

IMF Working Paper

The Transmission Mechanism in Armenia: New Evidence from a Regime Switching VAR Analysis

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Middle East and Central Asia Department

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November 2010

Abstract

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The introduction of inflation targeting in 2006, together with important economic developments such as dedollarization, marked the beginning of a new macroeconomic framework in Armenia, which is likely to have changed the effectiveness of monetary policy. This paper is the first attempt to analyze whether the transmission mechanism in Armenia has been subject to a structural break by employing a Markov-Switching VAR framework. Results support the existence of such a structural break around the time inflation targeting was introduced and reduced levels of dollarization were observed. Results from introducing a threshold variable into this framework furthermore show that reduced levels of dollarization are an important determinant of the effectiveness of monetary policy.

JEL Classification Numbers: O53, E4, E5

Keywords: Armenia, monetary policy, transmission mechanism, inflation targeting, dollarization

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¹ The authors would like to thank Aidyn Bibolov, Mark Horton, Daranee Saeju, Neil Saker, Ara Stepanyan as well as seminar participants at the Central Bank of Armenia for their helpful comments and suggestions. All remaining errors are ours.

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I. INTRODUCTION

The monetary framework in Armenia has undergone important changes in the last five years, including in particular the introduction of inflation targeting in 2006, levels of dollarization that were trending downwards prior to the global financial crisis and trending upwards as a result of the crisis, and a strengthening of banking sector regulation and supervision. While research prior to 2005 generally concluded that the monetary transmission mechanism in Armenia was weak, these recent economic developments and policy changes are likely to have changed the character of the monetary transmission mechanism.

The aim of this paper is to examine how the new monetary framework in Armenia has changed the effects of monetary policy on the real economy and whether there has been any impact on the nature of the different transmission channels. This analysis is conducted by first estimating a standard structural vector autoregression (VAR), the results of which can be directly compared to earlier findings for Armenia. The paper then employs an identified Markov Switching Vector Autoregressive (MSVAR) model. This method models structural breaks as regime switches and estimates the most likely timing of such a regime switch in the transmission mechanism. Provided that the regimes identified by the Markov switching estimation are long-lived and distinct, it is then possible to derive estimates of the effects of monetary policy on the real economy in the different regimes. While the MSVAR model checks for the existence of a structural break without making assumptions about its timing, it is unable to explain why a regime switch took place. Therefore the paper also estimates an MSVAR with a threshold variable, dollarization, which is likely to be one of the key factors underlying any change in the transmission mechanism in Armenia. To the best of our knowledge, this paper is the first attempt to estimate an MSVAR with a threshold variable in this particular context, and it thus provides an important contribution to the literature since these methods can be applied to a range of emerging economies, facing similar issues to Armenia.

Estimation results support the existence of a structural break around the time when inflation targeting and the dedollarization trend began. Before this regime switch, the effect of monetary policy on real economic activity and the rate of inflation is found to be very weak, mostly working through the exchange rate, if at all. After 2006, there are signs of a strengthening of the transmission mechanism, with the repo rate playing a stronger role in influencing consumer prices. Results from the MSVAR with a threshold variable furthermore show that dollarization levels are an important underlying explanation for these results. In the low dollarization regime after 2006, monetary policy is shown to be more effective than in the high dollarization scheme prior to 2006. The MSVAR with a threshold variable also found another regime switch in mid-2009 when dollarization levels rose.

The remainder of this paper is structured as follows. Section II provides an overview of the related literature on monetary transmission as well as a discussion of recent economic developments in Armenia. In Section III, estimation methods and results from a structural VAR, a Markov switching VAR and a Markov Switching VAR with a threshold variable are presented. Section IV provides policy recommendations and concludes.

II. BACKGROUND

A. Related Literature

The monetary transmission mechanism (MTM) describes the effect of monetary policy on real economic activity and the rate of inflation and therefore lies at the core of macroeconomics (Gerlach and Smets, 1995). Figure 1, which is adapted from Weber et al. (2009), provides a stylized representation of the transmission process:

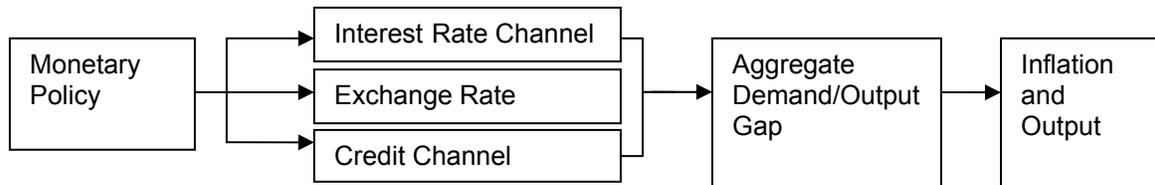


Figure 1: Stylized Representation of the Transmission Process (Source: Weber et al. 2009)

Mishkin (1995) describes the various channels through which monetary policy actions affect real economic activity and inflation in more detail:

- The *interest rate channel* enables the central bank to have an effect on the real cost of borrowing by changing the nominal policy interest rate. Changes in policy rates are transmitted through the banking system to longer-term lending and deposit rates and thereby affect household and firm spending and investment decisions.
- In open economies, additional real effects of changes in the short-term interest rate come about through the *exchange rate channel*. When the domestic nominal interest rate rises relative to its foreign counterpart, the domestic currency gradually appreciates in nominal and/or real terms. The nominal appreciation leads to a fall in the price of imports, thereby lowering inflation, while a real appreciation may reduce competitiveness and lead to fall in net exports.
- Two distinct *credit channels*, the *bank lending* and the *balance sheet channel* are also factors. The bank lending channel emphasizes the influence of monetary policy on the supply of bank loans. A contractionary monetary shock leads to a fall in bank reserves and therefore the total amount of bank credit available, leading to a decrease in investment by bank-dependent borrowers. The balance sheet channel on the other hand emphasizes that higher interest rates worsen corporate balance sheets by reducing the capitalized value of the firm's long-lived assets. Firms are then able to borrow less funds for investment purposes due to lower net worth that can be used as collateral.

Given the importance for policymakers to understand the channels by which changes in monetary policy affect the real economy, it is not surprising that in the last three decades there has been a surge in both the theoretical and empirical literature on the monetary transmission mechanism. While the theoretical literature focuses on how the Keynesian

interest rate channel operates within dynamic stochastic general equilibrium (DSGE) models (Clarida, Gali and Gertler, 1999, Woodford, 2003), much of the empirical literature builds on Sims's (1980) introduction of VAR models into macroeconomics.

The vast empirical literature on advanced economies generally concludes that the transmission mechanism mainly works through the interest rate channel (Angeloni et al, 2003). Interest rate changes are passed on to households and firms through a competitive financial sector. This contrasts with empirical findings for emerging and developing countries, which typically show that there is a limited direct impact of the real interest rate on economic activity and inflation, mainly due to weak banking systems (Mishra et al. 2010, Coricelli, Egert and MacDonald, 2006). Empirical findings on the transmission mechanism for Armenia by Dabla-Norris and Floerkemeier (2006) confirm these findings for emerging economies. They find that the ability of monetary policy to influence economic activity and inflation in Armenia is limited and that the interest rate channel is less effective than the exchange rate channel given a high degree of dollarization.

Despite the large number of empirical papers on the monetary transmission mechanism in advanced, emerging, and developing countries, the recent empirical literature has not paid much attention to whether the transmission mechanism in its entirety has changed in a particular country. The existing literature instead mostly focuses on how a specific channel, such as for example the bank lending channel has changed (for an excellent overview of this literature, see Weber et al. 2009). Notable exceptions to this are papers by Weber et al. (2009) and Fujiwara (2006). Weber et al. (2009) investigate whether there has been a significant change in the overall transmission of monetary policy in Europe by estimating a standard VAR and searching for a possible break date. Fujiwara (2006) uses a Markov-switching VAR framework to investigate whether there has been a structural break in the effectiveness of monetary policy in Japan due to the de-facto zero nominal interest rate policy.

Whether or not the transmission mechanism in its entirety has changed is an important policy issue both for advanced and emerging economies. There are many economic developments in these countries that could have potentially affected all channels of the transmission mechanism to some degree and in potentially different directions, so that their overall effect would have to be determined empirically. Some of these developments have been specific to particular countries, such as different levels of dollarization and the introduction of inflation targeting in many emerging economies; others are applicable to all countries such as increasing globalization.

The next section will provide a descriptive analysis of how recent economic developments are likely to have affected the different channels of the transmission mechanism in Armenia.

