

Understanding the money - prices relationship under low and high inflation regimes: Argentina 1970 - 2005¹

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Abstract

Recent cross-country empirical evidence indicates that the money-prices relationship depends on the average rate of inflation. This relationship is strong in economies with high inflation, but weakens under low inflation. Based on these findings, we study the dependence of the money-prices relationship on the level of inflation in Argentina along the last 35 years. We use descriptive analysis as well as cointegration tests to study the long run relationship between money growth and inflation. Proportionality holds for the high inflation period but weakens under low inflation. Money velocity is quite volatile but keeps a positive correlation with inflation in the long run. Under low inflation, velocity correlates negatively with money growth, a result consistent with the empirical evidence in the literature. Using VAR analysis, we focus on the transmission of nominal shocks to inflation in the short run. We enlarge the set of information to include other relevant macroeconomic variables such as the nominal interest rate, the multilateral nominal exchange rate depreciation and GDP growth. The results of this exercise allow us to identify different dynamics of money growth and inflation under low and high inflation. In particular we are able to capture the role played by inflation expectations implicit in nominal interest rates in driving the dynamics of money growth and inflation under high inflation. Although the money growth-inflation short run relationship weakens under low inflation, money continues to play a role in explaining inflation dynamics.

JEL Codes: C32, E31, E40

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1. Introduction

In Argentina, the return to an active monetary policy, after the years under a hard peg, has renewed the debate on the money growth –inflation relationship.

It is quite established in the literature that a strong positive correlation exists between money and prices in the long run (see Lucas (1980), Dwyer and Haffer (1988), McCandless and Weber (1995)) and that this relationship is close to proportional.

The short run relationship between those two variables is more controversial and, in spite of the large amount of literature devoted to the issue, it has not been possible yet to draw any stylized facts on it.

Recent empirical evidence from cross country analysis (see De Grauwe and Polan, 2001) suggests, however, that the money growth-inflation relationship could be dependent on the level of inflation. It seems to be strong for economies with high inflation, but weakens under low inflation.

The empirical evidence also indicates that money velocity is rather volatile, contrary to what theoretical models usually predict. Cross country analysis (see De Grauwe and Polan, 2001) also shows that money growth and velocity are positively correlated for countries with high inflation, but negatively for low inflation countries. Cash in advance models, based on Baumol-Tobin's money demand, with endogenous money velocity, have been recently developed by Alvarez, Atkinson and Edmond (2003), and Rodriguez Mendizábal (2006) to provide theoretical explanations for the finding of an unstable money velocity.

The fact that dynamics of money growth, money velocity and inflation could depend on the level of inflation is not trivial from the perspective of monetary policy, since it could imply that money is not relevant to explain inflation dynamics under low inflation. In fact, models based on price stickiness, which exclude money, are the most widely used to explain the short run inflation dynamics under low inflation (see Marcat and Nicolini, 2005).

Argentina is an interesting case to study this dependence using time series analysis, because of its inflationary history of the 70's and 80's. In this respect, Gabrielli, Mc Candless and Rouillet (2004) study the bivariate relationship between money and prices in Argentina over the periods 1976-1989 and 1991-2001 and find significantly different behaviors during both periods.

Based on these findings, we study the dependence of the money-prices relationship on the level of inflation in Argentina along the last 35 years (from 1970 to 2005). Briefly, the 70's and 80's were characterized by high inflation and hyperinflation outbreaks. Since the 90's till the end of our sample, inflation was much lower and the peso was fixed to the dollar under the Convertibility law. The abandonment of this regime in January 2002 renewed the money-prices debate, because it brought back certain fears of returning to high inflation.

The fact that the economy was subject to very different monetary regimes along these years makes it presumable that the money growth-inflation relationship did not remain stable. Our presumption is, however, that it is the level of inflation rather than the monetary regime, the relevant criterion to identify “regimes” in terms of this relationship. Under this a priori we adopt the strategy of (i) dividing the sample into sub-periods, (ii) looking at the relationship between those variables and (iii) testing for the validity of our a priori assumption using different approaches.

We split the sample in different sub-periods based on the average rate of inflation: (i) a period of high inflation from 1970 to the first half of 1975; (ii) a very high inflation period from the last half of 1975 to the end of 1988; (iii) the hyperinflation episode between 1989-1990, that we do not consider in our analysis, given its very particular features; and (iv) a low inflation period between 1993 and 2005. For some of the empirical exercises we conduct here, we separate the Convertibility period (1993-2001) from the managed floating (2002-2005) in order to evaluate to what extent they can be considered as different regimes in terms of the dynamic relationship of the variables under study.

We analyze the money growth - inflation relationship from two perspectives. The first one looks at the long run relationship between these two variables with the aim of verifying the relevance of some stylized facts quite established in the literature for the Argentine case: basically strong positive correlation and proportionality. For high frequency data the correlation between money growth and inflation is strongly positive during high inflation periods and much weaker under low inflation. When the high frequency data component of time series is discarded, the degree of co-movement between the two variables increases, with the exception of the managed floating period. Proportionality holds under high inflation and hyperinflation, but the relationship is much lower than one under low inflation.

We conduct cointegration analysis to test for the presence of a common trend between money and the price level along the complete period. This analysis reveals that there is not such a common trend but a changing one for the sub-periods in which we split the sample. While we cannot reject proportionality for the periods of high and very high inflation, the long run relationship between these two variables is much lower than one for the Convertibility and managed floating periods.

We also study the dynamics of money velocity over the 1970-2005 period and its relationship with inflation and money growth. Money velocity appears to be highly volatile and has a strong positive correlation with inflation for the whole sample. Consistently with the results in the literature, it has a negative correlation with money growth under low inflation.

From the second perspective, we look at short run dynamics using Vector Autoregressive Model (VAR) analysis, focusing on the transmission of nominal shocks to inflation. In this case we enlarge the set of information to include other relevant macroeconomic variables such as the nominal interest rate, the change in the multilateral nominal exchange rate and GDP growth. We are able to identify very different dynamics in the money growth-inflation relationship under low and high inflation. Between 1977 and 1988 the price expectations component in nominal interest rates plays a key role in explaining the

dynamics of money growth and inflation. On the contrary, from 1993 to 2005, a period of low inflation, impulse responses are more in line with the empirical regularities in the literature. However, the abandonment of the Convertibility regime has an impact on this short run dynamics, being the response of inflation to monetary impulses stronger than under Convertibility. These findings indicate that a multivariate analysis allows a better understanding of the sources of the different money growth-inflation short run dynamics under low and high inflation and that money growth continues to play a role in explaining the short run dynamics under low inflation.

The paper is organized as follows: Section 2 shortly revises the recent empirical literature on money growth and inflation. Section 3 focuses on the long run relationship between those two variables. In section 4, we analyze the behavior of money velocity and its relationship with money growth and inflation. In Section 5 the short run dynamics of money growth and inflation is studied through VAR analysis. Finally, Section 6 concludes.

2. Money and prices in the literature: theory and empirical evidence

The relationship between money and prices or money growth and inflation has been largely studied in both, theoretical and empirical literature. From the long run perspective some quite established stylized facts have been drawn. For example, persistently high inflation can be associated to persistent money growth. The interactions between those two variables in the short run is, however, much more controversial. In fact no stylized facts on this relationship have been established and accepted for high frequency data.

The theoretical literature provides two main explanations for persistently high inflation: (i) intends by governments to exploit the trade-off between unemployment which can lead to dynamic inconsistency problems and (ii) recurrent monetary financing of fiscal disequilibria. The first one was the theoretical explanation to explain the persistence of high inflation in developed countries during the 70's and 80's (see Kydland and Prescott, 1977). The second one was the theoretical argument initially developed by Cagan, to explain hyperinflation in the 20's. This argument was afterwards extended to the explain high inflation and hyperinflation in some developing countries, like Argentina, Israel and Brazil where inflation was mainly due to monetary financing of fiscal disequilibria. Heymann and Leijonhufvud (op. cit.) emphasize that in those cases, the limits between monetary and fiscal policy are not clear. Fiscal deficit can be treated as an exogenously determined variable that explains money growth which in this context can be considered as "passive" relative to the fiscal deficit and even to the inflation rate.

With respect to the long run relationship between money growth and inflation in the empirical literature, Lucas (1980), Mills (1983), Dwyer and Haffer (1988), McCandless and Weber (1995) find a strong positive correlation and proportionality between money growth and inflation in the long run after discarding the high frequency component of both time series.

More recently, De Grauwe and Polan (2001) look at a panel of 160 countries over 30 years (1969-1999) and find that the degree of co- movement between money growth and inflation depends on the average rate of inflation. In countries having experienced high inflation and hyperinflation, the correlation between money growth and inflation is strong

while this relationship weakens in countries with low average rates of inflation. They also find that money growth and velocity are positively correlated in countries with high inflation, suggesting the validity of a Cagan's money demand, while the opposite occurs in low inflation countries.

Marcet and Nicolini (2005) emphasize the difficulty of nesting both empirical findings in a comprehensive monetary theory, since rational expectation monetary models, with flexible prices, predict a strong positive correlation between money growth and inflation. To deal with this inconsistency two monetary theories have been developed: one describes a world of high inflation under rational expectations. The other tries to resemble the empirical correlations observed for low inflation countries by assuming some kind of price rigidity. Marcet and Nicolini find this solution quite imperfect, not only for theoretical reasons but also because of the policy recommendations coming from those two theories of inflation: while in a world of high inflation there is a crucial role of money growth in driving inflation dynamics, money could become irrelevant in a world of low inflation. In order to solve this inconsistency, Marcet and Nicolini intend to develop a model for high inflation economies in which agents learn from the economy and then adjust expectations with some delay.

Recent models on money demand have also addressed the empirical findings of a weak short run correlation of money growth and inflation and an unstable money velocity. Alvarez et al. (op. cit.), develop an inventory model for money demand based on Baumol and Tobin, in which money velocity can fluctuate in the short run. Their model can give account of the negative correlation of money velocity and money growth as well as the correspondently weak response of inflation to money growth. Mendizabal (2006) constructs a cash in advance version of the money demand model developed by Baumol and Tobin in which money velocity is endogenous and responds to changes in the interest rate. His model provides an explanation for the low correlation found in cross country analysis between money velocity, money growth and inflation.

