, internal consistency, width of coverage, and periodicity of data requires additional efforts to reach developed country data quality standards.

$e_t$  is (the logarithm of) nominal exchange rate expressed in drams per U.S. dollar,  
 $p_t$  is (the logarithm of) domestic price level measured by the consumer price index,  
 $p_t^*$  is (the logarithm of) foreign (U.S.) price level,  
 $m_t$  is (the logarithm of) narrow money, defined as currency plus demand deposits,  
 $i_t$  is the average nominal rate on time deposits measured in fractions,  
 $tot_t$  is the terms of trade index,<sup>10</sup>  
 $y_t$  is (the logarithm of) real GDP, measured in 1995 drams,  
 $ydev_t$  is the real GDP's deviation from its potential level,<sup>11</sup> and  
 $w_t$  is (the logarithm of) average economy-wide nominal wage.

The results of augmented Dickey-Fuller unit root (stationarity) tests outlined in Table 1 suggest that—with the exception of the terms-of-trade indicator—all variables described above are integrated of order one, i.e., I(1).

Table 1. Stationarity Tests

	Levels		First Differences	
	Lags included	Augm. DF test P-values	Lags included	Augm. DF test P-values
$e$	0	0.45	0	0.00
$p$	1	0.13	0	0.00
$m$	0	0.05	0	0.00
$p^*$	2	0.62	1	0.00
$tot$	1	0.04	1	0.00
$i$	4	0.76	3	0.00
$y$	11	0.99	2	0.00
$ydev$ 1/	9	0.85	11	0.01

1/ The augmented DF test for this series includes no intercept or deterministic trend.

<sup>10</sup> The series for terms of trade includes actual data compiled by the CBA for January 1996 to December 1999 (series is discontinued) and an inverted price-of-oil index thereafter. Using the price of oil as a proxy for the inverse of the terms of trade reflects Armenia's heavy reliance on oil imports. The results do not change significantly when the inverse of the oil price index is used to proxy terms of trade for the entire sample period, i.e., January 1996-June 2003.

<sup>11</sup> In the absence of reliable measures of labor and capital stock in Armenia, the paper uses the deviation from output trend (calculated by a Hodrick-Prescott filter) as a proxy for deviations from the potential level and/or (short-run) productivity movements.

### C. The Analysis of Long-Run Structure

This section investigates the long-run relationships between the data. It looks for the presence of cointegrating relationships between economic variables in certain markets, any deviations from which will be interpreted as deviations from the steady-state with a potential of influencing the short-run dynamics. For instance, the deviations from the long-run steady-state relationship in the foreign exchange (e.g., an overvalued real exchange rate) could result in adjustments in the contemporaneous price level by putting downward pressure to adjust. An important caveat is worth noting, however: relationships established in this section would not necessarily imply causality, but instead suggest stable relationships that hold in the long run.

#### Foreign Exchange Market

The long-run equilibrium in the foreign exchange market can be presented as:

$$e_t = p_t - p_t^* - tot_t + ydev_t \quad (3)$$

This equation states that the real exchange rate in the long run equals 1, if adjusted for the terms-of-trade and productivity shocks. The presence of terms of trade in this equation is consistent with the hypothesis that an improvement in the relative price of exports and imports in the long run would result in an appreciation of the nominal exchange rate, if it were to keep the real exchange rate from depreciating. Regarding the relative improvements in productivity (i.e., relative to trading partners in the tradable sector), these are likely to drive the price of tradable goods up and, therefore, lead to real exchange rate appreciation in the short-run (*a la* Balassa-Samuelson), to be offset by nominal depreciation in the long-run.

#### Money Market

In a simplified way, the long-run equilibrium in the money market can be expressed as follows:

$$m_t = p_t + y_t - i_t \quad (4)$$

This equation states that the equilibrium on the money market requires the supply to be equal to the demand for money. The latter assumes that nominal money balances held by the agents are a function of the price level, income, and the opportunity cost of holding money (i.e., the nominal interest rate).<sup>12</sup>

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<sup>12</sup> Here, because the own interest rate of money is virtually zero (since demand deposits do not generally earn any interest in Armenia), the net opportunity cost of holding cash would be equal to the yield of the alternative assets, that is, time deposits. Using the treasury bill rate as a measure of yield for alternative assets leads to qualitatively similar results. Due to the limited access of the general population to treasury bill market, time deposits are viewed as a better alternative to holding money than treasury bills.

## Labor Market

Finally, the long-run equilibrium in the labor market could be presented as:

$$w_t = p_t + ydev_t \quad (5)$$

This simple representation of wage setting behavior states that the nominal wage is a function of the price level and a measure of excess demand,  $ydev_t$ . The second term in Equation 5 can also be interpreted as productivity shocks, in which case the equation can be read as follows: any wage pressures beyond the underlying productivity gains will be passed through by firms in the form of higher prices. However, the employee bargaining power and, subsequently, wage-setting behavior is likely to be influenced by high unemployment in Armenia,<sup>13</sup> *ceteris paribus* suggesting a weaker causality from wages to prices. Moreover, since most transition countries have at some point undergone certain type of wage controls (along with either exchange rate or money based stabilization to curb inflation in the early stages of transition see, for instance, Sahay and Vegh, 1995), it is likely that elements of passive wage-setting (i.e., wages following prices, and not the other way around) prevail even in the post-stabilization period. Yet, given the size of the government in Armenia, large public sector wage increases may have an impact on price dynamics.