B. Recent Developments in Armenia and their Effect on the MTM

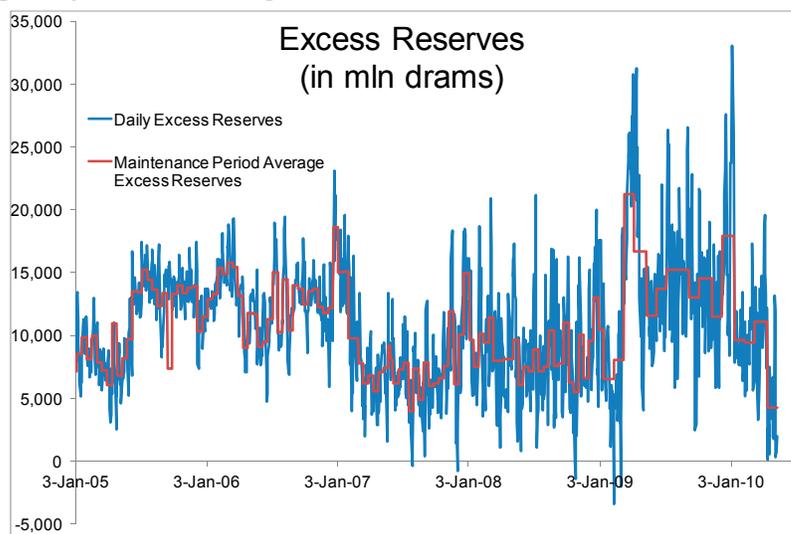
Previous research on Armenia studying the period before 2005 found specific channels of the monetary transmission mechanism to be weak and highlighted the features of the Armenian economy that hamper these channels. The interest rate and credit channels, key monetary transmission channels in advanced economies, have been shown to be insignificant. This has been explained by several factors, including the country's shallow money markets, low levels of financial intermediation, and high levels of dollarization. The bank lending and balance sheet channels also appeared to have been undermined by public distrust in banks, fueled by banking sector problems in the early part of the decade as well as weak corporate governance. Economic agents also tapped their own capital or used remittances from abroad instead of bank financing. As in other developing and emerging economies, the exchange rate channel emerged as the main channel for monetary policy to influence output and prices. With the economy characterized by high dependence on imports and high cash holdings of cash dollars, the population is sensitive to exchange rate volatility, strengthening the exchange rate channel. Heavy foreign exchange market intervention by the CBA in the past also encouraged inflation expectations to be influenced by movements of the nominal exchange rate.

Since 2005, several economic developments and policy changes may have changed the character of the monetary transmission mechanism:

The Interest Rate Channel

Many developments prior to the crisis point toward a strengthening of the interest rate channel. First, in January 2006, the CBA announced a move to an inflation targeting framework. The policy rate was chosen as the operational target, with an interest rate corridor around the target based on the overnight deposit and Lombard facilities. Previously, the CBA targeted monetary aggregates, guided by liquidity forecasts. This, however, became untenable as the CBA struggled with sterilizing liquidity injections from foreign exchange intervention to slow the pace of appreciation brought about by rising remittances and capital inflows. As a result, the CBA frequently missed its target. In addition, favorable

macroeconomic conditions and more confidence in the domestic currency increased the demand for money. This made it difficult to pin down the relationship between money growth and inflation. Under the inflation targeting regime, the CBA has aimed to keep short-term interest rates close to the announced policy rate and signal the monetary stance. One of the foreign banks has even started offering loans with floating interest rates linked to



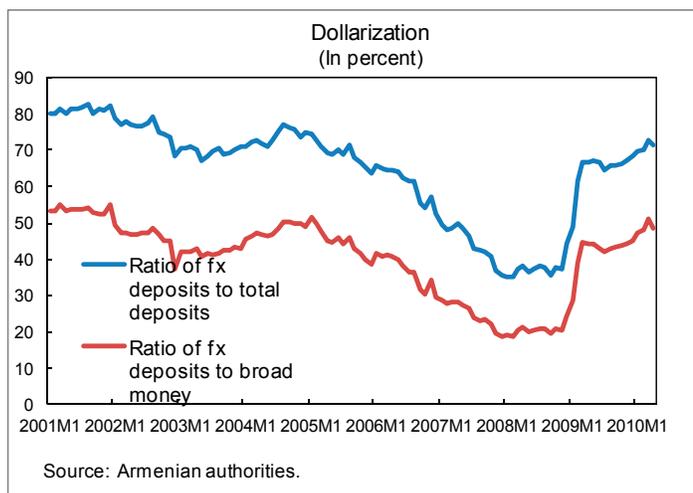
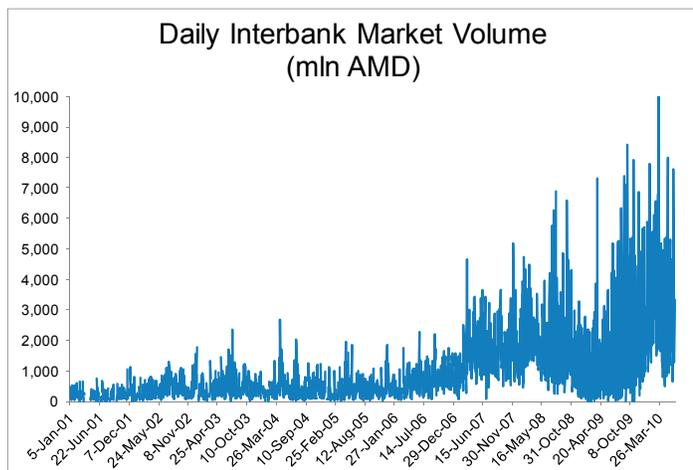
the central bank's policy rate. Evidence from other countries also shows that inflation targeting and the greater use of interest rate instruments have strengthened the interest rate channel, as seen in Leiderman, Maino, and Parrado (2006) for Peru and Bolivia.

Second, hand in hand with adopting inflation targeting, the CBA moved to mop up the excess liquidity that had previously weakened the monetary transmission mechanism through sale of its own securities. With structural liquidity then in excess, the CBA's operations did not have much traction on banks' marginal cost of funding. Banks had very little need to actively manage their liquidity positions and access the secondary market, which therefore remained shallow. With a shallow money market, the link from the policy rate to short-term and long-term market interest rates is impaired. Data show that the CBA was somewhat successful and excess liquidity dropped in 2007 and turnover in the secondary market increased from an average of 437 million drams in 2005 to 1.5 billion drams in 2009. Short-term money market rates appear to broadly track the policy rate.

Third, the government and the central bank made efforts to develop the market for local securities. The treasury increased its issuance of government securities, moving toward the establishment of benchmark rates for a longer yield curve. In addition, the CBA reached an agreement with the Ministry of Finance (MoF) to restrict repo transactions to the shorter end of the yield curve. Previously, the CBA used its own 6-month to 1-year securities to mop up excess

structural liquidity, as the government was reluctant to offer its own treasury bills in excess of the needed budgetary financing. Splitting the yield curve between the MoF and CBA has helped avoid confusion in the market on monetary policy operations. This is especially true when the MoF occasionally applies cut-off rates in auctions, creating differences in the yields of securities with the same maturity. With market rates not prevailing in some parts of the yield curve, the interest rate channel is distorted. Currently, the CBA issues repos of up to 12 weeks maturity only and the MoF issues securities at 13 weeks maturity and longer.

Fourth, the appreciating trend of the dram and the period of macroeconomic stability increased confidence in the domestic currency, fostering dedollarization. The ratio of foreign currency



deposits to total deposits dropped from a peak of more than 80 percent in 2001 to a low of less than 40 percent in 2008. Domestic currency loans also increased as a proportion of total loans. Previously, changes in domestic currency interest rates had very little impact on activity as many agents borrowed and saved in foreign currency. Dedollarization is expected to increase the link between interest rates and economic activity, strengthening the interest rate channel.

More recent developments during and after the crisis point toward a weakening of the interest rate channel. First, the transition to full-fledged inflation targeting was sidetracked, as the credibility of the framework may have weakened, as a result of the crisis. The framework, still in its infancy when the crisis struck, is best described as inflation targeting lite (Stone, 2003), given its relatively low credibility owing to the country's shallow financial system and vulnerability to economic shocks. However, when inflation targeting was announced in 2006, the economic environment bolstered the credibility of the framework: low inflation, high growth, strong external inflows, a strong fiscal position, low debt, and a trend toward de-dollarization. All these were reversed during the crisis. The large and rapid decline in current and capital inflows put enormous pressure on the exchange rate. A nominal depreciation of more than 20 percent in March 2009 increased inflation above the target band, and the significant decline in output, a deterioration of the fiscal position, and an increase in government debt complicated monetary policy, by placing pressures on the multiple objectives of the central bank.

Second, meeting these multiple objectives presented challenges to liquidity management. The central bank injected liquidity to stem the slowdown in credit growth. Banks' lending, however, remained cautious during the crisis, given the contracting economy, rising non-performing loans, and pervasive uncertainty. The resulting excess liquidity contributed to occasional turmoil in the foreign currency market, forcing the central bank to sometimes tighten liquidity conditions. This resulted in high short-term interest rate volatility, as market rates either dropped to the overnight deposit rates or rose to the overnight lending rates.

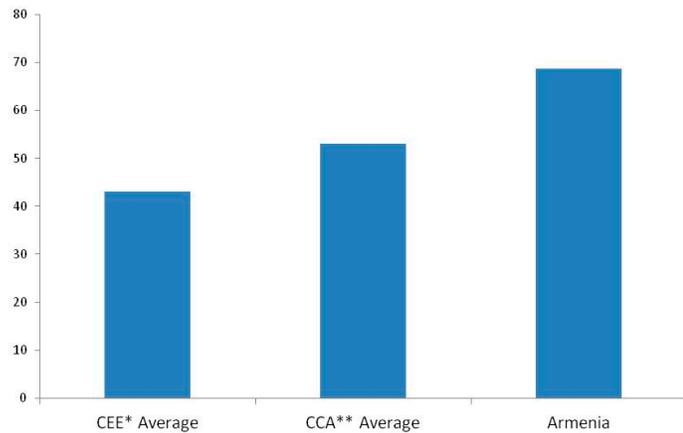
Third, the trend toward dedollarization reversed. An expectation of depreciation associated with the crisis triggered a move from dram to dollar deposits. The ratio of foreign currency deposits to total deposits increased to 67 percent by the time of the March 2009 depreciation. To close their positions, banks also increased dollar-denominated lending. Loan dollarization has risen to around 55 percent from a pre-crisis low of 39 percent.