In spite of the abundant empirical literature on the short run dynamic relation between money growth and inflation there are no established stylized facts on this topic. Theories on the business cycle provide different explanations for the observed cyclical movements in relevant macroeconomic aggregates and prices, as interest rates, money, GDP growth and inflation. The empirical validation of these different theories faces difficulties. Among them, the fact that time series decomposition and identification strategies imply by themselves the use of some theoretical a priori about the relationship among those variables (see Canova 1998), the results could be dependent on the restrictions imposed for identification. Another relevant pitfall to the study the transmission of nominal disturbances into the economy is the instability of money demand.² This instability is also an explanation for the abandonment of monetary aggregates as an intermediate target for monetary policy.

The channels through which money can affect the price level in the short run are multiple and dependent on the monetary regime. Changes in monetary aggregates reflect both the

² In this respect see Woodford (1997), Estrella and Mishkin (1996), and Friedman and Kuttner (1996).

response of the central bank and private agents to different shocks that can affect the economy. Given the endogenous nature of monetary policy, VAR models appear to be the most adequate tool to study the transmission of nominal shocks to the economy in the short run, and they have been extensively used in developed economies with mixed results.³ Much less is the empirical evidence for developing countries. However, in recent years, the movement towards the adoption of inflation targeting schemes in many developing countries stimulated the study of the transmission of nominal shocks to the economy for policy purpose.

In Argentina, rapid money growth after the abandonment of the convertibility regime stimulated a debate on the potentially inflationary effects of this outcome. The issue is not easy to address due to the fact that observations correspond to a very atypical period, in which a sharp depreciation of the currency took place jointly with a turbulent financial crises. Thus, both variables money growth and inflation experienced sharp changes. Gabrielli et al. (2004) use descriptive analysis to try to extract some lessons on the money growth inflation relationship in Argentina, by studying it over the periods 1976-1989 and 1991-2001. They find that under high inflation, inflation anticipates money growth, while the opposite occurs under low inflation.

In this paper, we extend their work in several dimensions. First, we include the managed floating period. Second, we study this long-run relationship using cointegration analysis. Third, we also look at the short run dynamics of money growth and inflation in a multivariate framework that incorporates other variables potentially relevant in the transmission of nominal shocks to inflation, as the nominal interest rate, GDP growth and the nominal exchange rate. This multivariate analysis allows us to identify very different short run dynamics in the transmission of nominal shocks to inflation under high (1977-1988) and low (1993-2005) inflation.

3. Some empirical regularities in money growth and inflation relation

3.1. Descriptive analysis

The purpose of this section is to analyze the time series properties of money growth and inflation and their co-movement in order to compare them with some basic theory predictions about the long term relationship between money and prices.

Recent empirical evidence confirms the presence of a long term positive correlation, but not proportionality, between money growth and inflation.⁴ Gabrielli et al. find a high positive correlation between money and prices from 1976 to 1989. As these findings do not imply causality from money to prices, we use cointegration tests to evaluate the validity of a conditional model of prices on money.

We study the relationship between money growth and inflation during the period 1970-2005, considering four sub-periods. This splitting is based on observed changes in the average rate of inflation (see Figure 4.1).

³ For an excellent review of the literature on this topic see Christiano et al. (1998). See also Sims (1992)

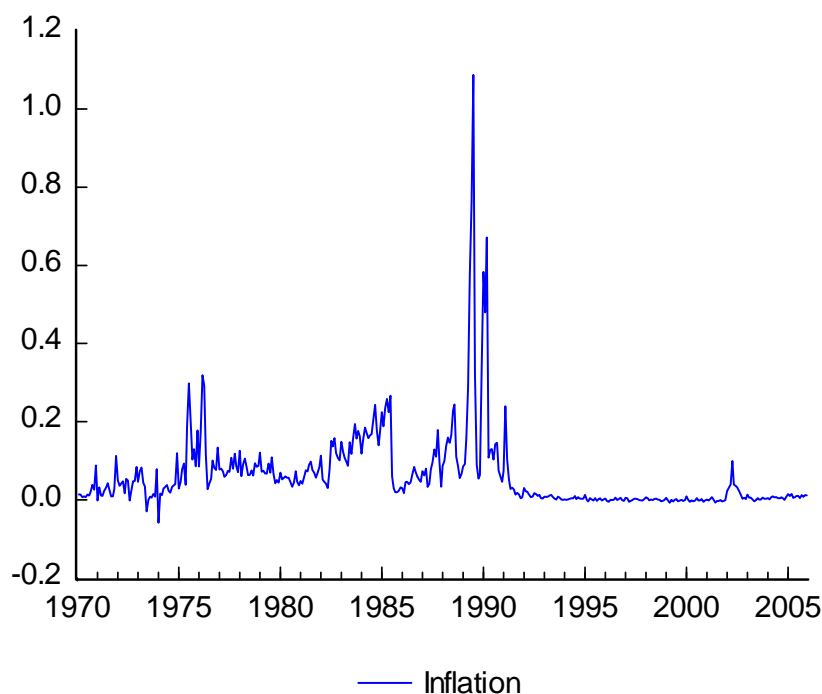
⁴ See Mc Candless and Weber (1995), Dwyer and Haffer, (1999) and De Grauwe and Polan (2001).

We identify four sub-periods or inflationary regimes:

- i. High inflation: 1970M01-1975M05
- ii. Very high inflation: 1975M06-1988M12
- iii. Hyperinflation: 1989M01-1991M03
- iv. Low inflation 1993M1-2005M12-2005.12

Additionally, we split the fourth period into two sub-samples to investigate the presence of a regime change after the adoption of a managed floating in January 2002. In the case of managed floating, we rule out the initial period because the series were seriously affected by the financial crisis and the dramatic change in relative prices after the abandonment of the peg.

**Figure 3.1: Monthly Change in Inflation
(1970-2005)**



Inflation is measured by the log of CPI index and money by the log of private sector holdings of M1 (currency plus current account deposits) seasonally adjusted.⁵ We are interested on transactional money holdings by the private sector.

⁵ We choose this definition of money because we are interested in transactional money holdings by the private sector. M1 is the most homogeneous aggregate along the full sample considered here and corresponds to end of period holdings. Since average data are not available for the whole period of analysis.

Table 3.1: Some empirical regularities in money growth (μ) and inflation (π)

	1970:1-2005:5		1970:1-1975:5		1975:6-1988:12		1989:1-1991:3		1993:1-2001:12		2002:09-2005:12	
	μ	π	μ	π	μ	π	μ	π	μ	π	μ	π
Mean (%)	6.34	6.26	3.36	3.21	9.49	10.20	23.31	25.94	0.36	0.06	2.54	0.57
Std. Deviation	0.102	0.103	0.033	0.031	0.091	0.062	0.201	0.266	0.049	0.004	0.034	0.004
Monthly change correlation (5% significance)	0.776 Yes		0.093 No		0.514 Yes		0.751 Yes		0.266 Yes		-0.119 No	
Annual change correlation (5% significance)	0.960 Yes		0.001 No		0.875 Yes		0.980 Yes		0.790 Yes		0.352 Yes	
Granger causality from μ to π (rezagos)	Simultaneous		No		Inverse (2, 4, 6)		No		Yes (2)		No	
Highest correlation μ and π (lag)	0.63 (0)		0.50 (0)		0.31 (0)		0.75 (0)		0.28 (2)		Negative	

Considering the whole sample, the means of money growth (μ) and inflation (π) are quite similar. μ and π are virtually the same during 1970M1–1975M5 and slightly different between 1975M6 and 1988M12 and throughout hyperinflation. (see Table 3.1)

During the Convertibility regime, the means of money growth and inflation are completely different. The average rate of money growth is six times higher than that of inflation. First, the sharp reduction of inflation after the setting of the hard peg led to an increase in money demand, i.e., a reduction in money velocity. Second, the dynamics of money under this particular regimen was mainly driven by money demand which was closely related to the balance of payment result. Finally, money growth was substantially higher than the inflation rate after the abandonment of Convertibility.

Money growth and inflation volatility are similar and relatively high considering the whole sample. Nevertheless, when splitting the sample, we find different behaviors. Both series are highly volatile during “high inflation” although money growth is more volatile than inflation. In hyperinflation the volatilities of both series are high and quite similar.

Under Convertibility, the volatility of both series reduced sharply, even though the money growth standard error is 12 times higher than that of inflation. In managed floating, money growth volatility is similar to that of the previous period, while inflation volatility increases a bit.

As mentioned before, the international evidence confirms strong positive co-movement between μ and π in the long run. Lucas (1980) finds a relation close to one between both series after filtering to get rid of the noise present in high frequency data. Mc Candless and Weber (1995) study the relation between average inflation and money growth rates for a long period of time and for a significant group of countries. Their results also confirm a positive co-movement between both series.

We first calculate correlations between μ and π for high frequency data (monthly growth change). The correlation between μ and π is strong and significant for the whole sample. In particular, the co-movement among series is relatively significant in the high inflation period and even greater during hyperinflation.

On the contrary, during Convertibility and the managed floating, both low inflation periods, the relationship between these series weakens. This result is consistent with findings for other economies using low frequency data (see Dwyer y Haffer, 1999 and De Grauwe y Polan, 2001).

Considering lower frequency data (annual growth rates), the correlation between μ and π increases on average, except for 1970M01–1975M05 period. This last period is rather atypical because of a price control policy implemented by the government.

With respect to the Convertibility and the managed floating, the correlation between both series increases when using low frequency data. From 1993M01– 2005M12, named from now on as the “low inflation” period, the correlation between μ y π increases from 0.13 for monthly changes to 0.68 for annual changes.

Figure 3.2 shows Cross-plot between μ and π annual changes for the different periods. In spite of the increase in correlations using low frequency data, the proportionality between both series weakens for the “low inflation” period, compared to the “very high inflation” period (1975M6 – 1988M12). It can be seen from Figure 3.2. that the slope of a regression line between both variables is much lower under low inflation than in the previous period.

The results are quite similar using moving averages. The correlation between μ y π strengthens as the size of the windows increases. This result is more significant for the “low inflation” period than for the high inflation one, as expected.

In particular, correlations for the Convertibility period increase from 0.26 for MA(0) to 0.74 for MA(2) (see Table 3.2).

Table 3. 2: Correlations between Inflation and Money growth* (MI)
Moving averages

	1970:1 2005:7	1970:1 1975:5	1975:6 1988:12	1989:1 1991:3	1993:4 2001:12	2002:1 2005:7	2002:9 2005:7
MA(0)	0.77597	0.09334	0.50678	0.75082	0.26555	0.10950	-0.22339
MA(2)	0.84189	0.16679	0.61905	0.81357	0.74471	0.04630	-0.35836
MA(4)	0.91100	0.15708	0.73847	0.91252	0.69303	0.13300	-0.54267
MA(6)	0.94309	0.12884	0.80621	0.95634	0.83776	0.26530	-0.52624
MA(12)	0.96838	0.00028	0.87580	0.98123	0.92707	0.38498	0.34314

* Seasonally adjusted

To sum up, inflation and money growth have a significant positive correlation in the long term. Once we remove the noise present in high frequency using moving averages or annual changes the correlation between money growth and inflation becomes very high, even for most of the part of the “low inflation period” that corresponds to the Convertibility regime.