Some discussion on the specifics of the estimation process and decision making that went into it is warranted here. It should be noted that in conducting our analysis of error correction modeling we addressed two pertinent issues. The first issue had to do with the number of lags to be included into the model. This was resolved in favor of the shortest lag length that resulted in autocorrelation-free residuals, and was achieved with only two lags of all variables. The second issue related to the choice of deterministic components (intercept, trend, and dummies) for which we ran a number of Johansen tests. Constants and trends were found to produce meaningful cointegrating relationships, and therefore were included in the analysis. In addition, since the time series used in the analysis were not deseasonalized, we included 11 monthly dummy variables. Finally, to account for a structural break in the data, we included a dummy variable to account for the bank liquidation process that began in Armenia in late 2000. The dummy variable takes the value of 0 before and of 1 after November 2000.<sup>14</sup>

The results of the cointegration analysis of the full model are reported in Table 2. Columns (1)-(3) contain regression outcome based on unrestricted vectors, while columns (4)-(6) contain output with simultaneous constraints imposed on a number of coefficients (see below).

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<sup>13</sup> Unofficial estimates place the unemployment rate in Armenia well in excess of 20 percent of the labor force.

<sup>14</sup> As this dummy variable proved insignificant, it is dropped from subsequent discussions.

Table 2. Cointegration Analysis of the Full Model

	<u>Unrestricted cointegrating vectors</u>			<u>Restricted cointegrating vectors</u>		
	Foreign Exch. Market	Money Market	Labor Market	Foreign Exch. Market	Money Market	Labor Market
	(1)	(2)	(3)	(4)	(5)	(6)
<i>e</i>	1.00	0.00	0.00	1.00	0.00	0.00
<i>m</i>	0.00	1.00	0.00	0.00	1.00	0.00
<i>w</i>	0.00	0.00	1.00	0.00	0.00	1.00
<i>p</i>	-1.13 (0.108)	-1.07 (0.165)	-5.01 (1.021)	-1.00	-1.00	-5.01 (0.832)
<i>p</i> *	1.28 (0.908)	0.00	0.00	1.00	0.00	0.00
<i>tot</i>	-0.06 (0.047)	0.00	0.00	-0.068 (0.045)	0.00	0.00
<i>y</i>	0.00	-2.73 (0.261)	0.00	0.00	-2.69 (0.261)	0.00
<i>ydev</i>	-0.0002 (0.0005)	0.00	-0.03 (0.005)	0.001 (0.0004)	0.00	-0.03 (0.004)
<i>i</i>	0.00	2.03 (0.195)	0.00	0.00	2.01 (0.193)	0.00
<i>trend</i>	-0.004 (0.002)	0.01 (0.001)	0.004 (0.004)	-0.004 (0.0003)	0.011 (0.0014)	0.004 (0.004)
<i>C</i>	-6.37	26.53	14.86	-5.70	25.64	14.85
LR test for binding restrictions (rank = 3):				$\chi^2_{12}=39.14$	<i>p</i> -value = 0.0001	

Standard errors in parentheses.

Since the coefficients on the domestic and foreign price levels in the foreign exchange equation are as predicted by the theory and suggest near homogeneity in domestic and foreign prices, we simplified the equation by restricting the coefficients on  $p_t$  and  $p_t^*$  to -1 and 1. These restrictions, along the one imposed on the money demand equation below, are tested jointly and were accepted. The resulting long-run cointegrating relationship for the exchange rate market can be presented as follows (*t*-statistics are reported in parentheses):

$$e_t - p_t + p_t^* = 5.7 + 0.07 \cdot tot_t - 0.001 \cdot ydev_t + 0.004 \cdot trend \quad (6)$$

(1.50)      (-1.51)      (15.2)

The cointegrating vector for the money market suggests homogeneity of narrow money in domestic prices. As earlier, we simplified the equation further by assuming homogeneity in prices and restricting the coefficients on  $p_t$  to 1. The resulting long-run relationship for real money balances can be presented as follows:

$$m_t - p_t = 25.6 + 2.69 \cdot y_t - 2.01 \cdot i_t - 0.01 \cdot trend \quad (7)$$

(10.3)      (-10.4)      (-7.6)

This is a well behaved money demand function, which suggests that the demand for real money balances in the long-run is positively related to the income level and is negatively related to the opportunity cost of holding money (i.e., the interest rate on deposits). The rather high sensitivity of money holdings with respect to income is worth noting in this regard: the coefficient is much greater than the one assumed by pure monetarist (i.e., 1.0) and Baumol-Tobin-type (i.e., 0.5) assumptions. The reason for this could be: (1) the inappropriateness of using GDP as a proxy for household income in Armenia, given the extent of transfers and remittances, and (2) a reflection of cash-in-advance properties present in Armenia and other transition countries. The negative and significant coefficient of the trend also has an intuitive explanation: if interpreted as a proxy for financial innovations, this suggests that the demand for real money balances declines as the financial system becomes more sophisticated (e.g., similar to the effect that the introduction of ATMs had on the demand for money).

Finally, the cointegrating vector for the labor market can be shown as follows:

$$w_t = -14.86 + 5.01 \cdot p_t + 0.03 \cdot ydev_t - 0.004 \cdot trend \quad (8)$$

(6.02)      (7.04)      (-0.92)

Unlike the previous two equations, there is no homogeneity in domestic prices in this equation. Instead, this specification suggests that wages are highly sensitive with respect to movements in prices: a one percent increase in prices leads to a five percent increase in the nominal wage rate. This suggests that the real wage (i.e.,  $w - p$ ) does not hover around the productivity alone but moves with prices. This may be a result of a measurement issue. To see this, assume, for instance, that the measured wage rate is actually that of the nontradable sector—which is typically more volatile than the overall wage rate. If this is the case, the aggregate price fluctuations would be associated with higher volatility of (incorrectly measured) wages, as shown in equation 8. Finally, unlike the foreign exchange and monetary equations, the above equation does not have a statistically significant trend.