The Credit Channel

The same factors that strengthened the interest rate channel may also have boosted the credit channel. Under inflation targeting, the central bank's monetary stance should become more transparent and easier to understand. The policy rate drives monetary operations that influence the supply of funds. Lower excess liquidity also gave the CBA more control of the supply of funds, as banks become more responsive to the policy rate. Dedollarization increased the supply of dram funding, as the population is more willing to hold dram assets. In addition, the CBA made progress in strengthening its banking sector regulation and supervision, contributing to raising financial intermediation.

The public's trust in banks appears to have improved markedly, as reflected in the steady increase in deposits even during the crisis. The total loan portfolio of the banking system also did not contract. With more economic activity transacted through banks, the impact of monetary policy through the credit channel should strengthen. However, there are still weaknesses in the institutional infrastructure that inhibit lending, including in the areas of creditor protection and corporate governance. Moreover, many enterprises and individuals continue to rely on remittances or capital inflows as alternative sources of financing and/or remain in the shadow economy.

Foreign currency deposits to total deposits, 2009



Source: Staff estimates and Database used in Eduardo Levy Yeyati, Financial Dollarization: Evaluating the Consequences, Economic Policy, January 2006, pp. 61-118, updated August 2010.

* Central and Eastern Europe
 ** Caucasus and Central Asia

The Exchange Rate Channel

The impact of recent developments on the exchange rate channel is less obvious. The period between 2006 and the global financial crisis was characterized by dedollarization and the move to inflation targeting, both of which are expected to weaken the exchange rate channel. With lower dollar holdings, the public is less impacted by changes in the exchange rate. In addition, the experience of Peru and Bolivia shows that the adoption of inflation targeting should also have reduced the exchange rate pass through by anchoring inflation expectations on the target (Armas and Grippa, 2005). However, the pre-crisis period was also characterized by sizable interventions by the central bank, as it initially leaned heavily against appreciation pressures and eventually resisted against depreciation pressures when the trend reversed. This may have increased the significance of the exchange rate among its instruments and enhanced the effectiveness of the exchange rate channel. In addition, to the extent that the dollarization level even at its lowest point was still relatively high and the episode of relatively low dollarization was not long enough to overcome the public's sensitivity to the exchange rate, the exchange rate channel has likely remained strong.

Meanwhile, the period during the crisis up to the present has been characterized by increased dollarization and reduced interventions.

While previous work concluded that the monetary transmission mechanism in Armenia is weak, the recent developments described above and summarized in Tables 1 and 2 suggest that updating the analysis would be important to not only check if the old conclusions still hold but also to test if the nature of the different channels have changed and, if so, when. The next section describes the approaches that we will take to answer these questions.

Table 1. Effects of Recent Pre-crisis Developments on the MTM

	Interest rate channel	Credit channel	Exchange rate channel
Move to inflation targeting	↑	↑	↓
Better liquidity management	↑	↑	
Development of local currency market	↑	↑	
Dedollarization	↑	↑	↓
Stronger banking sector regulation and supervision	↑	↑	
Increased foreign currency intervention			↑

Table 2. Effects of Recent Crisis and Post-crisis Developments on the MTM

	Interest rate channel	Credit channel	Exchange rate channel
Slow transition to full-fledged inflation targeting	↓	↓	↑
Less consistent liquidity management	↓	↓	
Continued development of local currency market	↑	↑	
Redollarization	↓	↓	↑
Stronger banking sector regulation and supervision	↑	↑	
Reduced foreign currency intervention			↓

III. MONETARY TRANSMISSION IN ARMENIA

A. Evidence from a Standard VAR Analysis

Methodology and Data

The baseline unrestricted VAR specification can be written in matrix form as

$$Y_t = A(L)Y_{t-1} + B(L)Z_t + \varepsilon_t \quad (1)$$

where Y_t is the vector of endogenous variables, Z_t is the vector of exogenous variables and ε_t is the vector of serially uncorrelated disturbances that have a zero mean and a time invariant covariance matrix. The coefficient matrices are denoted as A and B whereas L denotes the lag operator.

The vector of endogenous variables consists of output as measured by real GDP (y_t), the consumer price index (p_t), the repo rate (s_t), which is the key short-term interest rate used by the CBA to signal its monetary stance, domestic narrow money or M1 (m_t) and the nominal effective exchange rate or NEER (x_t):

$$Y_t = [y_t, p_t, s_t, m_t, x_t] \quad (2)$$

Thus, we follow Dabla-Norris and Floerkemeier (2006) and order output before prices on the assumption that it adjusts more sluggishly². Furthermore, the money supply is ordered before the exchange rate. This reflects the underlying assumption that the nominal effective exchange rate is immediately affected by all type of shocks, whereas the money supply is affected by shocks to monetary policy, output and prices and the interest rate in the short term responds contemporaneously to shocks in output and prices, but not to changes in financial variables.

The vector of exogenous variables contains an index of world oil prices ($oilp_t$), and the U.S. Federal Funds Rate (s_t^{US}). As in Dabla-Norris and Floerkemeier (2006), the world oil price index is included as a proxy for the development of remittances since it is highly correlated with gas prices and economic growth in Russia, the main source of remittances to Armenia. The U.S. Federal Funds Rate is included to capture interest rate parity. Thus:

$$Z_t = [oilp_t, s_t^{US}] \quad (3)$$

The endogenous and exogenous variables are all seasonally adjusted and are expressed in natural logarithms with the exception of the repo rate and U.S. Federal Funds Rate, which are

² We also estimated the VAR model ordering prices before output and found that the main results of the analysis were not significantly affected. Detailed results are available from the authors upon request.

in levels and not seasonally adjusted. We use data for the period of 2000M1-2010M5. A detailed overview of data sources is provided in Table A.1 in the Appendix.

Standard information criteria are used to determine the lag length of the VAR. Following Weber et al. (2009), we use the Hannan-Quinn (HQ) and Schwartz Criterion (SC). The Akaike criterion is disregarded since it overestimates the order with some probability as shown by Luetkepohl (2005). We follow a number of papers (e.g. Weber et al. 2009, Al-Mashat and Billmeier, 2008 and Dabla-Norris and Floerkemeier, 2006) and estimate the VAR in levels, although the null hypothesis that some of the variables are integrated of order one and therefore follow a unit root process cannot be rejected. We do this for two reasons. First, we would like to be able to compare our results to the earlier findings on the MTM in Armenia by Dabla-Norris and Floerkemeier (2006). Second, while imposing cointegration restrictions improves the efficiency of the estimation, given the short data series, it may result in inconsistencies. In addition, as demonstrated by Sims, Stock and Watson (1990) even if the system includes non-stationary variables, the OLS estimators are still consistent when the model is estimated in levels.

Results

Table 3 presents the results of the bivariate and multivariate Granger causality tests as preliminary evidence of the causal links between the repo rate and real economic activity and inflation. The results suggest that the repo rate and domestic narrow money both have a significant effect on output while only the NEER has a significant effect on inflation.³

Table 3. Multivariate and Bivariate Block Granger Causality Tests

	<i>p-values</i>
<i>Effect on output</i>	
Interest Rate (s)	0.00***
Money Supply (m)	0.00***
Exchange Rate (x)	0.05**
Block (p, s, x, m)	0.00***
<i>Effect on prices</i>	
Interest Rate (s)	0.96
Money Supply (m)	0.15
Exchange Rate (x)	0.03**
Block (p, s, x, m)	0.14
<i>Effect on NEER</i>	
Interest Rate (s)	0.03**
Money Supply (m)	0.06*
Block (p, s, x, m)	0.02**

Note: *, **, and *** denote rejection of the null hypothesis at the 10, 5, and 1 percent significance levels, respectively.

³ Granger causality tests were also performed using M2 data instead of M1. This did not change the results significantly.

Evidence from the Granger causality tests thus points to a very weak transmission mechanism. The link between policy rates and inflation is indirect in that the repo rate can influence the exchange rate, which in turns significantly affects inflation. The standard VAR is then estimated and the impulse response functions for interest and money supply shocks to output and prices are depicted in Figure 2.⁴

The results of the VAR model confirm the results from the Granger causality tests. Both interest and money shocks have persistent effects on output but small and insignificant effects on prices. These results are also in line with the findings by Dabla-Norris and Floerkemeier (2006) who use a shorter sample period with data only up to the end of 2005. We also confirm the findings of a study on inflation targeting in Armenia and Georgia by Dabla-Norris et al. (2007), which shows that the exchange rate pass-through to domestic prices is rapid and statistically significant in Armenia. However, in contrast to our findings and those of Dabla-Norris and Floerkemeier (2006), Dabla-Norris et al. (2007) find the interest rate channel to be effective in influencing prices. The difference in results is likely due to the fact that Dabla-Norris et al. (2007) estimate a slightly different VAR specification with only the U.S. Federal funds rate as an exogenous variable and currency in circulation as an additional endogenous variable. They also use a different sample period: January 2001-December 2005.