During the very high inflation period, cross-plots between μ and π converge to the 45° slope, in line with Lucas (1980). In contrast, in low inflation the proportionality between these series, weakens, even for low frequency data. These results are consistent with recent empirical evidence (De Grauwe y Polan, 2001).

In terms of monetary policy decisions, it is interesting to answer the question about how changes in money are informative about the future path of prices. With this aim, we study if μ leads π through Granger causality tests. Since we focus on the short run dynamics of money growth and inflation, tests were done using monthly changes on M1 (seasonally adjusted) and retail prices.

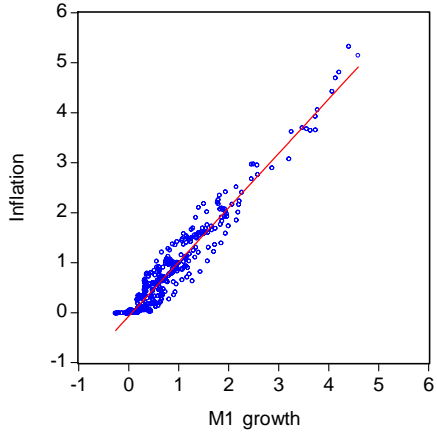
First, when we consider the full sample, we find a feed back relationship between the two variables that is robust to changes in the lag length.

During the “high inflation” period (1970M01– 1975M05), we do not find any kind anticipation from one variable to the other a result consistent with the low correlation found between these two series for this sub-sample. As it was mentioned before, this could be due to price controls implemented during 1973.

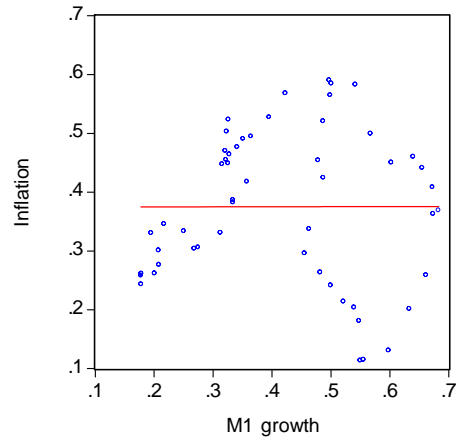
For the “very high inflation” (1975M06 – 1988M12) period, we find that inflation leads money growth, a result that is robust to changes in the lag length. Although apparently counterintuitive, this could be consistent with a real money demand that responds negatively to expected inflation (see Cagan, 1956) in an environment of very high inflation. The fact that inflation anticipates money growth could be due to adaptative expectations or the to the fact that inflation was highly persistent. Since bivariate analysis does not allow to identify “inflation expectations” this is only a presumption. Multivariate analysis in Section 5 will allow a better assessment of inflation expectations

Figure 3.2: Annual change in money (M1) and inflation (CPI)

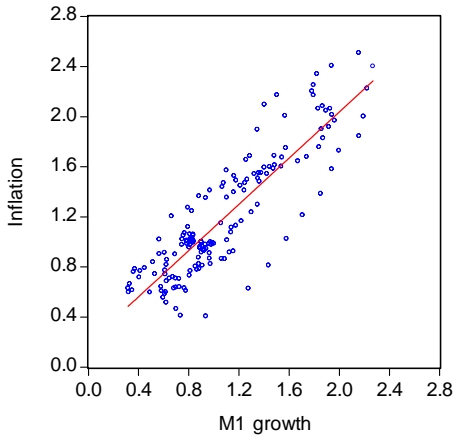
1975.1 - 2005.12



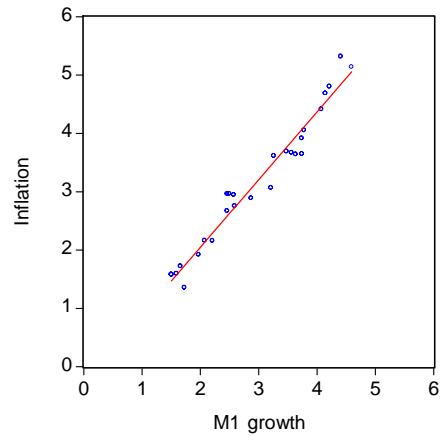
1970.1 - 1975.5



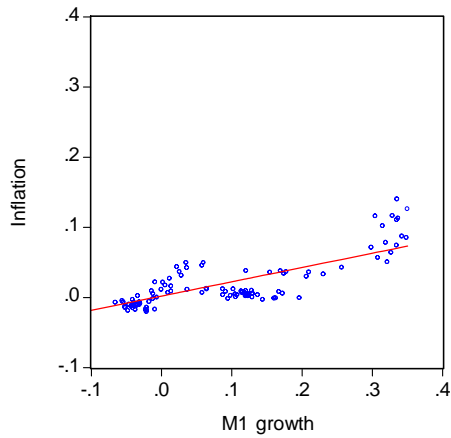
1975.6 - 1988.12



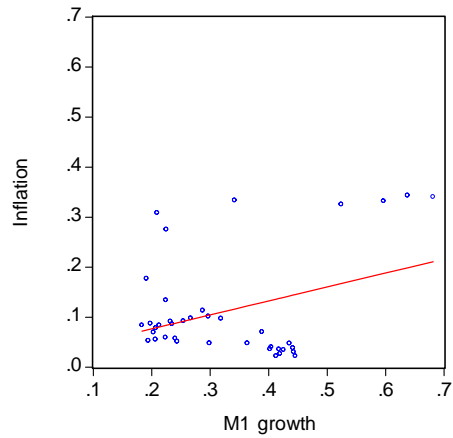
1989.1 - 1991.3



1993.1 - 2001.12



2002.9 - 2005.12

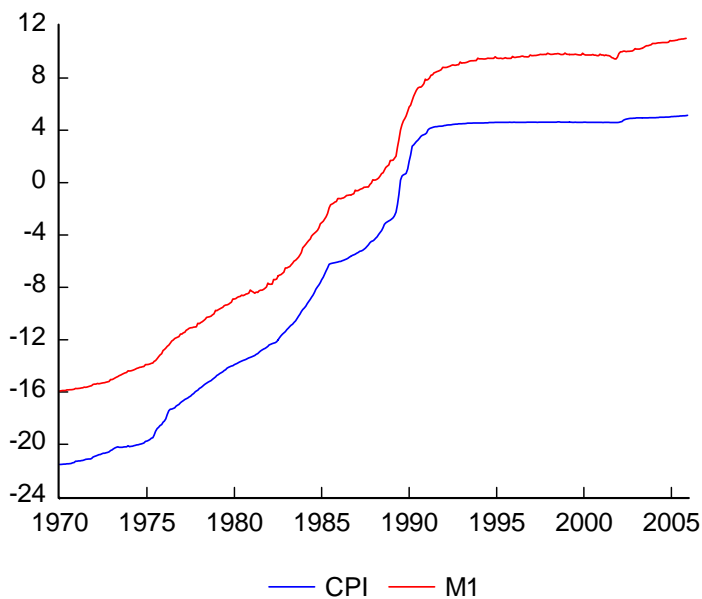


For the Convertibility (1993M01 – 2001M12) period, we find that money growth leads inflation. Finally, during managed floating, Granger Causality tests suggest that money changes anticipate inflation either. Nevertheless, these results need to be taken cautiously, due to the expansionary bias of the central bank policy related to its role as a lender of last resort during the financial crisis 2001-2002. Excluding the first nine-month of 2002, we do not find any anticipation from money growth to inflation.

3.2. The long-run relationship between money and prices

The finding of similar growth rates of money and prices for the whole sample and the time series inspection suggest a long run trend for both variables, money and prices (see Figure 3.3). This could imply the presence of a co-integration relation. However, the great macroeconomic instability of the analyzed period suggests that the long run relationship could not be unique and stable along the whole sample.

Figure 3.3: Money (M1) and Consumer Price Index (CPI) in logs (1970 – 2005)



The existence of a long run relationship between money and prices has been evaluated using the system-based procedure of Johansen (1988) and Johansen and Juselius (1990). The Vector Error Correction Mechanism allows testing the validity of the conditional models through the “weak exogeneity tests”.

The starting point to evaluate cointegration is to analyze the time-series properties of the variables. We analyze the order of integration of the both time series using the

Augmented Dickey Fuller (ADF) test, a standard unit root test; the Phillips-Perron (PP) and other versions of Dickey-Fuller recursive and rolling which allow to evaluate changes in mean and trend. These tests have a null hypothesis of non-stationarity against the alternative of stationarity. The conventional tests (ADF y PP) indicate that we can't reject the null hypothesis of the presence of a unit root in MI and IPC (measured in logs). However, the results of the other Dickey Fuller versions are not conclusive about the order of integration of both time series.⁶

Given that not only economic theory but also the empirical literature are in favor of its treatment as stationary in differences, this paper considers money and prices as integrated of order 1, I(1). The long-run relationship between them is evaluated for the same sub-periods mentioned in Section 3.1. The cointegration analysis was made using quarterly data.

Table 3.3: Money and prices: Long-run relationship and exogeneity

Period	Cointegration	Exogeneity	Equilibrium Correction Term
1970-2005	no		
1970-1975	yes	money	$Dlcpi_t = - 0.58 [lcpi_{t-1} - 0.96 lm1_{t-1}]$
1977-1988	yes	money	$Dlcpi_t = - 0.14 [lcpi_{t-1} - 1.03 lm1_{t-1}]$
1992-2001	yes	money	$Dlcpi_t = - 0.49 [lcpi_{t-1} - 0.17 lm1_{t-1}]$
2002-2005	yes	money	$Dlcpi_t = - 0.36 [lcpi_{t-1} - 0.23 lm1_{t-1}]$

Table 3.3 shows the presence of a positive long-run relationship between money and prices for the selected periods, except for the hyperinflation period. The system-based procedure of Johansen (1988) and Johansen and Juselius (1990) indicates the presence of a positive long-run relationship between money and prices for the complete sample except for the hyperinflation period. The relationship is quite stable until 1988, an increment of money generates a proportional change in prices in the long run. Since the Convertibility regime, the long run impact of money on prices is less than one (0.17) and the long run effect increases a little since the abandonment of such a regime to 0.23. If the whole sample is considered, it is not possible to find a long run stable relationship, this finding validates the prior of different behavior during high and low inflation regimes. Exogeneity tests indicate that money is weak exogenous, which also validates the conditional model of prices on money.