### D. The Analysis of the Short-Run Structure

We now move on to estimate the short-run relationships between the variables of interest following Equation 2. As indicated before, the estimates of coefficients on error correction terms would indicate the speed of adjustment in the short run to long-run disequilibria in all three underlying markets. Using the long-run structures obtained in the previous sections (i.e., Equations 6, 7, and 8), the error correction terms could be presented as follows:

$$\begin{aligned} ecm(ppp)_t &= -5.7 + e_t - p_t + p_t^* - 0.07 \cdot tot_t + 0.001 \cdot ydev_t - 0.004 \cdot trend \\ ecm(m)_t &= -25.6 + m_t - p_t - 2.69 \cdot y_t + 2.01 \cdot i_t + 0.01 \cdot trend \\ ecm(w)_t &= 14.86 + w_t - 5.01 \cdot p_t - 0.03 \cdot ydev_t + 0.004 \cdot trend \end{aligned}$$

Figure 2 plots these error correction terms on a single panel chart. They appear to be well behaved. Table 5 below reports the results of the final estimation of short-run equations for prices, nominal exchange rate, and wages (chosen from the full system of equations).<sup>15</sup>

#### Weak Exogeneity Tests

A variable is called weakly exogenous if it does not react to long-run disequilibria in other markets, but may still react to changes in the same variables in the short-run. In a partial (or conditional model), weak exogeneity is important to establish in order to allow one to condition the endogenous variables on the weakly exogenous (and other endogenous) variables, to obtain efficient estimates, and to be able to focus on one (or a few) equation(s) of interest from the full model specification (see Johansen, 1992). The fact that we test a full system allows us to get away without having to test for weak exogeneity. Nevertheless, as we strive to demonstrate the policy relevance of our analysis, we conducted tests for weak exogeneity to make inferences about causality, at least in its weakest form.<sup>16</sup> Technically, testing for weak exogeneity is

<sup>15</sup> After estimating the model, we tested whether the residuals normally distributed. We ran a Jarque-Bera (JB) normality test, which provided the comfort level necessary to proceed with the discussion of the findings. The results of the test are reported below.

Short-Run Eq. of Interest	JB-stat value	p-value
<i>e</i>	3.33	0.188
<i>m</i>	0.18	0.911
<i>w</i>	4.93	0.084
<i>p</i>	0.57	0.753

The residuals in all four equations of interest appear to be normally distributed at 5 percent confidence level. (Note, that the null hypothesis in this case that residuals are normally distributed, so the higher p-value indicates the normality of residuals).

<sup>16</sup> Granger causality, which tests for a specific relationship between variables and their lags, is stronger than weak exogeneity.

equivalent to testing for zero adjustment coefficients on all three error correction terms in the full model.

Table 3. Weak Exogeneity Tests 1/

	<i>Chi-square</i>	<i>Degrees of freedom</i>	<i>p-value</i>
<i>e</i>	14.3	3	0.00
<i>m</i>	6.3	3	0.10
<i>w</i>	9.8	3	0.02
<i>p</i>	41.4	3	0.00
<i>p</i> *	5.5	3	0.14
<i>tot</i>	2.6	3	0.46
<i>y</i>	21.3	3	0.00
<i>ydev</i>	50.0	3	0.00
<i>i</i>	29.1	3	0.00

1/ The null hypothesis is the presence of weak exogeneity.

As expected, both foreign price level and the terms of trade are weakly exogenous to the model. In addition, money appears to be weakly exogenous at a 5 percent confidence level. This suggests that at least in the long run, money is not driven by any variables, such as real GDP, interest rates, or prices, but instead is likely to influence them by itself. This has implications for policy analysis as it suggests that narrow money can be used as a policy instrument in Armenia.

### Estimation Results

Let us now turn to the results of the estimation of short-run specification, which are definitely worth looking into! First of all, the stability of the coefficients (attested to by the recursive coefficient estimates for the price equation plotted on Figure 3) provides the necessary comfort level. In addition, given the quality and frequency of the data, the model provides a reasonable in-sample fit (Figure 4).

Second, it offers evidence of a very strong adjustment in prices as a result of disequilibria in the foreign exchange market: over 18 percent of the deviation is being adjusted in one month. In other words, it takes approximately six months for an impact of an exchange rate shock to work through the system.

Third, the sign of the coefficient on the excess money (i.e.,  $ecm(m)_t$ ) suggests that prices adjust to long-run disequilibria in the money market. However, the magnitude of the coefficient is much smaller than the adjustment coefficient on the  $ecm(ppp)_t$  term and is insignificant.

Fourth, there is no evidence of above-productivity wage pressures being passed on to consumers in the long run: the coefficient on the third error correction term in the first equation is small and highly insignificant. There is also no short-run impact of wages on prices, as hypothesized above.

Fifth, the model demonstrates a strong price inertia: the coefficient on once-lagged change in price equals 0.4 and is highly significant.

Sixth, even though there is only weak evidence of any adjustment in prices to the disequilibria in the money market, in the short run prices appear to be responsive to changes in money: the coefficient on the once-lagged change in money is positive and significant. Furthermore, the magnitude is consistent with the estimates obtained in a similar context by Kuijs (2002) for Slovakia. However, money appears to have no effect on the real exchange rate: the coefficients on money in both price and exchange rate equations have equal magnitudes. This is consistent with the neutrality of money hypothesis, at least when it comes to movements in the trade account.