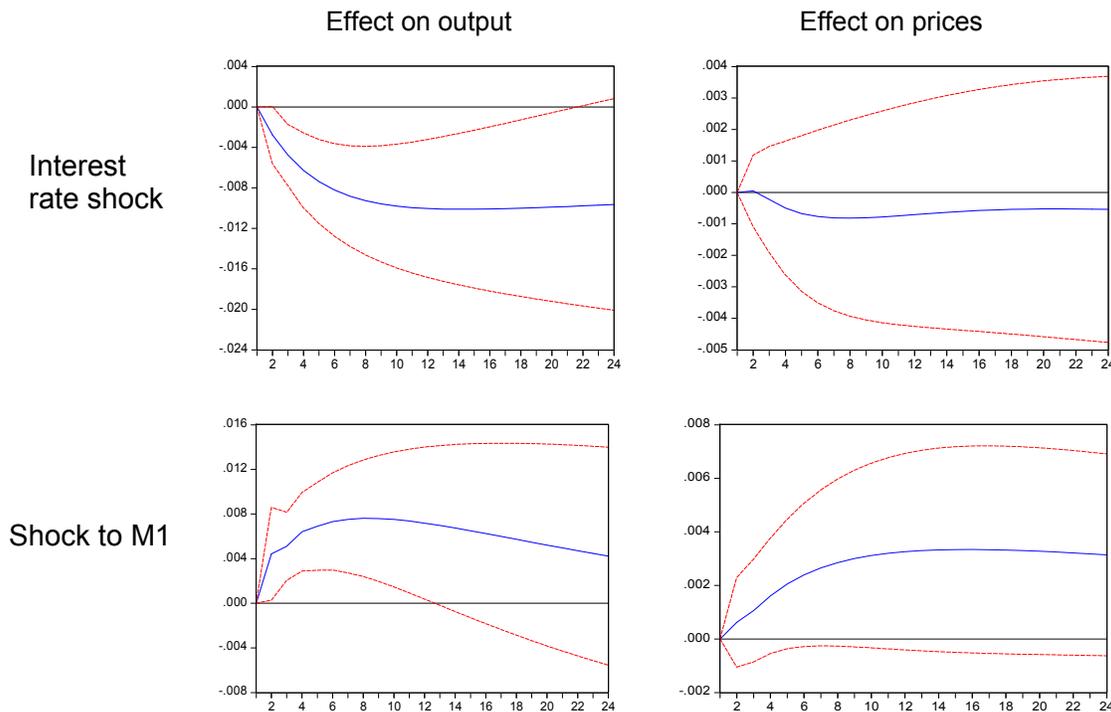


Figure 2: Impulse Responses for the Standard VAR Model
(Response to One S.D. Innovations ± 2 S.E.)

⁴ A complete set of impulse response functions is available from the authors upon request.

The different results across these studies highlight a significant shortcoming of the simple VAR analysis. Armenia is a country that has undergone significant structural changes in the past years. Most significantly, there was the introduction of inflation targeting in 2006 and decline of dollarization levels between 2006 and 2008. Therefore, it is likely that the transmission mechanism has changed and that the parameters that are estimated in the standard VAR have not remained constant over time. This is a likely explanation of why results differ between VAR estimations with different sample periods. The next section will estimate a regime-switching VAR, without any prior assumption as to when the transmission mechanism in Armenia is likely to have undergone significant changes.

B. Evidence from a Markov Switching VAR Analysis

Methodology

The aim of this section is to examine whether the effects of monetary policy on the real economy have been subject to a structural break without making prior assumptions about its timing. We therefore employ a technique known as Markov Switching Vector Autoregression (MSVAR). This method allows us to model structural breaks as Markov regime switches and to compare the monetary transmission mechanism before and after a regime switch.

We examine the most general MSVAR model in which K endogenous variables are explained by a K dimensional intercept vector, \mathbf{v} , autoregressive terms of order l , a residual vector of normally distributed fundamental disturbances uncorrelated at all leads and lags, \mathbf{U}_t , which is pre-multiplied by a regime-dependent matrix \mathbf{A} . In this specification all parameters may switch between m regimes:

$$\mathbf{Y}_t = \mathbf{v}(\mathbf{r}_t) + \mathbf{B}_1(\mathbf{r}_t)\mathbf{Y}_{t-1} + \dots + \mathbf{B}_l(\mathbf{r}_t)\mathbf{Y}_{t-l} + \mathbf{A}(\mathbf{r}_t)\mathbf{U}_t \quad (4)$$

where $\mathbf{r}_t = 1, \dots, m$

and $\mathbf{U}_t \sim N(0, \mathbf{I}_k)$.

According to the above specification, the variance of each fundamental disturbance is normalized to unity. However, because the residuals are pre-multiplied by a regime dependent matrix, the variance-covariance matrix of the residuals $\mathbf{A}(\mathbf{r}_t)\mathbf{U}_t$ is also regime dependent:

$$\Sigma_i = \mathbf{A}\mathbf{A}' \quad (5)$$

We assume that the regime r_t follows a hidden m -state Markov chain and that the probability of regime i occurring next period given that the current regime j is exogenous and constant. Since this is a regime switching model, the number of regimes needs to be fixed before the estimation. Given the short sample period, we fix this number to two regimes. The transition matrix can then be expressed as follows:

$$\mathbf{R} = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix} \quad (6)$$

where

$$r_{i,j} = \Pr(r_{t+1} = j \mid r_t = i), \sum_{j=1}^2 r_{ij} = 1 \text{ for all } i, j \in (1,2).$$

The elements of the matrix R show the probability of being in regime 1 in the next period given that the current regime is regime 1, that is r_{11} , as well as the probability of being in regime 2 in the next period given that the current regime is regime 1, r_{12} , and vice versa if the current regime is regime 2.

As shown by Hamilton (1990) all parameters of the above hidden Markov chain can be estimated jointly by applying the Expectations-Maximization (EM) algorithm. Under the EM algorithm, the hidden Markov chain is first inferred for a given set of parameters and subsequently the parameters for this hidden Markov chain are estimated in the maximization step. This procedure is repeated until convergence. The application of this algorithm allows us to find estimates of the coefficients and variance-covariance matrix for each regime as well as the transition matrix and an optimal inference of the hidden Markov chain, that is the probability that the current regime is $i=1,2$ for $t=1, \dots, T$.

The endogenous variables used for the estimation of the MSVAR model are real GDP (y_t), the consumer price index (p_t), the repo rate (s_t), M2 (m_t) and NEER (x_t) and the sample period continues to be 2006M1-2010M5. Again, the optimal number of lags is determined using the Hannan-Quinn (HQ) and Schwartz Criterion (SC). Following Fujiwara (2006) the model is estimated in levels and the Choleski decomposition is used to identify the system for contemporaneous relationships between macroeconomic variables.

The model is estimated in Oxmetrics using the MSVAR package, which was developed by Krolzig (1998). In general, impulse response functions can be derived within this MSVAR framework as shown by Krolzig and Toro (1999) and Ehrmann et al (2003), who derive regime dependent impulse response functions. However, the code provided by Ehrmann et al. (2003) currently does not allow models to have more than four endogenous variables. We therefore provide coefficients of the VAR model under the two regimes, which also facilitates an analysis of how the transmission mechanism has changed.

Results

Table 4 shows the estimation results for the five-variable MSVAR estimated in this paper. It can be seen that the coefficients differ between regimes, and that according to the transition matrix each regime is highly persistent. Furthermore, according to the linearity test statistic, the model is highly non-linear and coefficients switch significantly between regimes, which suggests that the MSVAR is an appropriate method to estimate the model. Diagnostic tests furthermore confirm that the errors can be considered normally and independently distributed as shown in Figures A2-A4.

Table 4: Estimation Results for MSVAR(2 regimes)

(1) Coefficients					
	<i>y</i>	<i>p</i>	<i>s</i>	<i>m</i>	<i>x</i>
<i>Regime 1</i>					
<i>c</i>	0.22	0.46	58.16***	4.81***	1.36*
<i>y</i> (-1)	0.42***	-0.04	-11.74***	0.61**	0.08
<i>p</i> (-1)	-0.05	0.92***	9.76**	-0.14	-0.22
<i>s</i> (-1)	-0.00	-0.00	0.85***	0.00***	0.00
<i>m</i> (-1)	0.01	0.01	1.76	0.61***	-0.01
<i>x</i> (-1)	-0.04	-0.00	1.74	0.26*	0.91***
<i>Regime 2</i>					
<i>c</i>	6.85***	-1.21**	1.16***	0.92	6.68***
<i>y</i> (-1)	0.39***	0.05**	4.83***	0.35**	0.08
<i>p</i> (-1)	-1.82**	1.29***	2.29	1.75***	-0.33
<i>s</i> (-1)	-0.00	-0.01**	0.61***	-0.00	0.04***
<i>m</i> (-1)	0.26***	0.02**	-2.64***	0.95***	-0.19**
<i>x</i> (-1)	-0.40**	-0.09***	1.86	0.25	0.82***

Note: *, **, and *** denote rejection of the null hypothesis of no significance at the 10, 5, and 1 percent significance levels, respectively.