These results confirm that long run relationship between money and growth depends on the level of inflation. In particular we observe two relevant regimes, according to cointegration analysis. Proportionality holds in the long run between money and prices under the period of high inflation but their relationship weakens during the period of low inflation. The results also validate the splitting of the sample based on the average level of inflation. In particular, we broadly identify two regimes: high inflation between 1970 and 1988 and low inflation between 1993 and 2005. In all cases the exogeneity test validate a conditional model of prices on money.

⁶ Appendix I presents an exhaustive analysis of these results.

4. Inflation and velocity

If the quantity theory holds, money has a transactional role and real balances should keep a stable relationship with aggregate transactions. This ratio is money velocity, which is assumed to be relatively stable in short run, since it depends on financial technologies, agents' preferences, or institutions, that remain stable in a short horizon.

The empirical evidence that indicates that money velocity is in general volatile has contradicted the idea of stable velocity. Under high inflation regimes, in which the inflationary tax usually is a significant source of tax revenues, inflationary expectations are a main determinant component of real money demand and velocity is not independent of those expectations. Money growth accelerations, through their effects on inflationary expectations lead the public to get rid off their real money holdings. Consequently, increases in money velocity feed inflationary dynamics. In high inflation economies it is usual to observe that both, accelerations of inflation and stabilizations have significant effects on money demand and velocity.

With the purpose of investigating the dynamics of money velocity and its relationship with money growth and inflation we calculate it according to the quantity equation:

$$M * V = P * Q$$

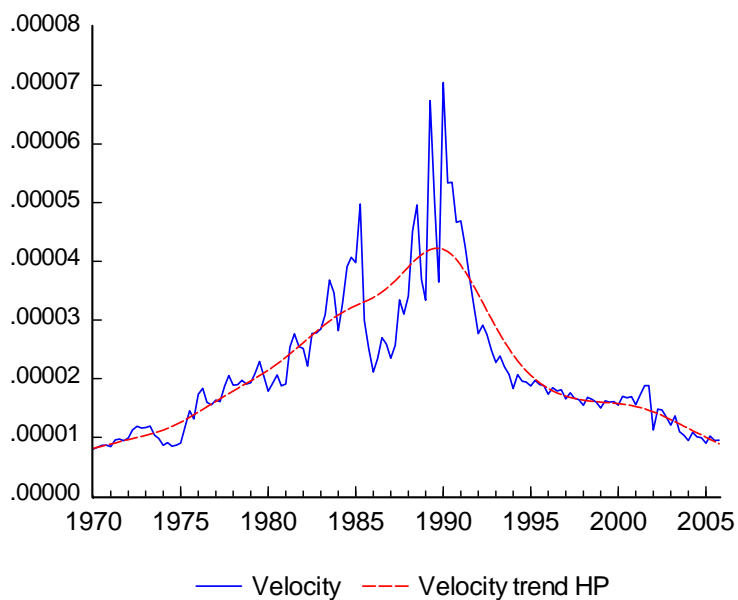
where M is money in nominal terms, V is money velocity, P is price level and Q is real output. So, velocity can be presented as:

$$V = (P * Q) / M$$

Using nominal output, according to the methodology described in Appendix I, we calculate income velocity for M1 over the period 1970-2005 (quarterly basis).

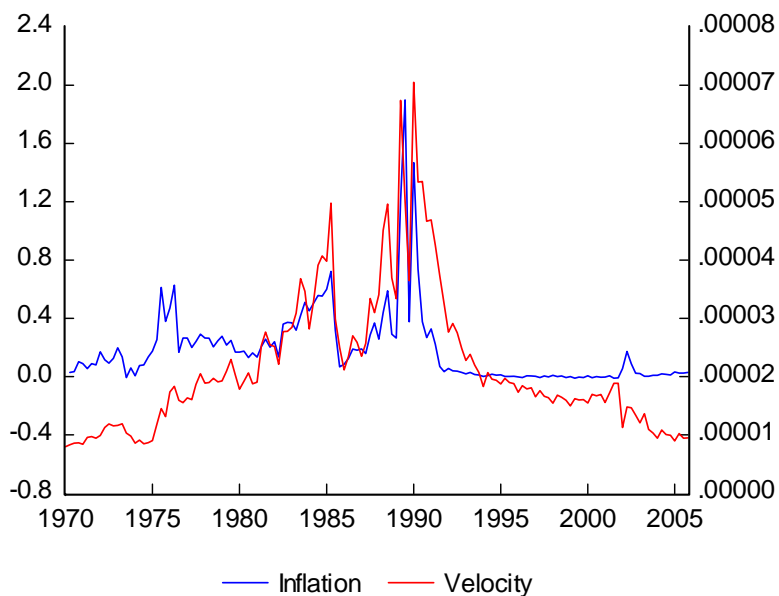
Figure 4.1 shows that M1 velocity (Veloc1) is highly volatile. Detrending velocity by Hodrick-Prescott filtering (Veloc1 trend HP), indicates an increasing trend from 1970 to 1990, and a decreasing one between 1991 and 2005.

**Figure 4.1: Money Velocity
(1970-2005)**



Additionally, we verify that velocity is positive correlated with inflation for the full sample (lineal correlation between this series is 0.72).

**Figure 4.2: Inflation and Money velocity
(1970-2005)**



During most of seventies and eighties except for the brief stabilization of the *Plan Austral* in 1985, inflation shows an increasing trend. After the sharp reduction of inflation that followed the Convertibility regime, velocity shows a persistently decreasing trend. Since the 2001 financial crisis, this diminishing trend deepened and still persists despite the slight acceleration of inflation in 2005.

From Figure 4.2, two different periods can be identified: the first one of, “high inflation” (from 1970Q1 and 1988Q4); and the second one, a period of “low inflation” (1993Q1-2005Q4). We analyze the relationship between velocity, money growth (μ) and inflation (π) for those two periods (see Table 4.1). It can be seen from Table 4.1 that for the first one, an acceleration of money growth is related to a rise in inflation and velocity. During this period, the correlations between velocity and inflation, and velocity and money growth are 0.72 and 0.71, respectively. These results are consistent with Cagan findings (1956) for high inflation countries. Under “low inflation”, velocity is negatively correlated to π and μ . In particular, from 1993Q1 to 2005Q4, the correlation between velocity and π is -0.20 , and between velocity and μ is -0.33 .

Table 4.1: Correlation between Velocity (V) and Inflation (π), and Velocity and Money growth (μ)

Correlation	1970Q1-2005Q4	1970Q1-1988Q4	1989Q1 - 1991Q1	1993Q1 - 2005Q4
V - π	0.72095	0.72153	0.62203	-0.20174
V - μ	0.70587	0.78213	0.38427	-0.33407

Note: μ is quarterly change of M1 seasonal adjusted, π is quarterly change of CPI

De Grauwe and Polan (op. cit.) suggest that in the case of low inflation economies, the negative correlation between velocity and μ could be explained by the liquidity effect. Increases in money growth lead to interest rates drops, which also lead to a rise in money demand (i.e. a decrease in velocity).

Our results for the “low inflation” period are consistent with international panel data analysis that shows a negative correlation between money growth and velocity for low inflation economies (see De Grauwe and Polan, op. cit.).

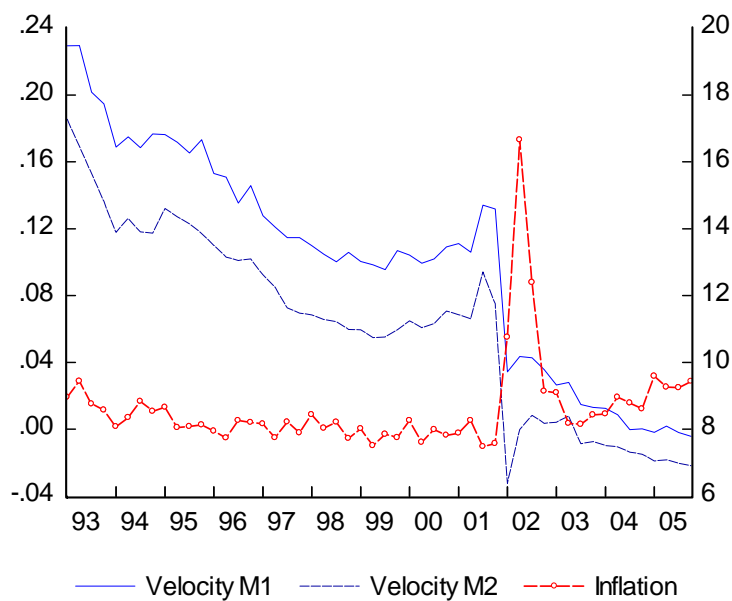
In high and unstable economies, as it is the case of Argentina, macroeconomic stabilizations usually lead to a re-monetization of the economy. We observe this empirical regularity after the Plan Austral, the convertibility and the 2001-02 financial crisis.

It is interesting to analyze the relationship between velocity and inflation during the managed floating. After the abandonment of Convertibility in January 2002, inflation reached a pick in April in 2002. However, velocity, measured for M1 and M2⁷, show a

⁷ M2 is defined as M1 plus deposits in savings accounts.

persistently decreasing trend (see Figure 4.3). This dropping trend could reflect a greater liquidity preference whose causes could be multiple.

Figure 4.3: Inflation and Money velocity
(1993Q1- 2005Q4)



On the one hand, there are institutional factors related to the change in monetary regime that led to a de-dollarization of the economy. On the other hand, more temporary factors, as the negatives effects of the 2001-02 crisis on confidence of the public on the financial system, can also explain a higher liquidity preference.

Regards to the institutional factors, the abandonment of the currency board, eliminated the implicit currency insurance of the Convertibility Law⁸. Additionally, the government implemented several polices aiming to de-dollarize the economy particular, domestic financial liabilities, utilities tariffs, and the financial system balance- sheet were *pesified*.⁹ Finally, in order to discourage potential re-dollarization of the financial system, financial restrictions were introduced to the use of dollar deposits and higher banks reserves were required to them either. These measures rose the cost of using dollar as a transaction currency, decreased the incentives for dollar funding and increased the exchange risk exposure to dollar denominated contracts. The percentage of peso deposits to total deposits increased from 34% in 2001 to 90% at the end of 2005.