Seventh, even though the sign of coefficient on lagged exchange rate in the price equation is negative, there might be a very intuitive explanation for this. If prices were to overshoot in response to changes in exchange rate before returning to the level consistent with the new exchange rate, it would produce a negative correlation between short-run exchange rate and price movements (Figure 5).

Finally, the interest rate and the terms of trade have no impact on the short-term dynamics of prices, exchange rate, and wages (coefficients are left out because they are all insignificant).

The above results were also tested for robustness. To gain extra degrees of freedom, we seasonally adjusted the series prior to estimating Equation 2.<sup>17</sup> This had only a marginal impact on estimates and did not change signs or significance pattern of coefficients.

#### IV. CONCLUSIONS

This paper is the first attempt to look at inflation dynamics and monetary transmission mechanisms in Armenia in the context of a full-information model containing three interrelated markets: foreign exchange, money, and labor. This has allowed us to condition the dynamics in variables of interest by a larger set of economic indicators and, therefore, offer a more complete picture of linkages between markets and economic indicators. The estimation proves economically plausible and provides statistically robust coefficients that were discussed in detail in the previous section.

Despite its shortcomings, the model performs reasonably well as demonstrated by out-of-sample predictions in Figure 6. The model reflects the non-monotonic dynamics of the exchange rate and prices that prevailed in the second half of 2003. Relatively poor predictions regarding narrow money may be explained by the latter's weak exogeneity.

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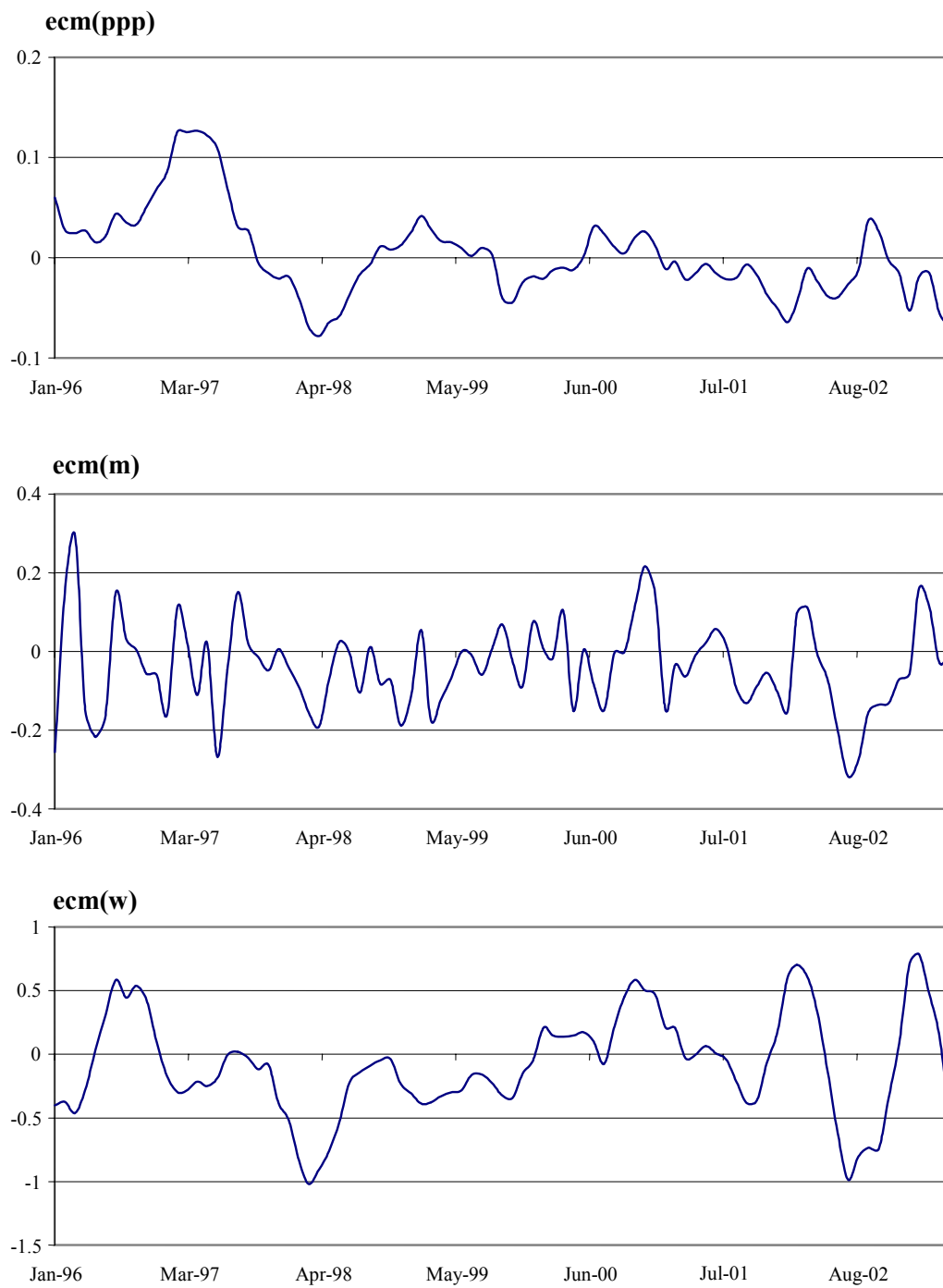
<sup>17</sup> This was suggested by one of the referees. Estimates are available from the authors upon request.

Although the accuracy of estimates and predictions would certainly benefit from further refinements of the model and from improvements in the quality of data, we believe that the model can usefully be applied to forecasting and policy analyses in Armenia. Already the short- and long-run relationships between variables discussed above could shed some light on underlying economics and could be used for policy making purposes. As Hunt and Isard (2003) point out, uncertainty about exchange rate pass-through is likely to be costly in terms of macroeconomic performance, especially if the strength of the pass-through is underestimated (as opposed to overestimated) by the policymakers.