(2) Transition Matrix

	<i>Regime 1</i>	<i>Regime2</i>
Regime 1	0.9873	• 0.01266
Regime 2	1.862e-010	• 1.000

(3) Likelihood and information criteria

<i>Log-likelihood</i>		<i>AIC</i>	
non-linear	linear	non-linear	linear
1263.6902	1069.4012	-18.5641	-16.4130

(4) Linearity test

<i>LR linearity test:</i> 388.5780	<i>Chi</i> (60)=[0.0000]**	<i>Chi</i> (62)=[0.0000]**	<i>DAVIES</i> =[0.0000]**
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An important advantage of the MSVAR model is that it estimates the timing of the regime switch without any prior assumptions on when this switch is taking place. Figure 3 shows smoothed regime probabilities, which suggest that there was a regime switch in mid-2006. The results in Table 4 also show that the transmission mechanism was strengthened after the regime switch in 2006. In regime 2, the repo rate has a significant effect on inflation and the exchange rate, which indirectly significantly affects inflation. On the contrary, in regime 1, a

change in the repo rate or exchange rate causes no significant effect on inflation or output. Therefore, these results point to a less effective monetary policy in regime 1.

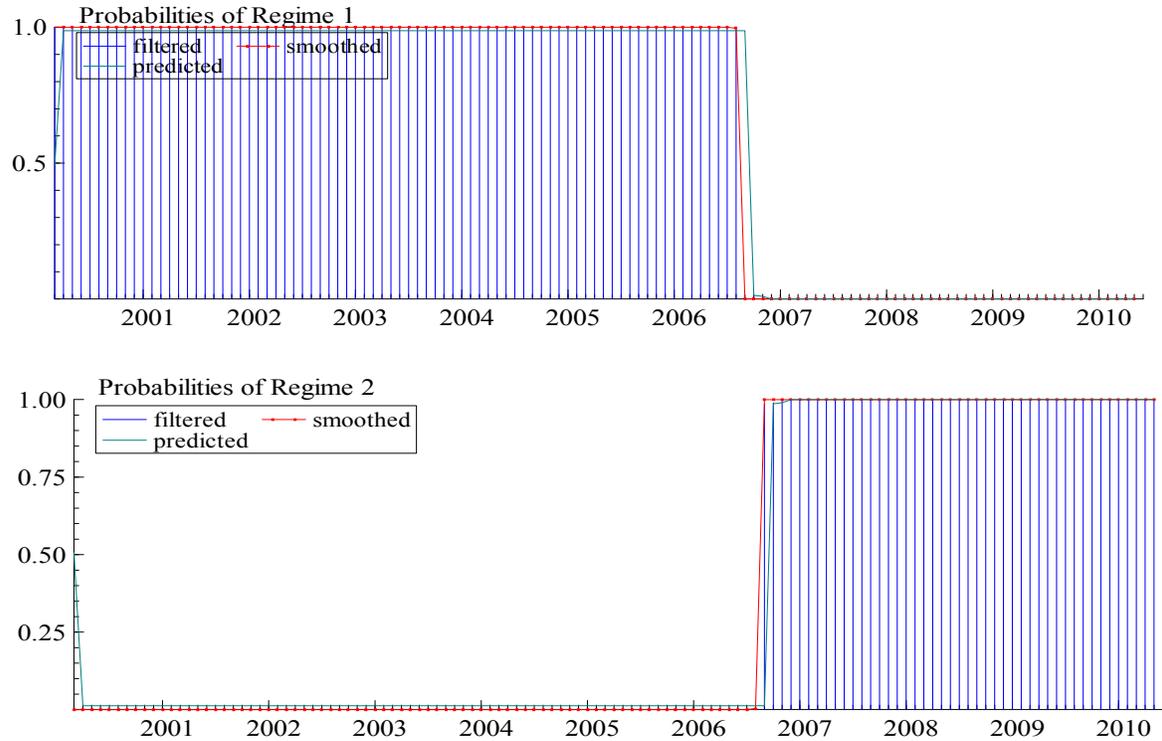


Figure 3. Regime Probabilities for MSVAR(2).

Given the timing of the regime switch, it is likely that several factors -- the introduction of inflation targeting, reduced levels of dollarization, and the several measures to develop the market for dram instruments and improve liquidity management -- played a role. However, the model is unable to tell us why a regime switch took place; it merely estimates its most likely timing. The next section will therefore introduce dollarization in the model, which is one of the underlying factors explaining the regime switch in the Armenian MTM.

C. Evidence from a Markov Switching VAR with a Threshold Variable

Methodology and Data

The analysis in the previous section suggests that there was a regime switch in mid-2006. Several factors can explain this regime switch, including the shift to inflation targeting, the improvement in the central bank's liquidity management, as well as the dedollarization process occurring in this period. In this section, we will consider one of these factors, namely the level of dollarization, and formally evaluate whether it affects the strength of the MTM and therefore explains the regime switch in mid-2006. If it does have an impact, we will then analyze its effect on the MTM by looking at the response of the economy to an exogenous monetary policy shock within a structural VAR framework.

As in the previous section, we consider an MSVAR with 2 regimes, with the regimes determined by the level of dollarization:

$$Y_t = v(r_t) + B_1(r_t)Y_{t-1} + \dots + B_l(r_t)Y_{t-l} + A(r_t)U_t \quad (7)$$

where

$$r_t = \begin{cases} 1 & \text{if } d_t < D \\ 2 & \text{if } d_t \geq D \end{cases}$$

and

$$U_t \sim N(0, I_k).$$

The coefficients and covariance matrix are all regime-dependent and d_t is the threshold variable whose value relative to the threshold D determines the regime. The threshold variable, which in this paper is the level of dollarization, is assumed to be exogenous. This means that shocks to the system do not affect the level of dollarization and, thus, the prevailing regime. The assumption is restrictive, given that many shocks that affect the endogenous variables also affect the level of dollarization. In addition, the relationship between dollarization and the MTM does not just go in one direction. While it is accepted that dollarization weakens the MTM, Ize and Yeyati (2005) also suggest that low credibility of the monetary authorities, which weakens the MTM, can create conditions – specifically, high inflation – such that the optimal portfolio of the public leans toward a higher share of foreign currency assets. Dollarization in this case is endogenous.

The assumption therefore does not allow us to analyze the complete response of the economy to changes in monetary policy. However, it does allow us to estimate regime-dependent coefficients and impulse response functions. Since the purpose of the paper is not to analyze the overall effect but to look closely at differences in the MTM across the two regimes, regime-dependent impulse responses will satisfy our purpose.

We use the same set and ordering of endogenous variables as in the previous section. The variables are transformed in logs and then in first differences to ensure stationarity. The ratio of foreign currency loans to total loans is used to measure the level of dollarization. In Armenia, this measure tends to lag behind other measures such as the ratio of foreign currency deposits to total deposits since banks cannot immediately react to shifts in the composition of liabilities. However, it captures a more complete shift in the regime since loan dollarization must be preceded by deposit dollarization.

Results

The software MSVAR by Krolzig (1998) is used, which estimates the critical value, D , that maximizes the conditional log-likelihood of the model. Estimation results are presented in Table 5. The threshold level is 51 percent. This divides the sample into two regimes. Periods where the ratio of foreign currency loans to total loans is below 51 percent belong to the low

dollarization regime and the rest to the high dollarization regime. The estimated critical value for the threshold suggests that the Armenian economy moved from a high dollarization regime in late 2006, stayed in a low dollarization regime until mid-2009, and moved back to a high dollarization afterwards. According to these results, the economy is currently in a high dollarization regime. This result is broadly consistent with the results in the MSVAR in the previous section which showed a similar regime switch in 2006. However, the second regime switch shows up only in this approach. This can be explained by other factors in addition to dedollarization that have affected the nature of the MTM. Another reason could be that the time series after the second regime switch in the MSVAR with threshold variables (11 months) is too short to identify another regime switch when applying the MSVAR in the previous section.

Table 5. Estimation Results for Threshold MSVAR

Estimated threshold	51
Period of high dollarization	2000:3 – 2006:11 2009:7 – 2010:5
Period of low dollarization	2006:12 – 2009:6
Log likelihood	1238.35
LR Linearity test	329.84
p-values (adjusted chi-squared)	[0.0000]

To test the null hypothesis of the linear model explaining the data better than the nonlinear threshold VAR model, the likelihood ratio between the two models was computed. The p-values suggest that the threshold VAR model explains the data better. Figure 4 also presents the smoothed regime probabilities.