Regards to temporary factors, the less public confidence in the banking system probably reflected in changes in the portfolio to more liquid asset. Despite the strengthening of the financial system, the ratio time deposits to GDP is still below the one observed through

⁸ 23.928 Law. Since the Civil Code reform it was authorized denominate financial contacts in dollars terms.

⁹ In 25.561 Law and 214 Decree specify the scope of *pesification* and its exceptions.

nineties. At the same time, the ratios of money aggregates to GDP considerably exceed the levels reached during '90s.

To sum up, the decreasing trend in velocity in this last period can be explained by multiple causes. Permanent and temporary factors affecting agent's behavior generate instability in money holdings by the private sector, making it difficult to predict money demand or inflation conditional on money growth.

5. The short run dynamics of money growth and inflation

In this Section we study the short run relationship between money growth and inflation. We enlarge our variables set to include other relevant macroeconomic aggregates and prices that could potentially play a relevant role in the transmission of nominal shocks to the economy and in particular, to inflation: the nominal interest rate, GDP growth and the change in the nominal exchange rate.

We estimate Vector Autoregressive Model (VAR) models using these variables, following the methodology originally proposed by Sims (1980a), which allows for treating all variables of the system as endogenous.

VAR analysis provides useful tools to study short run dynamics: (i) impulse-response functions, which quantify the response of all endogenous to a shock (impulse) on any of them, and (ii) variance decomposition, that allows calculating how each endogenous variable contributes to explain others and its own variability.

The calculation of impulse-response functions and variance decomposition requires restrictions to identify shocks. We use the Cholesky decomposition that is not theory based and simply requires imposing restrictions on the contemporaneous relationship of variables. We choose using this decomposition because our interest is to describe the joint dynamics of the variables under study rather than to conduct policy analysis or forecast. Thus, we want to introduce the less theory-based restrictions.

To identify shocks we impose the following ordering for the Cholesky decomposition. The nominal interest rate was put first, assuming that it is highly probable that this variable can have a contemporaneous effect on the other variables in the system, while the opposite is much less probable. The interest rate is then followed by money growth, the change in the multilateral nominal exchange rate, the GDP growth and lastly, the inflation rate.¹⁰

Interest rate shocks (impulses) are not necessarily interpreted here as monetary policy shocks. During the very high inflation period they can probably reflect shocks to inflation expectations, which in this context could even drive the interest rate dynamics (as in Cagan, 1956).

¹⁰ This ordering assume no contemporaneous effects of financial variables as money and the nominal exchange rate on the nominal interest rate, what is quite plausible for monthly data, but can be under question for quarterly data, which is the case here.

Under the Convertibility regime there was no active monetary policy, so movements on interest rates in the domestic currency mainly reflected changes on exchange rate depreciation expectations and sovereign risk perceptions. A managed floating was set in 2002. Since then, the interest rate on Central Bank bills, which influences the liquidity in the inter-bank market began to be used as an instrument for monetary policy.¹¹

We estimated VAR models for the whole sample as well as for the high inflation period 1977Q3-1988Q4, the Convertibility period 1993Q1-2001Q4 and the low inflation period, 1993Q1-2005Q4. The reason for considering the Convertibility first and then extending the sample to the managed floating is to identify changes in the joint short run dynamics of variables.

Models were estimated for quarterly data which include the following variables: the nominal interest rate on time deposits (LTNA), the real GDP growth (DLPIB), the change in the multilateral nominal exchange with main trade partners (DLTCN3S) and the CPI inflation (DLIPC).

The models selected according to the standard criteria of normality, non autocorrelation and homoskedasticity. We also checked the stability of VAR models. Dummy variables were incorporated when necessary to control for outliers. The lag-structure was selected based on Akaike, Schwarz and Hannan-Quinn criteria.

VAR models are specified in differences mainly because our interest in this section is to study short run dynamics. This treatment is supported by unit root tests, which are in general in favor of the hypothesis of unit roots for all variables, except the nominal interest rate.¹² Variables were specified in natural logs differences, except for the interest rate.

When considering the whole sample (1977Q1-2005Q4) we are not able to obtain a model that satisfies the conventional criteria.¹³ In particular, models are highly heteroskedastic, what is an indication of a changing volatility of the joint dynamics of the variables under study.

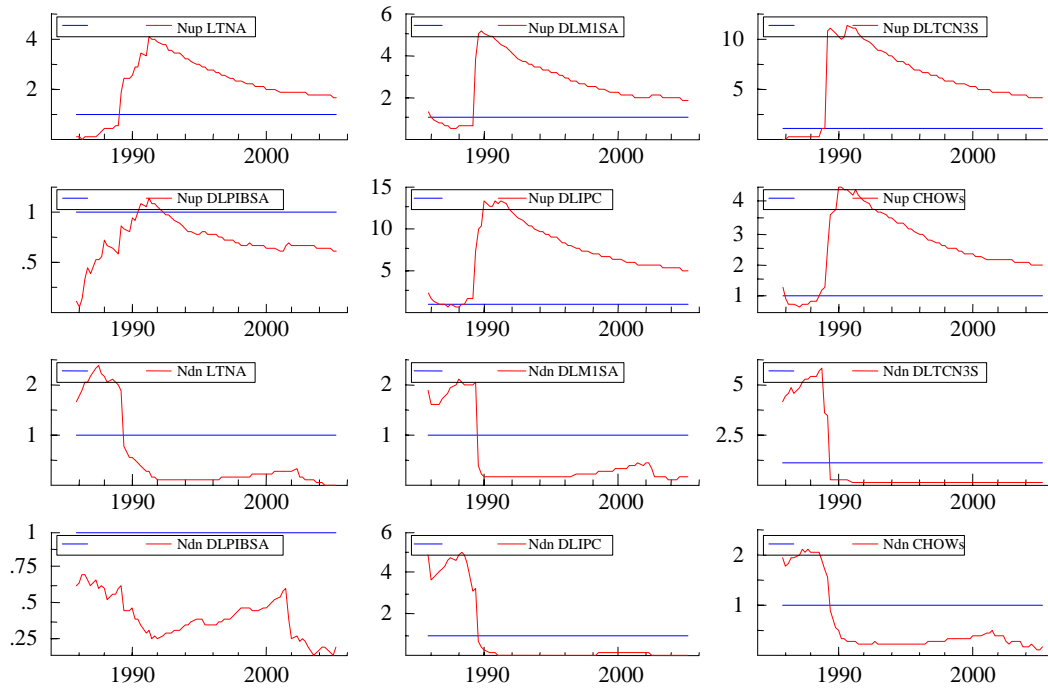
Since very different monetary regimes were in place over our sample period, we face the problem of regime changes. We partially identified them in Section 3, when studying long run dynamics through descriptive and cointegration analysis. In this section we evaluate parameters stability through recursive Chow tests. Recursive analysis using Chow Break-point tests (N descendent) and Forecast (N ascendent) to test for parameters stability, reveal the presence of a structural break in the hyperinflation period (see Figure 5.1). This evidence supports the splitting of the sample into periods based on “mean inflation”, which was, to some extent, the criterion adopted a priori for the descriptive analysis.

¹¹ LEBAC (Central Bank notes).

¹² The presence of a unit root for the variables in the VAR system was evaluated running conventional augmented Dickey Fuller and Phillips Perron tests as well as sequential and rolling test to check for the presence of structural breaks in the mean or the slope of time series. See Appendix I.

¹³ The sample had to be restricted to the period 1977Q1-2005Q4 when including the interest rate in the analysis, given the lack of data for the period 1970Q1- 1976Q4.

Figure 5.1: Parameters stability



The presence of structural breaks restricts the possibility of estimating a model for the complete period using conventional estimation techniques. More sophisticated instruments, as varying coefficient models have to be used to address the problem. Our approach to the problem here is rather simple. We split the sample and study the dynamics under high and low inflation and also check for the presence of significant changes in dynamics after the abandoning of the Convertibility regime, given the results of the Chow break point tests, which do not detect a structural break associated to the change in the monetary regime.

Table 5.1. shows the correlation VAR residuals for the different periods. It can be observed that for all the sub-periods, these correlations are significant. This result implies that the order imposed to the variables for the Cholesky decomposition has an influence on the obtained impulse response functions. Thus, changing the ordering can change the results.

Table 5.1: VAR Models – Residuals Correlation Matrix

1977Q3 - 1988Q4					
	LTNA	D(LMISA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
LTNA	1				
D(LMISA)	-0.130	1			
D(LTCN3S)	0.352	0.283	1		
D(LPIBSA)	0.204	-0.088	-0.138	1	
D(LIPC)	0.657	0.377	0.633	0.007	1
1993Q1 - 2001Q4					
	LTNA	D(LMISA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
LTNA	1				
D(LMISA)	-0.575	1			
D(LTCN3S)	-0.127	0.036	1		
D(LPIBSA)	-0.356	0.545	0.153	1	
D(LIPC)	0.146	-0.081	0.053	0.009	1
1993Q1 - 2005Q4					
	LTNA	D(LMISA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
LTNA	1				
D(LMISA)	-0.642	1			
D(LTCN3S)	-0.308	0.092	1		
D(LPIBSA)	-0.381	0.348	0.175	1	
D(LIPC)	0.402	-0.132	-0.165	-0.138	1

(i) *Short run dynamics under high inflation*

During most part of the high inflation period the nominal exchange rate was used as a policy instrument to reduce and stabilize inflation.

Results of estimating a VAR model for this period are summarized in Figure 5.2 and Table 5.2 that show impulse-response functions and variance decomposition respectively.

Looking at impulse-response functions, a first striking result is the positive response of changes in money growth to changes in the interest rate. It is possible however, that in a regime of very high inflation, as it was the case of Argentina during part of the 70's and 80's, money demand was mainly determined by inflation expectations, which in turn were the main component governing the dynamics of the nominal interest rate. In this context, movements in this rate cannot be interpreted as the result of policy actions. On the contrary, they would rather reflect changes in inflation expectations. Thus a possible dynamics could be one in which increasing inflation expectations lead to a reduction in money holdings by the private sector followed by a response of the central bank increasing money supply.

Contrary to the results of bivariate analysis in Gabrielli et al, (op. cit) and the Granger Causality tests performed here in Section 3, once we broaden the variables set to include

the nominal interest rate, impulses on inflation do not have an effect on money growth. The finding of Granger Causality from inflation to money growth could be due to the fact that inflation captures the effect of inflation expectations on money growth that are omitted when using bivariate analysis.