Subsequent research could attempt to employ a different measure of income that would incorporate sizable transfers and remittances taking place between various Diaspora communities and Armenia. In addition, a follow-up paper could attempt to model the elements of high dollarization in Armenia, which, as discussed above, limits the effectiveness of monetary transmission channels. Finally, given Armenia's expanding trade relations, a trade-weighted foreign price index and nominal exchange rate could be more appropriate indexes to use for estimating the dynamics of the foreign exchange market.

As is, however, the results offer some insights into the policy options faced by the CBA. Given a limited ability to sterilize (owing to its small portfolio of domestic money market instruments) a steady inflow of remittances and other foreign capital, the CBA continues to accumulate reserves to avoid nominal appreciation. This, of course, makes the monetary base heavily dependent on these flows and constitutes a de facto preference for exchange rate stability as opposed to stability of monetary aggregates and prices, as declared in the formal policy framework. This dependency will undoubtedly have implications for the intentions to switch to inflation targeting framework for monetary policy implementation. With virtually no pass-through from money to prices and a strong one from the exchange rate to prices, as documented in the paper, the ability of the monetary authorities to target prices and inflation would be severely limited. Given the uncertain nature of capital inflows, the CBA may, therefore, choose—in coordination with the government—to develop and accumulate more money market instruments to mitigate its policy dependence on these flows and enhance its control over the monetary aggregates, and hence the price movements.

Figure 2. The Structure of Error Correction Terms



Source: Authors' calculations.

Table 4. Short-Run Specifications Based on a Full Information Model

Lags	Dependent variables					
	$\Delta p_t$		$\Delta e_t$		$\Delta w_t$	
	1	2	1	2	1	2
$ecm(ppp)$	0.18** (4.26)		0.16** (3.22)		0.06 (0.53)	
$ecm(m)$	0.02 (0.89)		-0.04 (-1.5)		0.07 (1.13)	
$ecm(w)$	0.003 (0.64)		0.009* (1.7)		-0.03** (-2.66)	
$\Delta p$	0.40** (3.36)				0.55* (1.71)	
$\Delta e$		-0.31** (-2.67)		-0.33** (-2.46)		
$\Delta m$	0.06** (2.00)		0.06* (1.69)			
$\Delta w$					-0.26** (-2.52)	-0.20** (-2.04)
$\Delta p^*$				-1.93** (-2.06)		
$\Delta y$		-0.18** (-1.96)		-0.22** (-2.05)		
$\Delta y_{dev}$		0.0006* (1.67)		0.001** (2.26)		-0.002* (-1.81)
$C$					0.16** (2.91)	
<i>Monthly dummies</i>	Yes		Yes		Yes	
<i>R-squared</i>	0.83		0.55		0.93	

Except for the error correction terms, only the coefficients that are statistically significant at a 10 percent confidence level are reported. \* and \*\* indicate significance at 10 and 5 percent, respectively. The number of observation is 89 after adjusting for end points. *t*-statistics in parentheses.