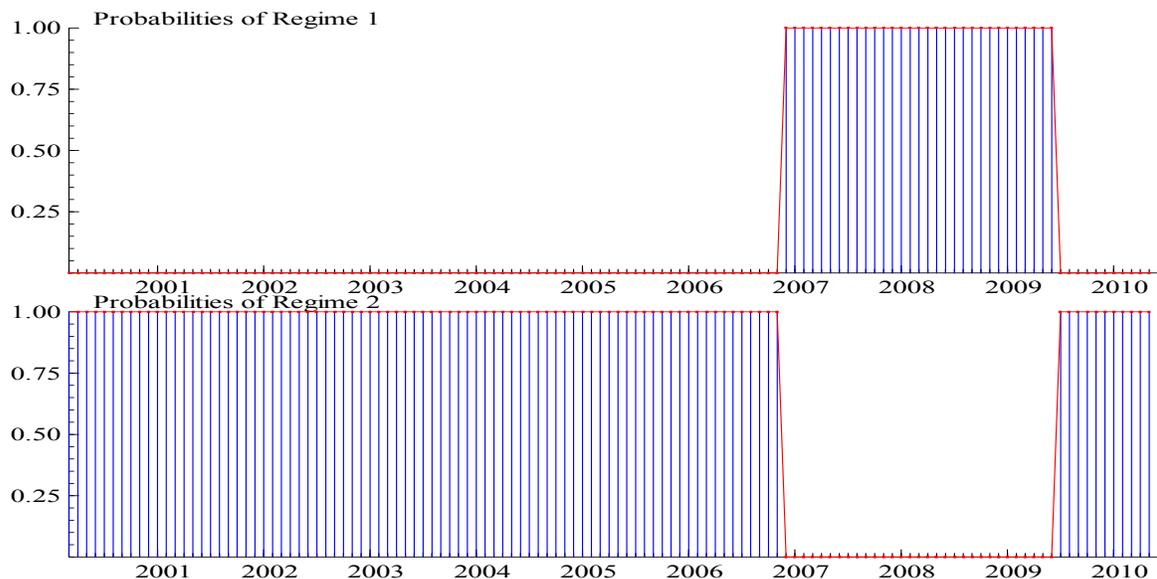


Figure 4. Regime Probabilities for Threshold MSVAR

We then proceed to analyze the difference between the two regimes. To do so, we compute regime-dependent impulse response functions and plot the response of growth and inflation to a one unit shock to the repo rate, money, and the nominal effective exchange rate. Since we assume that the threshold variable is exogenous, we implicitly assume that shocks to the system do not change the regime. This allows us to divide the sample between the two regimes, run a reduced form VAR on each regime, and perform a Cholesky decomposition to compute the structural parameters for each regime.

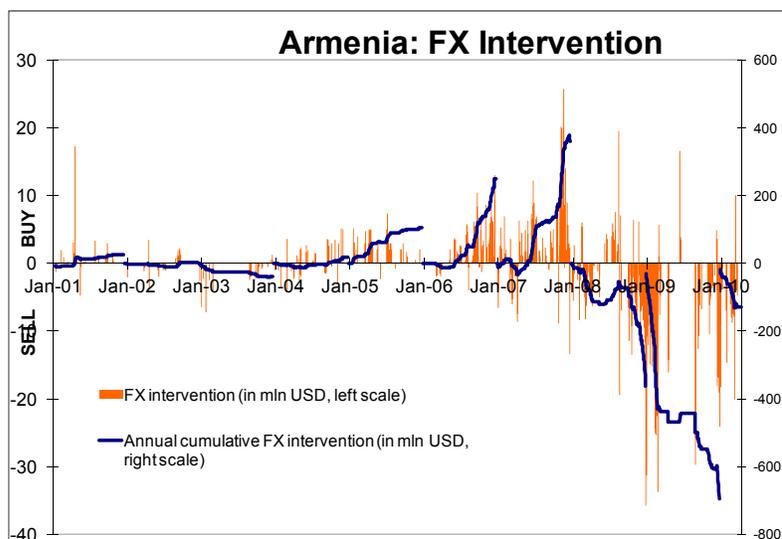
Figures 5 to 7 present the regime-dependent impulse response functions with 95 percent standard error bands. Figure 5 shows the impact of an increase in the repo rate under the two regimes. The impact of a 100 basis point increase in the repo rate on GDP growth is negative and significant under both low and high dollarization. However, the impact under low dollarization is nearly 10 times stronger. Turning to inflation, the repo rate has a negative impact on inflation. Under low dollarization, the response of inflation to the repo shock is much larger but remains insignificant suggesting that the interest rate channel has strengthened with the drop in dollarization but remains weak.

Figure 6 presents the response of GDP growth and inflation to a 1 percentage point increase in money growth under both regimes. The response of GDP growth to a shock on money has the expected sign and is stronger under the low dollarization regime but does not appear to be significant under both regimes. The overall impact on inflation is significant under both regimes and, again, we find that the impact is stronger under low dollarization. The significant impact of money growth as opposed to the policy rate on inflation during the low dollarization regime attests to the early stages of the CBA's inflation targeting framework. As mentioned above, despite the announced move, the central bank does not always strictly adhere to the framework, suggesting that the framework is inflation targeting lite. The experience of other emerging market inflation targeters shows an increase in the interest rate pass through immediately after the adoption of inflation targeting (see Armas and Grippa, 2005, for example). In these countries, the volatility of short-term market interest rates was reduced quickly, enhancing the credibility of their policy rate. In contrast, Armenia's short-term interest rates are volatile and frequently diverge from the policy rate, diminishing the relevance of the latter. The central bank can make more effort to actively manage liquidity and reduce short-term interest rate volatility.

Figure 7 presents the response of GDP growth and inflation to a 1 percentage point increase in the nominal effective exchange rate under both regimes. The exchange rate pass through during the high dollarization period appears to be weaker than in the low dollarization regime in Armenia. This result differs from empirical evidence (for example, Reinhart, Rogoff, and Savastano, 2003) associating high dollarization with higher exchange rate pass through. It is not however unusual. There has been evidence of lower exchange rate pass through in highly dollarized settings during recessions, due to balance sheet effects and the offsetting impact of lower demand (for example, Carranza, Galdon-Sanchez, and Gomez Biscarri, 2004). Depreciation in a dollarized economy could be contractionary, lowering demand, and offsetting the standard effect of the nominal exchange rate on output and prices. This could explain the low pass through in the high dollarization period that started in 2009. In Armenia, the global crisis which started in 2008 and contracted the economy in 2009 came with a

significant depreciation in the first quarter of 2009. The subsequent drop in demand kept inflation below 5 percent during the year, despite a 20 percent drop in the value of the local currency and deposit dollarization rising above 65 percent.

Another explanation for the pattern of exchange rate pass through in the periods of high and low dollarization in Armenia could be the increasing use of exchange rate interventions during the low dollarization period. During the low dollarization period, Armenia experienced substantial inflows of remittances and foreign direct investment. As a result, the local currency appreciated and the central bank became a net purchaser



of foreign exchange to slow the appreciation. This reversed at the end of 2008, when the global crisis started. Depreciation pressures increased, and the central bank became a net seller. In both episodes, interventions were frequent, contributing to the enhanced role of the exchange rate in managing inflation expectations and thus increasing the pass through in the low dollarization period. Meanwhile, in the high dollarization episodes before 2006 and after the crisis, the annual cumulative interventions were significantly lower. Before 2006, inflows were not substantial and the central bank intervened less. After the large depreciation in 2009, the central bank moved to a flexible exchange rate regime, adopting an intervention strategy that minimized interventions to smoothing excessive volatility and rebuilding reserves.

The extent of exchange rate pass through in Armenia is often used to justify frequent interventions as the central bank relies on the exchange rate channel to influence economic activity and inflation. However, higher exchange rate pass through often signifies the lack of monetary policy credibility and many countries with longer experiences in inflation targeting have seen a drop in exchange rate pass through, even with dollarization remaining high. In Armenia, a more consistent and credible monetary and exchange rate policy, in addition to dedollarization, will be necessary to reduce the exchange rate pass through.