Another non-standard result is that shocks to the nominal interest have a positive effect on nominal depreciation. But again, if shocks to the nominal interest rate mainly reflect shocks to inflation expectations, the response in an economy in which currency substitution was a relevant phenomenon could be one in which higher inflation expectations induce a flight from the domestic currency to a reserve currency as the dollar, and a consequent nominal depreciation.

The response of GDP growth to shocks to the interest rate is negative but weak and non persistent. Shocks to money growth have a slightly effect on GDP growth.

Impulses on money growth have a positive effect on inflation that lasts three quarters, but reaches a peak on the first quarter. Shocks to changes in the nominal exchange rate also have a positive effect on inflation, which is only significant for one quarter.

Given that it is not possible to identify the inflation expectations component of the interest rate, which seems to play a key role in this period, we estimated a VAR model excluding the nominal interest rate in order to check which of the variables seem to capture its impact on the rest of the variables in the system. Interesting results come from this exercise: (i) the response of money growth to inflation becomes significant and (ii) GDP does not respond to impulses on money growth whereas it negatively responds to shocks to the inflation rate.

Variance decompositions are shown in Table 5.2. from which it can be observed that the movements on the nominal interest rate are mainly explained by its own variability, while at the same time it contributes to explain a high proportion of the variability of the rest of the variables in the system. In particular 56% of the variability of the change in the nominal exchange rate is due to shocks to the nominal interest rate, which in turn contributes to explain 54 % of the variability of inflation and 44% of the variability of GDP growth. Finally, shocks to the interest rate account for 32% of the variability of money growth.

Summing up, during the period of high inflation, money growth and inflation appear to be mainly driven by inflation expectations. Shocks to the interest rate have a significantly positive effect on money growth and inflation and a negative effect on GDP growth. A simple exercise excluding interest rates from the VAR system suggests that the main driver of the nominal interest rate could be the inflation expectations component. Monetary impulses have a significantly positive effect on inflation but do not affect GDP growth.

Figure 5.2 VAR- 1977Q1 – 1988Q4 Impulse response functions

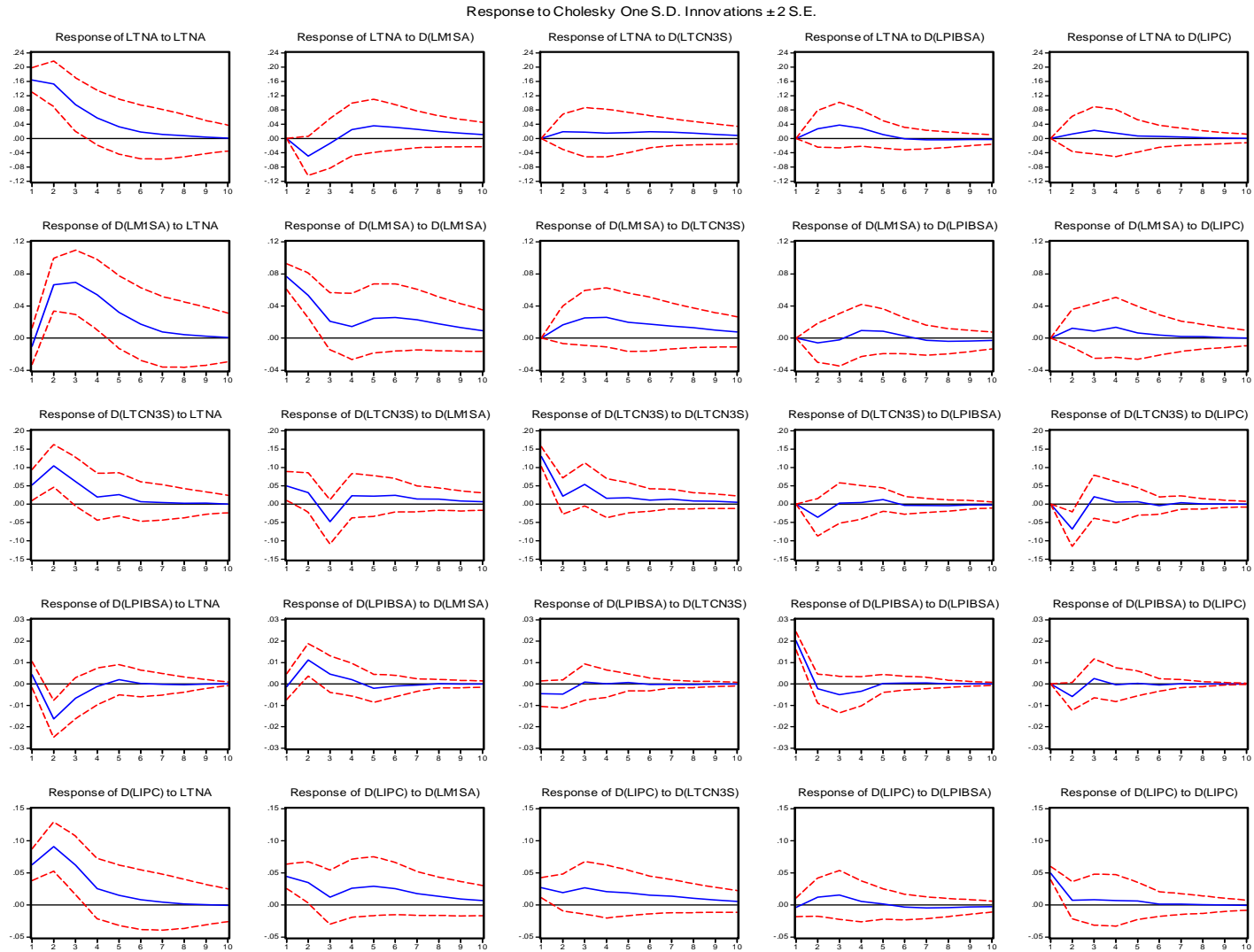


Table 5.2. VAR- 1977Q1 – 1988Q4
Variance Decomposition

Variance Decomposition of LTNA:

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.164	100.000	0.000	0.000	0.000	0.000
2	0.232	93.223	4.484	0.634	1.373	0.286
3	0.255	90.730	3.983	0.984	3.282	1.022
4	0.265	88.747	4.586	1.214	4.197	1.256
5	0.270	86.875	6.106	1.545	4.197	1.278
6	0.274	85.361	7.268	1.975	4.102	1.293
7	0.276	84.289	8.007	2.347	4.059	1.298
8	0.277	83.629	8.435	2.604	4.039	1.292
9	0.277	83.242	8.675	2.763	4.033	1.287
10	0.278	83.017	8.808	2.855	4.036	1.283

Variance Decomposition of D(LM1SA):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.077	1.682	98.318	0.000	0.000	0.000
2	0.117	33.102	63.559	1.997	0.250	1.091
3	0.140	47.560	46.497	4.596	0.199	1.148
4	0.154	51.706	39.426	6.622	0.541	1.705
5	0.161	51.427	38.501	7.569	0.773	1.730
6	0.165	50.116	39.091	8.324	0.765	1.704
7	0.167	48.855	39.825	8.881	0.769	1.669
8	0.169	48.033	40.206	9.301	0.811	1.649
9	0.170	47.559	40.400	9.557	0.852	1.633
10	0.170	47.306	40.483	9.709	0.879	1.624

Variance Decomposition of D(LTCN3S):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.148	12.379	11.018	76.603	0.000	0.000
2	0.201	33.766	8.505	43.047	3.208	11.474
3	0.223	34.931	11.506	40.807	2.622	10.136
4	0.226	34.869	12.250	40.331	2.600	9.950
5	0.229	35.079	12.782	39.610	2.809	9.721
6	0.231	34.657	13.680	39.264	2.789	9.610
7	0.232	34.416	13.939	39.286	2.795	9.564
8	0.232	34.237	14.218	39.222	2.812	9.512
9	0.233	34.161	14.313	39.228	2.811	9.488
10	0.233	34.112	14.374	39.221	2.817	9.476

Variance Decomposition of D(LPIBSA):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.021	4.170	0.385	4.674	90.770	0.000
2	0.030	31.806	14.160	4.824	45.385	3.825
3	0.032	33.171	14.855	4.422	43.448	4.104
4	0.032	32.748	14.980	4.347	43.878	4.048
5	0.032	32.839	15.278	4.357	43.507	4.020
6	0.032	32.790	15.363	4.357	43.449	4.042
7	0.032	32.773	15.387	4.356	43.442	4.041
8	0.032	32.778	15.384	4.365	43.431	4.042
9	0.032	32.778	15.385	4.366	43.430	4.042
10	0.032	32.777	15.386	4.367	43.429	4.042

Variance Decomposition of D(LIPC):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.095	43.198	21.753	7.976	0.152	26.921
2	0.138	63.671	16.671	5.760	0.848	13.049
3	0.155	66.373	13.819	7.501	1.690	10.617
4	0.161	64.162	15.448	8.644	1.690	10.055
5	0.166	61.540	17.728	9.463	1.608	9.661
6	0.169	59.671	19.420	9.977	1.593	9.338
7	0.170	58.624	20.141	10.434	1.632	9.170
8	0.171	58.016	20.536	10.698	1.675	9.075
9	0.172	57.697	20.730	10.850	1.700	9.024
10	0.172	57.530	20.828	10.924	1.719	8.999

Cholesky Ordering: LTNA D(LM1SA) D(LTCN3S) D(LPIBSA) D(LIPC)