Figure 3. Recursive Estimates of Coefficients in the Price Equation 1/

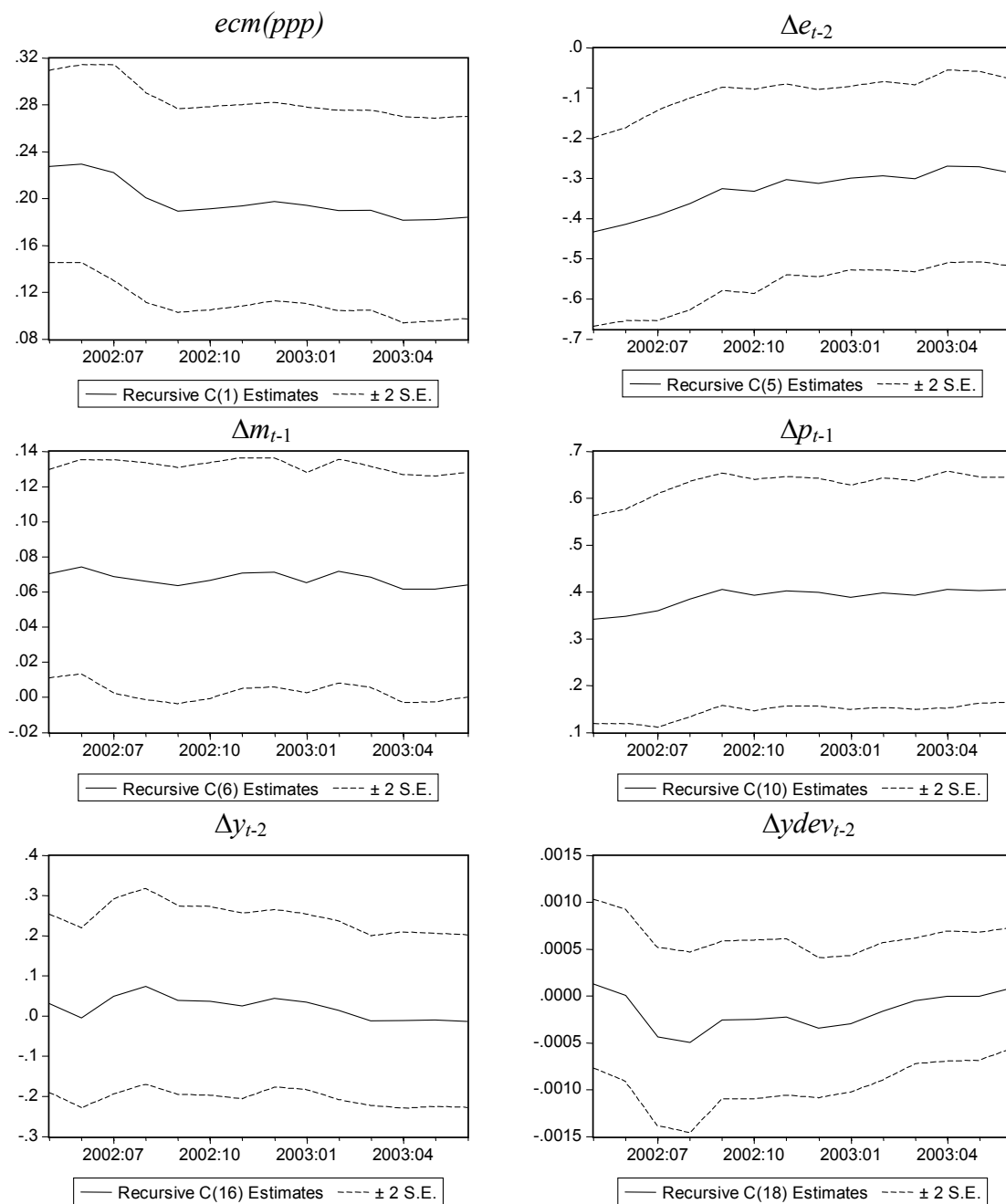
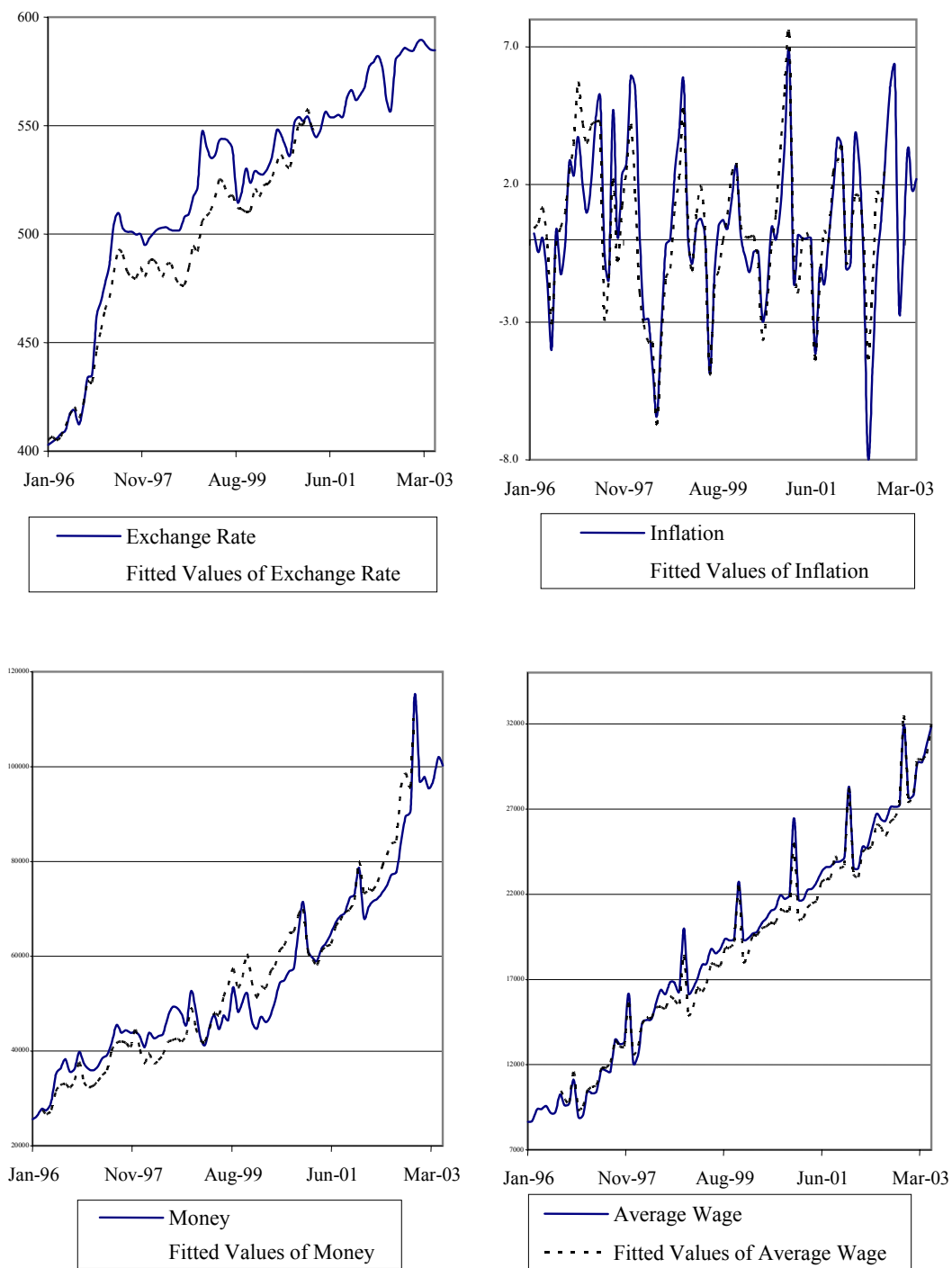


Figure 4. Actual versus Fitted Values of Selected Indicators



Source: Central Bank of Armenia; International Financial Statistics, IMF; and authors' calculations.