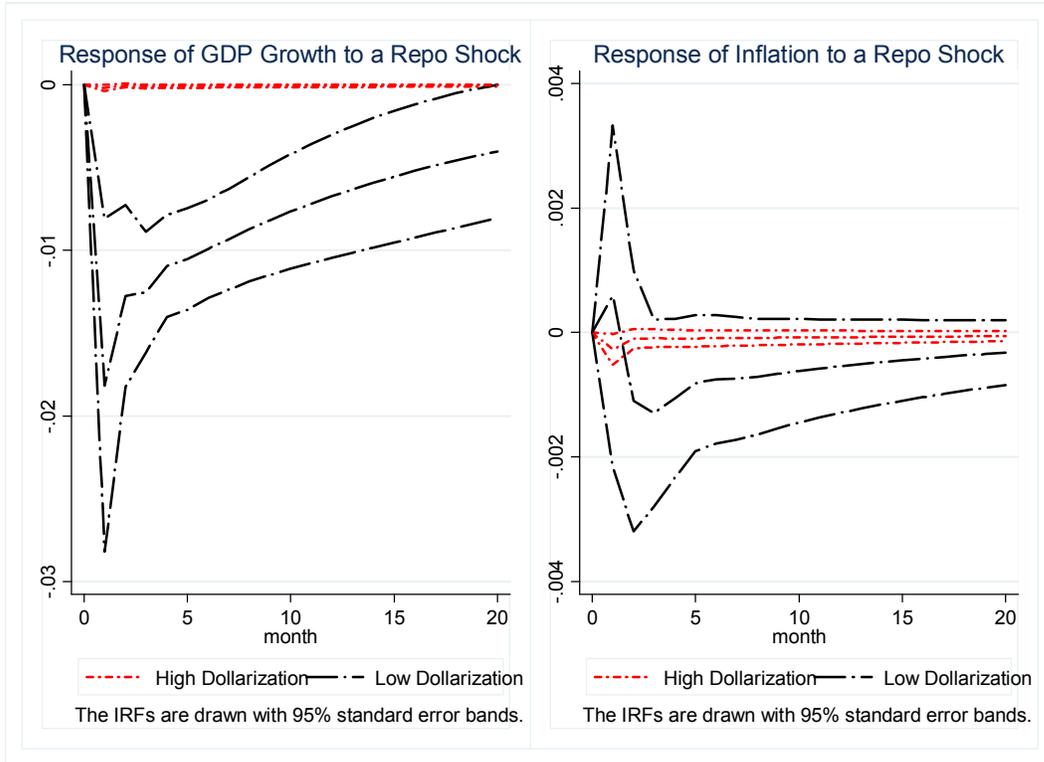


Figure 5. Threshold MSVAR: Response to a Repo Shock

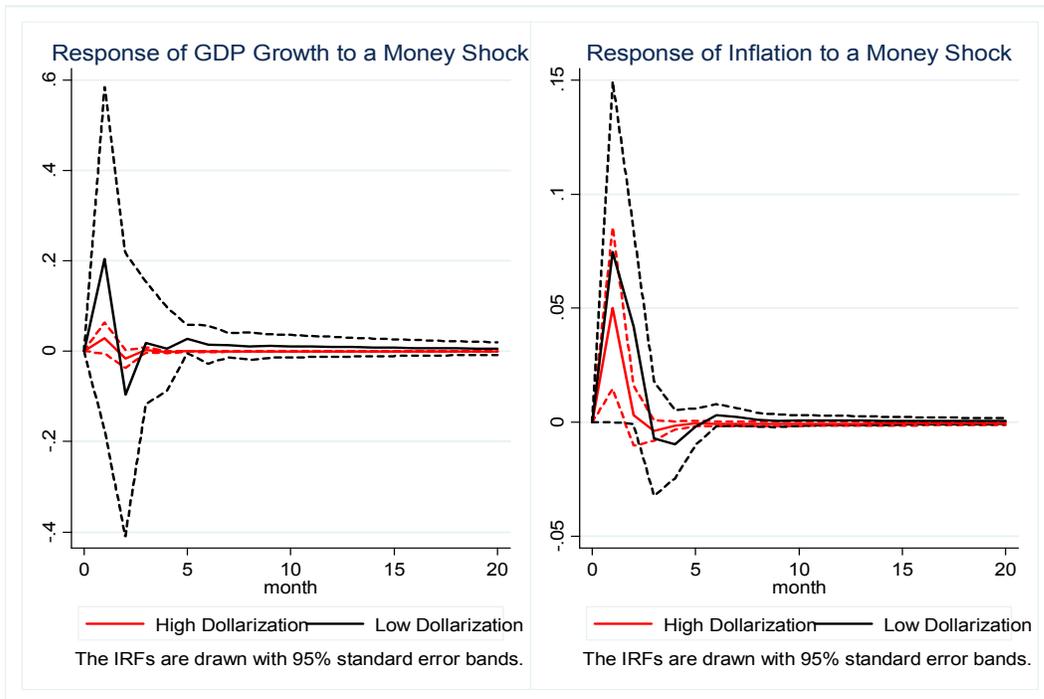


Figure 6. Threshold MSVAR: Response to a Money Shock

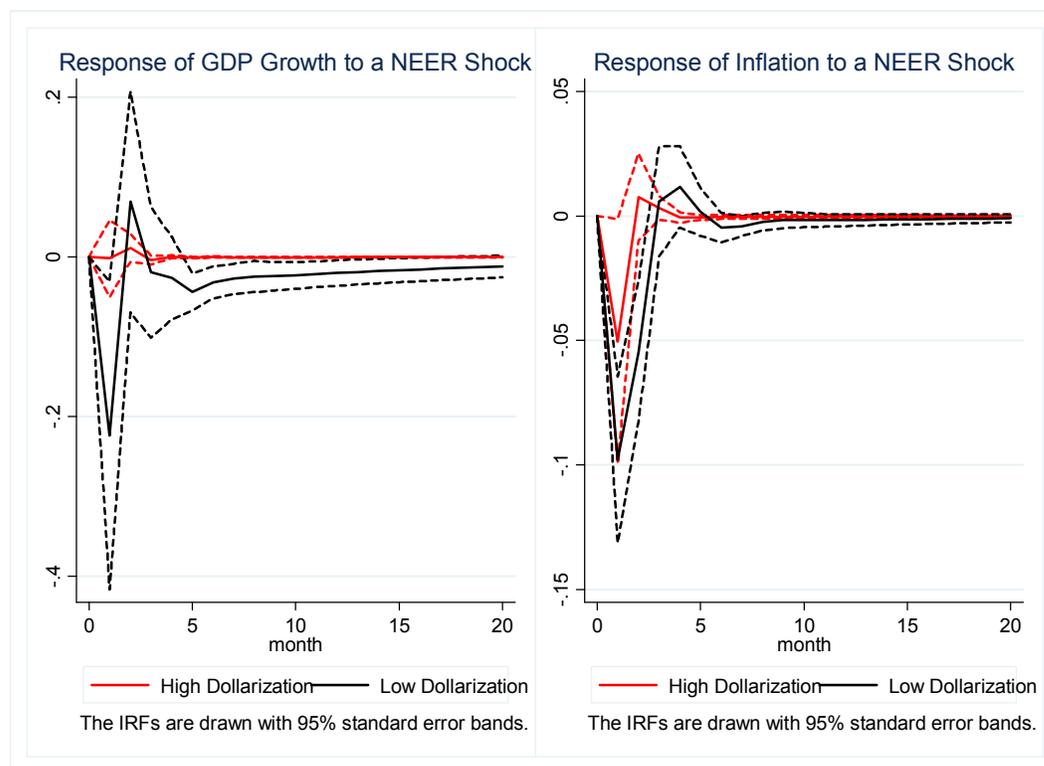


Figure 7. Threshold MSVAR: Response to a NEER Shock

IV. SUMMARY AND CONCLUSIONS

The paper analyzes the monetary transmission mechanism in Armenia using three approaches. First, the paper updates earlier work that estimates a standard structural vector autoregression (VAR). Second, the paper takes into consideration a possible change in the nature of the MTM during period of analysis. The paper then employs a Markov Switching Vector Autoregressive (MSVAR) model to estimate the likely timing of the regime switch as well as the effects of monetary policy on the real economy in both regimes. Third, the paper considers one possible source of the regime switch, namely the level of dollarization, to identify the two regimes. The level of dollarization becomes a threshold variable in the MSVAR analysis and the differences in the transmission of monetary policy in the low and high dollarization regimes are then characterized. The methodology developed in this paper can be applied to a wide sample of transition economies that also have underdeveloped financial structures and markets. In future work, our approach could thus be used to include Armenia in a wider set of transition economies. This would also shed further light on the robustness of the results in this paper, which are summarized below.

Both MSVAR models (with and without a threshold variable) point to a regime switch in the second half of 2006. The MSVAR with a threshold variable identified the turning point as the level when credit dollarization fell below 51 percent. The MSVAR with a threshold variable also point to another regime switch at mid-2009, when dollarization rose above the threshold. The MSVAR with no threshold variable did not pick up this last switch perhaps because

there are too few observations in the last regime. The MSVAR without a threshold variable also captures other factors that affect the nature of the MTM.

Both models also suggest that the monetary transmission mechanism strengthened in the period after 2006. The impact of the policy rate on prices remains weak although there is evidence that it strengthened after the regime switch, supporting the hypothesis that de-dollarization strengthens the MTM. The impact of the policy rate on prices likely remains weak, even as dollarization dropped, for several reasons. First, dollarization levels remain high even in the low dollarization regime. Second, the use of the policy rate as an operational target under the inflation targeting framework is at its early stages. The central bank sometimes diverges from this short term interest rate target, going above it when its concern with inflation coupled with the high exchange rate pass through impels it to raise short-term market rates quickly and going below it when its concern with sluggish credit growth impels it to inject more liquidity.

Results also point to a stronger transmission from money to prices after the end of 2006. The threshold MSVAR shows that the effect of money growth on inflation is significant as opposed to the effect of the policy rate on inflation. This suggests that the inflation targeting framework remains rudimentary.

The transmission between the nominal effective exchange rate and prices appears to have strengthened as well after 2006 and before 2009. The result is surprising, as it suggests that the exchange rate pass through is stronger in a low dollarization regime. However, the frequency and size of interventions by the central bank increased significantly during this period. This may have strengthened the status of the exchange rate in influencing inflation expectations. In the period after mid-2009, the decline in the pass through in a high dollarization regime could also be explained by the recession. The sizable contractionary depreciation in March 2009 may have increased uncertainty, reduced aggregate demand, and put downward pressure on prices, offsetting the usual impact of depreciation on the prices of imports as well as inflation expectations.

The results have a number of policy implications. First, a strong track record of macroeconomic stability will be crucial in strengthening the MTM. Macroeconomic stability is a precondition for dedollarization, which results in the paper show will strengthen the MTM. Compared to the pre-crisis period, the outlook for Armenia is more challenging. While the economy is currently on the path to recovery, the current account deficit of more than 15 percent will continue to put pressure on macroeconomic conditions, suggesting that measures to bring it down will have to accompany dedollarization efforts. In addition, fiscal consolidation to keep debt in check and minimize vulnerabilities to shocks will also be necessary.