(ii) *Short run dynamics under low inflation*

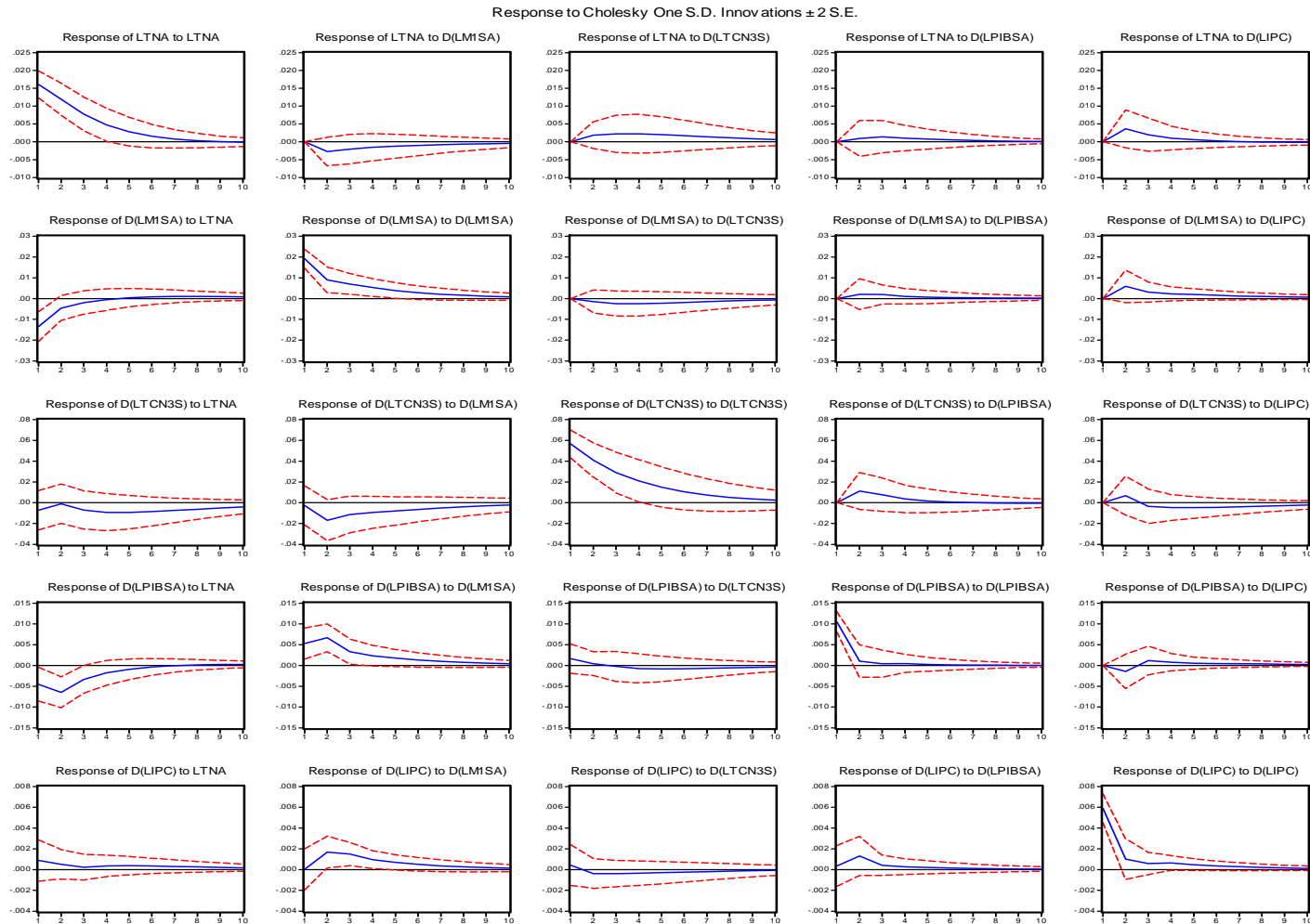
According to our definition, the low inflation period goes from 1993 to 2005, including two different monetary regimes: Convertibility, from 1993 to the end of 2001 and a managed floating since January 2001 to the end of the sample. The main difference between those two periods regarding the relationship between money and prices is that Convertibility, by providing implicit exchange rate insurance, induced a dollarization of financial assets, contracts and to a certain extent, cash transactions in the economy, which mostly reversed after the abandonment of this regime. Since we do not have enough observations to study these two periods separately and evaluate to what extent the change in the monetary regime lead to a statistically different short run dynamics, we proceeded in two steps: we estimate VAR models for both the Convertibility and the complete low inflation period and compare the results.

Figure 5.3 shows the impulse response functions for the Convertibility period, under which the nominal exchange rate to the dollar remained fixed as a mean to provide a nominal anchor to the economy. Under this scheme monetary policy was essentially passive and the dynamics of money was mainly driven by money demand and closely related to movements on the capital account of the balance of payments. Impulse response functions reflect a very different dynamics compared to the high inflation period. First, the response of money to the nominal interest rate is more in line with those in the literature, since it is positive. It is however, very rapid and remains significant over the first quarter. GDP growth responds negatively to shocks to the nominal interest rate, as expected, whose effects remain significant over three quarters.

Impulses on money growth have a positive effect on GDP growth, which is also rapid and remains significant for three quarters. They also have a significant but relatively weak effect on inflation, which becomes significant with some delay, after one quarter and persist for four quarters. Shocks to the nominal exchange rate do not have any impact on the rest of the variables of the system. This result is not surprising, given that, although we are including here a multilateral nominal interest rate (with respect to the three main trade partners of Argentina), the variability of this multilateral exchange rate was extremely low over this period.

Variance decompositions are shown in Table 5.3. They indicate that the dynamics of the interest rate, money and inflation are mainly exogenously driven. The nominal interest rate explains, however, 25% of the variability of money growth. On the contrary, a high proportion of the variability of GDP growth is explained endogenously, mainly by impulses to the nominal interest rate and to money growth.

Figure 5.3 1993Q1 – 2001Q4 Impulse-response functions



**Table 5.3. VAR- 1993Q1 – 2001Q4
Variance Decomposition**

Variance Decomposition of LTNA:

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.0161	100.00	0.00	0.00	0.00	0.00
2	0.0206	94.13	1.79	0.81	0.19	3.09
3	0.0224	92.02	2.38	1.67	0.54	3.39
4	0.0231	90.73	2.68	2.51	0.70	3.39
5	0.0234	89.77	2.90	3.19	0.78	3.36
6	0.0235	89.10	3.06	3.68	0.82	3.33
7	0.0236	88.66	3.17	4.01	0.84	3.31
8	0.0236	88.38	3.25	4.22	0.85	3.30
9	0.0237	88.21	3.30	4.35	0.85	3.30
10	0.0237	88.11	3.33	4.42	0.85	3.30

Variance Decomposition of D(LM1SA):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.0234	33.06	66.94	0.00	0.00	0.00
2	0.0263	29.28	64.84	0.32	0.62	4.94
3	0.0276	26.99	65.18	1.06	1.05	5.72
4	0.0284	25.67	65.37	1.76	1.13	6.07
5	0.0288	24.95	65.26	2.30	1.16	6.34
6	0.0290	24.60	65.05	2.66	1.17	6.52
7	0.0292	24.45	64.85	2.89	1.17	6.63
8	0.0293	24.41	64.68	3.02	1.17	6.71
9	0.0294	24.41	64.56	3.10	1.17	6.76
10	0.0294	24.43	64.47	3.14	1.18	6.79

Variance Decomposition of D(LTCN3S):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.0570	1.62	0.21	98.18	0.00	0.00
2	0.0735	0.99	5.46	90.36	2.35	0.83
3	0.0805	1.58	6.52	88.14	2.87	0.89
4	0.0844	2.64	7.15	86.30	2.79	1.12
5	0.0867	3.63	7.62	84.73	2.68	1.35
6	0.0881	4.44	7.91	83.50	2.60	1.55
7	0.0890	5.05	8.08	82.60	2.55	1.72
8	0.0895	5.48	8.18	81.98	2.52	1.84
9	0.0898	5.76	8.24	81.57	2.51	1.92
10	0.0900	5.94	8.27	81.31	2.50	1.97

Variance Decomposition of D(LPIBSA):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.0127	12.69	17.26	1.63	68.42	0.00
2	0.0158	24.93	28.80	1.12	44.33	0.82
3	0.0165	26.85	30.29	1.04	40.56	1.26
4	0.0168	27.00	31.17	1.19	39.22	1.42
5	0.0170	26.83	31.72	1.42	38.54	1.50
6	0.0171	26.62	32.01	1.63	38.19	1.56
7	0.0171	26.48	32.15	1.79	37.98	1.61
8	0.0171	26.39	32.22	1.90	37.85	1.64
9	0.0172	26.35	32.25	1.96	37.77	1.67
10	0.0172	26.33	32.26	2.00	37.72	1.69

Variance Decomposition of D(LIPC):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.0060	2.14	0.00	0.52	0.36	96.98
2	0.0065	2.47	6.77	0.80	4.43	85.53
3	0.0067	2.42	11.29	1.09	4.52	80.68
4	0.0068	2.61	12.86	1.31	4.52	78.70
5	0.0069	2.87	13.59	1.47	4.52	77.55
6	0.0069	3.09	13.95	1.58	4.52	76.86
7	0.0069	3.26	14.13	1.65	4.51	76.45
8	0.0070	3.39	14.21	1.69	4.51	76.21
9	0.0070	3.48	14.25	1.71	4.50	76.06
10	0.0070	3.54	14.27	1.72	4.50	75.98

Cholesky Ordering: LTNA D(LM1SA) D(LTCN3S) D(LPIBSA) D(LIPC)

Finally the results for the VAR incorporating the managed floating period are shown in Figure 5.4 and Table 5.4. The model includes a dummy variable controlling for the effects of the sharp depreciation of the peso during the first quarter of 2002.¹⁴ The two models also differ in their lag structure. The model for the Convertibility period includes two lags of endogenous variables and the one for the complete period only one.