Figure 5. Overshooting of Prices as a Result of a One-Step Increase in the Exchange Rate

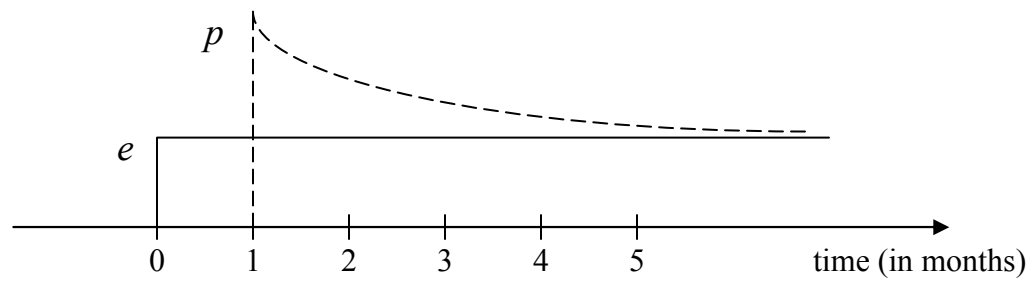
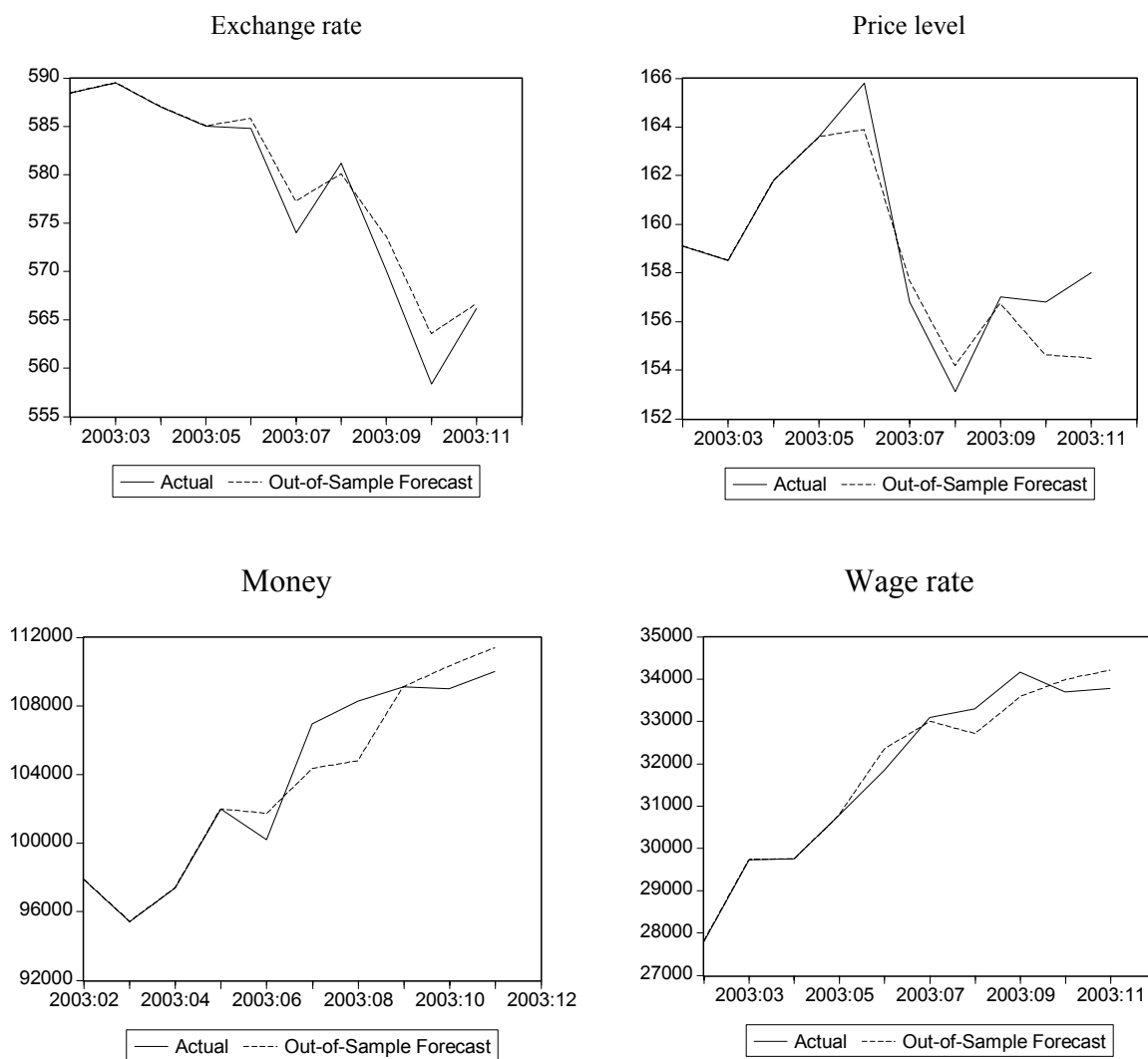