Second, consistent monetary and exchange rate policies, guided by a solid communication strategy, will be key to strengthening the MTM. The current macroeconomic environment will test the ability of the central bank to balance many objectives, while maintaining its credibility. With the economy stabilizing, the central bank can reaffirm its commitment to the single objective of price stability and renew efforts to communicate this objective and the framework to achieve it. Results show that giving emphasis and attention on the nominal

exchange rate (for example through interventions) will only strengthen the exchange rate channel of the MTM and likely not develop other channels such as interest rate or credit. Given the difficulty of using the exchange rate channel credibly when the country is frequently affected by external shocks and reserves are not high, the central bank should strive to develop these other channels. Specifically, the central bank should manage liquidity more actively to ensure that its policy rate becomes more relevant. In cases when the central bank uses the policy rate to influence the exchange rate, a clear communication strategy should explain that the ultimate objective is not the exchange rate but inflation. Greater central bank credibility will reduce the exchange rate pass through, even when dollarization remains high, as was evident in the case of many Latin American inflation targeters.

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Table A1: Data Description and Sources

Variable	Description	Frequency	Sample	Source
Real GDP	In previous year's constant prices, seasonally adjusted, in natural logarithms	Monthly	2000M1-2010M5	NSS and staff calculations
Consumer Price Index	Seasonally Adjusted, in natural logarithms	Monthly	2000M1-2010M5	NSS
Nominal Effective Exchange Rate	Seasonally Adjusted, in natural logarithms	Monthly	2000M1-2010M5	IFS
Repo Rate		Monthly	2000M1-2010M5	CBA
M1	Seasonally adjusted, in natural logarithms	Monthly	2000M1-2010M5	IFS
M2	Seasonally adjusted, in natural logarithms		2000M1-2010M5	IFS
M2X	Seasonally adjusted, in natural logarithms		2000M1-2010M5	IFS
Petroleum Average Crude Price	Index , in natural logarithms	Monthly	2000M1-2010M5	IFS
U.S. Federal Funds Rate		Monthly	2000M1-2010M5	IFS

Figure A2: MSVAR(2) Diagnostics

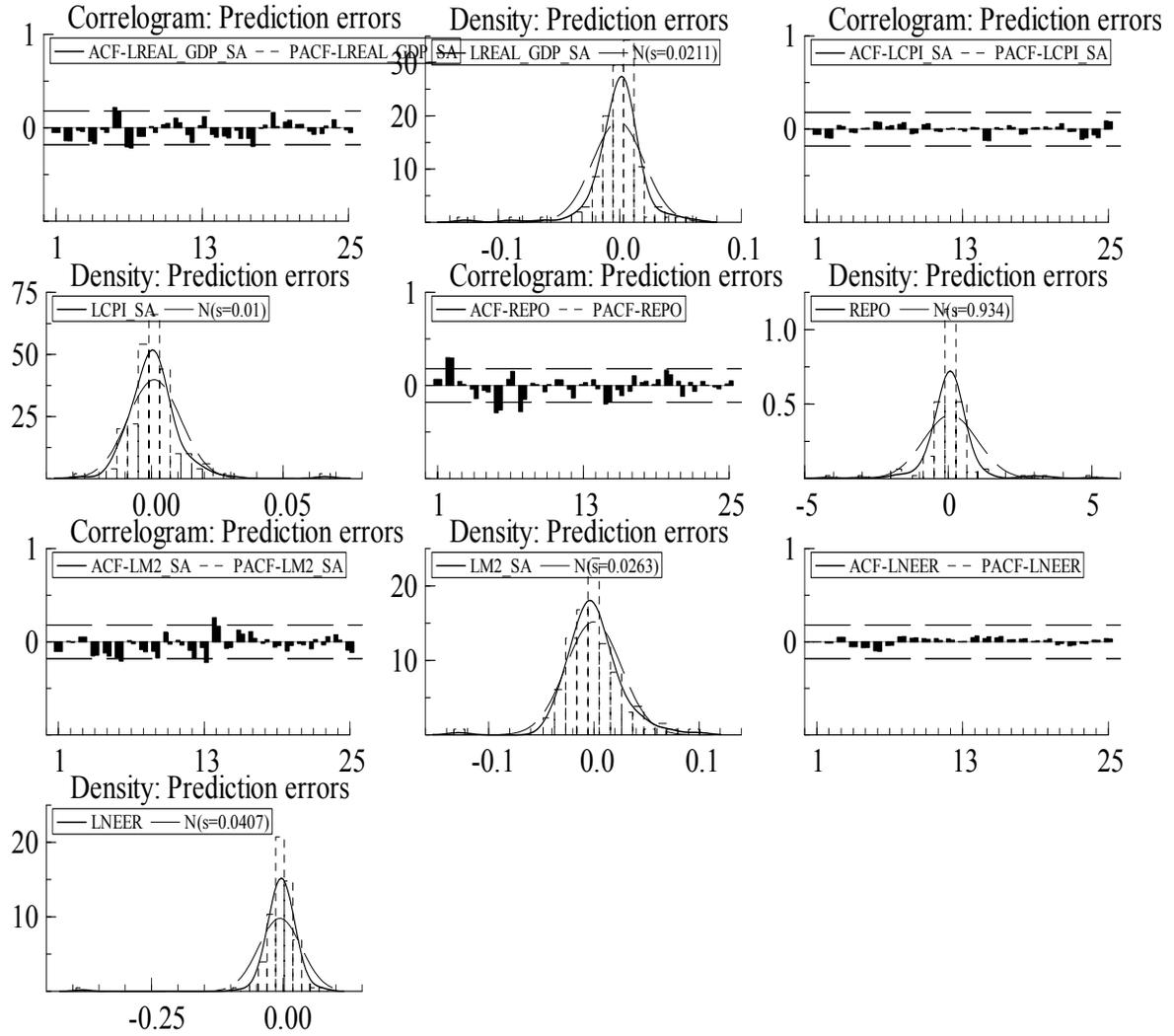


Figure A3: MSVAR(2) Residuals

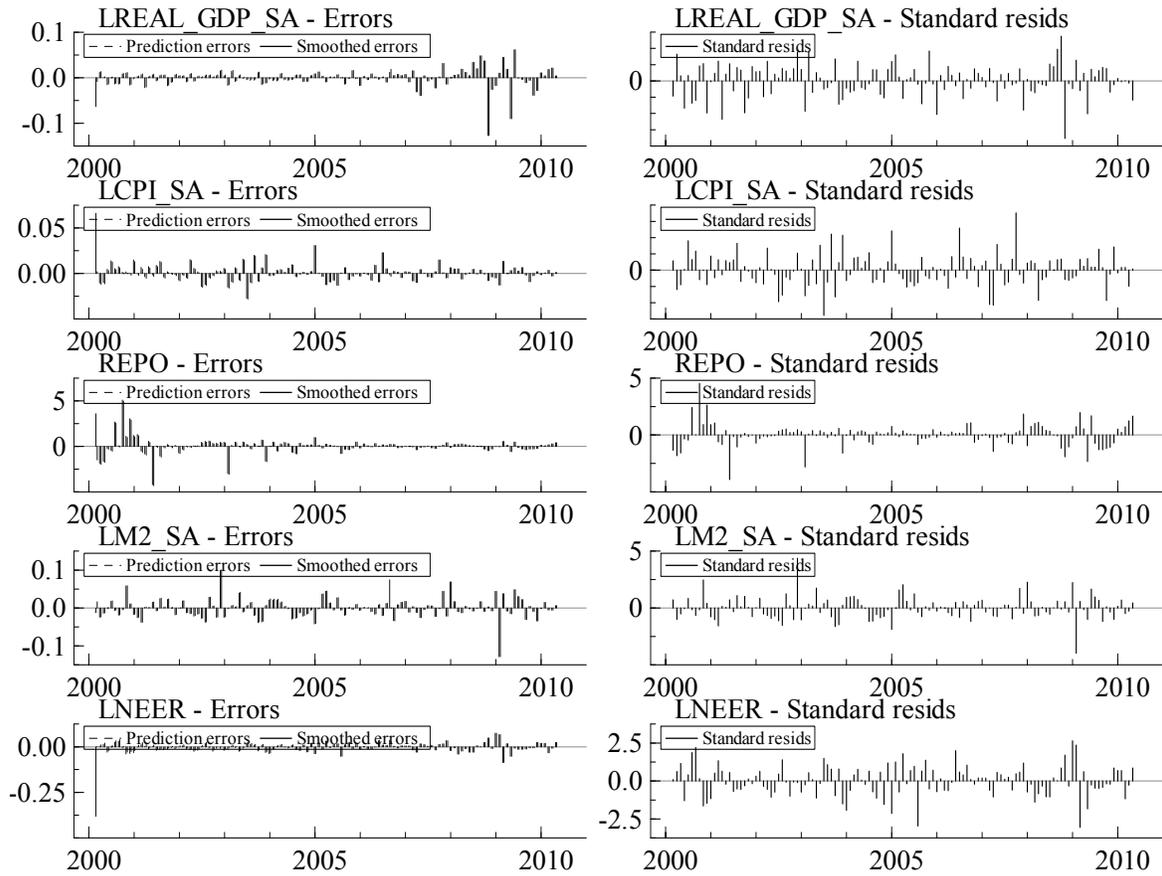


Figure A4: MSVAR(2) Fitted and Actual Values