Figure 6. Out-of-sample Forecast of Select Indicators, June 2003-December 2003



## References

- Billmeier, A. and L. Bonato, 2002, "Exchange Rate Pass-Through and Monetary Policy in Croatia," IMF Working Paper 02/109, Washington: International Monetary Fund.
- Calvo, Guillermo, and Carmen Rainhart, 2000, "Fixing for Your Life," NBER Working Paper No. 8006, Cambridge, Massachusetts: National Bureau of Economic Research.
- de Melo, Martha, and Cevdet Denizer, 1997, "Monetary Policy During Transition: An Overview," Policy Research Working Paper No. 1706, Washington: World Bank.
- Duguay P., 1994, "Empirical Evidence on the Strength of the Monetary Transmission Mechanism in Canada: An Aggregate Approach," *Journal of Monetary Economics*, Vol. 33, No. 1.
- Grigorian, David, 2003, "Banking Sector in Armenia: How to Turn a Basket Case Into a Beauty Case?" *Armenian Journal of Public Policy*, Vol. 1, No. 1.
- Hunt, Benjamin, and Peter Isard, 2003, "Some Implications for Monetary Policy of Uncertain Exchange Rate Pass-Through," IMF Working Paper 03/25, Washington: International Monetary Fund.
- Johansen, Soren, 1992, "Weak Exogeneity and Cointegration in the U.K. Money," *Journal of Policy Modeling*, Vol. 14, No. 3.
- Kuijs, Louis, 2002. "Monetary Policy Transmission and Inflation in Slovakia," IMF Working Paper 02/80, Washington: International Monetary Fund.
- Meltzer, A., 1995, "Monetary Credit and (Other) Transmission Processes: A Monetarist Perspective," *Journal of Economic Perspectives*, Vol.9, No. 4.
- McCallum, Bennett, 1994, "A Monetary Impulse Measure For Medium-Term Policy Analysis," IMF Working Paper 94/146, Washington: International Monetary Fund.
- Poghosyan, T., and A. Khachatryan, 2001, "Factor Analysis of Interest Rate Spread in the Armenian Banking System," *Central Bank of Armenia Journal of Quarterly Publications*, No. 01(3).
- Poghosyan, T., A. Mkrtchyan, and A. Khachatryan, 2001, "Implication of MCI for Monetary Policy Implementation in Armenia," *Central Bank of Armenia Journal of Quarterly Publications*, No. 01(1).
- \_\_\_\_\_, 2002, "Implication of Monetary Policy Rules in Armenia: Efficiency of the Base Money Rule," *Central Bank of Armenia Journal of Quarterly Publications*, No. 02(3).

Thiessen, Gordon, 1995, "Uncertainty and the Transmission of Monetary Policy In Canada," unpublished; Toronto: York University.

Vardanyan V., A. Mkrtchyan, and A. Khachatryan, 1998, "Practical Implication of Monetary Impulses In Armenia," *Central Bank of Armenia Journal of Quarterly Publications*, No. 98(2).

## **Appendix**

### **Chronology of Key Events in the Monetary and Financial Sector**

#### **1994:**

- first monetary policy program was developed
- the CBA established an interest rates floor for non-auction loans
- all loan rates were determined by the CBA's refinance rate
- the CBA began guaranteeing interbank credits, a practice that was quickly abolished as a result of several bank closures
- the concept of reserve requirements was introduced and the banks were asked to deposit 15 percent of their domestic and foreign exchange liabilities with the CBA
- first program with the IMF was launched in December

#### **1995:**

- introduction of additional requirements for banks wishing to participate in credit auctions (the intention was to restrict participation of problem banks)
- preliminary work on the introduction of the treasury bills market and issuance of the "Procedures for Allocation, Circulation, and Maturity of Treasury Bills"
- the CBA started to offer liquidity, using treasury bills as collateral
- surrender requirements for export proceeds were abolished and the interbank foreign exchange transactions were permitted
- the official exchange rate was determined on a daily basis instead of tri-weekly
- the Monetary Policy Committee was established, which meets weekly to discuss developments in markets and prices

#### **1996:**

- the CBA introduced deposit auctions, which could serve as an alternative instrument to absorb excess liquidity in the banking system
- short-term liquidity projection scheme was developed
- first steps toward monetary and fiscal policies coordination were made. The regular meetings of the Minister of Finance and the Chairman of the CBA focused on policy coordination and implementation of monetary policy
- all restrictions on current and capital account operations were abolished

#### **1997:**

- modifications to the "Procedures for Allocation, Circulation, and Maturity of Treasury Bills" were made, creating an environment for institutional coordination between monetary and fiscal policies
- Armenia accepted the IMF's Article VIII obligations

#### **1998:**

- the stock of the CBA's credit to the government was securitized and steps to cease the practice of direct credit were made
- the CBA and the Ministry of Finance signed an agreement about the coordination of monetary and fiscal policies and the operation of treasury accounts in the banking system
- the CBA announced its intentions to develop monetary policy instruments and place special attention on the path of the interest rates
- first repurchase agreements with commercial banks were signed

**1999:**

- further revisions of the regulation on conduct of monetary policy and instruments were made
- the CBA began disclosing the minutes of the Board discussions on the short-term monetary policy program, which were discussed on a bi-weekly basis
- new regime for reserve requirements came into effect in April, according to which the reserve requirement against both dram and foreign currency liabilities should be kept only in Armenian dram
- the monetary policy program introduced the notion of the band ( $\pm 2$  percent)
- resolution on new principles and approaches for use of the CBA monetary policy instruments was adopted. It underlined that the CBA announces the interest rate only for repurchase agreements for 14 days (as a main signal of the monetary policy stance), and for stand-by facilities as the principal instrument for short-term liquidity management with the Central Bank

**2000:**

- Financial Sector Assessment Program and Review of Observance of Standards
- Regulation on the “Interrelations Between the Central Bank and the Ministry of Finance and Economy” was adopted by the CBA and the MOFE
- the CBA announced its compliance with the International Code of Transparency in Monetary and Financial Policies

**2001:**

- Armenia joined General Data Disseminated System (GDDS)

**2002:**

- the legal framework of the banking system was modified
- the Law on Credit Organizations was adopted

**2003:**

- commercial bank reserve requirements were reduced to 6 percent
- Armenia joined IMF's Special Data Dissemination Standard (SDDS).