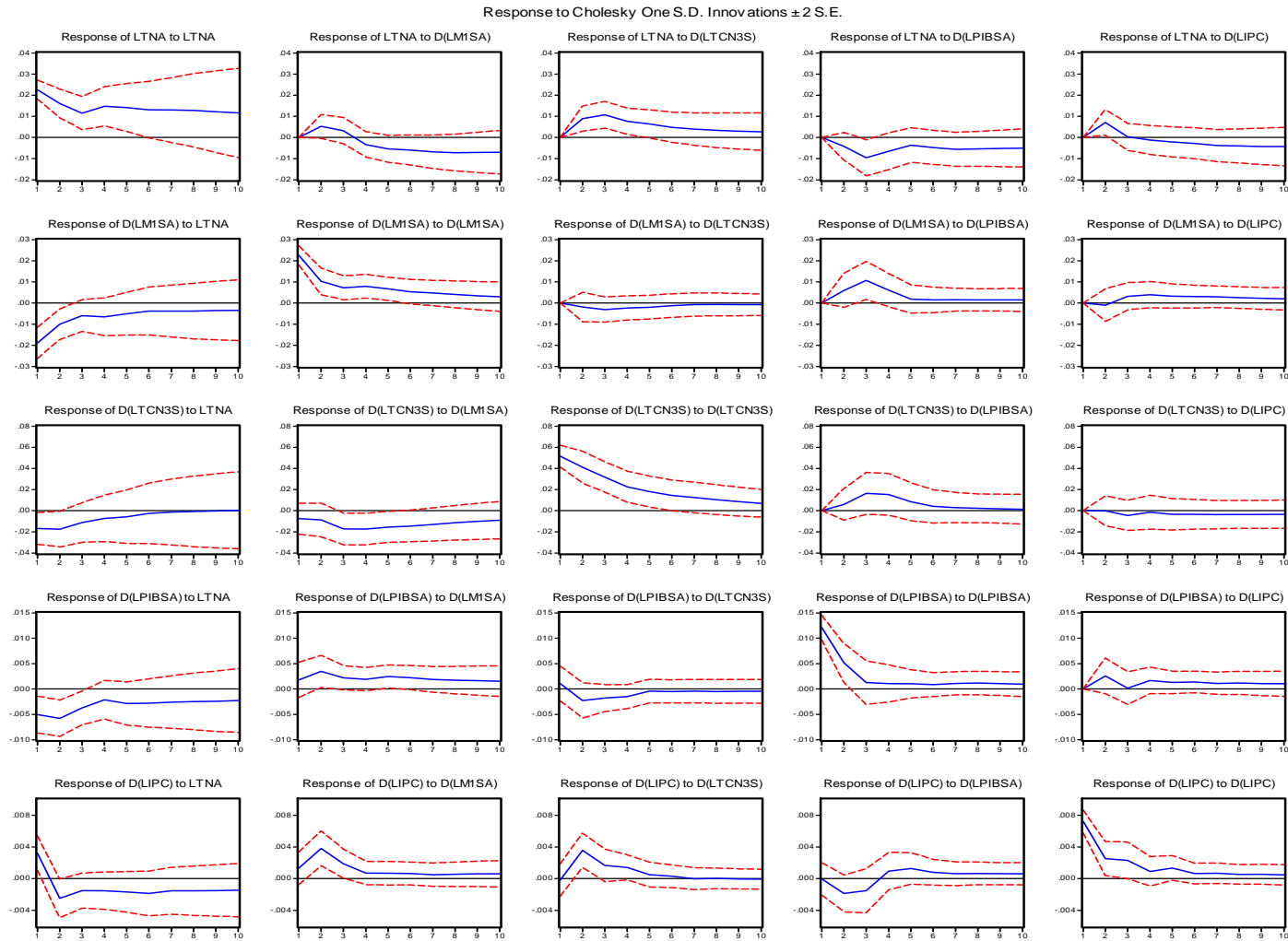
Figure 5.4. shows that the nominal interest rate responds positively to shocks to the nominal exchange rate. Money growth has a stronger and more persistent negative response to changes in the nominal interest rate compared to the Convertibility period. GDP growth responds with approximately the same intensity to impulses to the nominal interest rate, but its response to money growth is slightly more significant.

The main difference in the joint dynamics of the variables in the VAR system, compared to managed floating is that the dynamics of inflation is mainly endogenously determined. Inflation positively reacts to impulses on the nominal interest rate, money growth and nominal depreciation. In particular the response to money growth is stronger and more rapid than for the Convertibility sub-sample.

Summing up, once we control for the crisis period, it is possible to find a model describing the dynamics of the interest rate, money growth, nominal depreciation, GDP growth and inflation for the complete low inflation period. Impulse-response functions and variance decomposition indicate, however, relevant changes in dynamics with respect to the Convertibility period. In particular, there is a significant response of inflation to nominal depreciation and its response to impulses on money growth is stronger compared to the Convertibility period.

¹⁴ VAR residuals were evaluated according to the standard criteria of non-autocorrelation and normality. The presence of unit roots, indicating a divergent behavior of the VAR system was also checked. The presence of outliers was controlled introducing dummy variables as to ensure no rejection of normality tests according to conventional criteria.

Figure 5.4 VAR- 1993Q1 – 2005Q4 Impulse response functions



**Table 5.4 VAR- 1993Q1 – 2005Q4
Variance Decomposition**

Variance Decomposition of LTNA:

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.02	100.00	0.00	0.00	0.00	0.00
2	0.03	81.51	2.91	8.44	1.83	5.31
3	0.04	69.64	2.93	15.06	8.48	3.88
4	0.04	68.85	3.01	15.59	9.37	3.18
5	0.04	68.97	4.08	15.36	8.65	2.94
6	0.05	68.62	5.24	14.58	8.62	2.93
7	0.05	67.76	6.55	13.57	8.91	3.21
8	0.05	67.00	7.80	12.62	9.10	3.49
9	0.05	66.28	8.83	11.87	9.23	3.80
10	0.06	65.63	9.70	11.23	9.34	4.10

Variance Decomposition of D(LM1SA):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.03	41.16	58.84	0.00	0.00	0.00
2	0.03	41.11	55.23	0.33	3.24	0.09
3	0.04	36.95	49.94	0.98	11.29	0.84
4	0.04	35.77	48.67	1.24	12.53	1.79
5	0.04	35.39	48.77	1.41	12.06	2.37
6	0.04	35.07	48.85	1.45	11.78	2.86
7	0.04	34.91	48.77	1.44	11.59	3.29
8	0.04	34.93	48.60	1.44	11.45	3.58
9	0.04	35.01	48.39	1.44	11.36	3.79
10	0.04	35.13	48.16	1.45	11.31	3.95

Variance Decomposition of D(LTCN3S):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.05	9.47	1.89	88.64	0.00	0.00
2	0.07	11.53	2.63	85.12	0.72	0.00
3	0.08	10.43	6.31	78.51	4.47	0.29
4	0.09	9.64	9.21	74.03	6.85	0.28
5	0.09	9.25	11.24	71.99	7.13	0.39
6	0.10	8.86	12.98	70.70	6.96	0.49
7	0.10	8.55	14.28	69.74	6.79	0.62
8	0.10	8.33	15.25	69.02	6.67	0.73
9	0.10	8.17	15.99	68.43	6.57	0.84
10	0.10	8.05	16.57	67.94	6.49	0.94

Variance Decomposition of D(LPIBSA):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.01	14.50	1.82	0.65	83.03	0.00
2	0.02	22.69	5.83	2.43	66.48	2.56
3	0.02	25.73	7.04	3.35	61.52	2.36
4	0.02	25.99	7.96	3.96	58.91	3.19
5	0.02	27.21	9.43	3.80	56.02	3.54
6	0.02	28.25	10.48	3.69	53.62	3.95
7	0.02	29.16	11.12	3.61	51.96	4.15
8	0.02	29.88	11.59	3.56	50.57	4.41
9	0.02	30.59	11.98	3.51	49.35	4.58
10	0.02	31.19	12.29	3.47	48.32	4.73

Variance Decomposition of D(LIPC):

Period	S.E.	LTNA	D(LM1SA)	D(LTCN3S)	D(LPIBSA)	D(LIPC)
1	0.01	16.18	2.70	0.04	0.00	81.08
2	0.01	15.38	15.19	11.84	3.23	54.36
3	0.01	15.22	16.05	12.55	4.67	51.51
4	0.01	16.23	15.63	13.45	5.14	49.56
5	0.01	17.48	15.18	12.94	6.07	48.33
6	0.01	19.31	14.94	12.54	6.32	46.90
7	0.01	20.47	14.76	12.24	6.43	46.10
8	0.01	21.57	14.63	11.97	6.58	45.25
9	0.01	22.58	14.55	11.71	6.69	44.47
10	0.01	23.51	14.49	11.48	6.80	43.73

Cholesky Ordering: LTNA D(LM1SA) D(LTCN3S) D(LPIBSA) D(LIPC)

6. Conclusions

We analyze in this paper the relation between money growth and inflation from two perspectives. The first one focuses on the identification of empirical regularities in their dynamics and the stability of their relationship under different inflation regimes in Argentina. From the long run perspective, changes in inflation are positively related with changes in money growth. A long run relationship is found with coefficients that vary across sub-samples. In both cases, proportionality between money and prices holds under high inflation regimes but weakens in low inflation. These findings confirm that high and persistent inflation is related to sustained money expansions.

The money velocity is unstable even within the same inflationary regime. During high inflation, the accelerations in inflation are associated with higher money growth and velocity increases. On the contrary, during low inflation periods money growth and velocity are negatively correlated. These findings are in line with the international empirical evidence for countries with low inflation.

The second perspective focuses on the transmission of monetary shocks to prices in the short run, considering an extended set of information. In this case we include other relevant macroeconomic variables such as the nominal interest rate, the change in the multilateral nominal exchange rate and GDP growth. We are able to identify different dynamics of money growth and inflation under low and high inflation. Between 1977 and 1988 shocks to the interest rate have a positive effect on money growth and nominal depreciation. The price expectations component in nominal interest rates plays a key role in explaining the dynamics of money growth and inflation which cannot be captured by bivariate analysis. These findings are not in line with the empirical evidence reported by the literature on the transmission of nominal shocks to the economy. Although shocks to the nominal interest rate have a negative impact on output, when the interest rate is excluded from the VAR system, models show a negative response of output growth to inflation. Previous bivariate analysis was not able to capture this relevant role of inflation expectations implicit in the nominal interest rate.

On the contrary, during the period of low inflation, impulse responses are more in line with the empirical regularities in the literature. Shocks to the interest rate generate negative responses of money growth. In addition, the inflation rate responds positively to money. They also have a negative impact on output.

During Convertibility, the dynamics of inflation is mainly exogenously determined. On the contrary, when we extend the sample to the complete low inflation period, inflation responds greatly to shocks to other variables of the system. In particular, the effect of monetary impulses on inflation become stronger while at the same time nominal depreciation has an effect on inflation.

These findings indicate that multivariate analysis allows a better understanding of the sources of the different money growth-inflation short run dynamics under low and high inflation. Our results also suggest that money continues to play a role in explaining inflation dynamics in the short run under low inflation.

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Appendix I: Unit-root tests

	<i>Lm1_sa (with mean and 3 lags)</i>				<i>Lipc (with mean and 3 lags)</i>			Critical value at 10%
	Statistic	Date	Conclusion		Statistic	Date	Conclusion	
Ho: unit-root								
Dickey-Fuller A.	-1.45		not rejected		-1.54		not rejected	-2.58
Phillips-Perron	-1.17		not rejected		-1.39		not rejected	-2.58
<i>Recursive</i>								
Min ADF	-3.17	2005.II	not rejected		-7.37	2005.II	rejected	-4.00
Max ADF	1.76	1989.III	not rejected		-1.23	1989.III	not rejected	-1.73
<i>Rolling</i>								
Min ADF	-17.56	1996.IV	rejected		-40.83	1997.II	rejected	-4.71
Max ADF	1.25	1989.III	not rejected		3.93	2002.II	not rejected	-1.31
Ho: no changes in mean								
<i>Secuencial mean shift</i>								
Max F	112.67	1991.II	rejected		99.10	1990.IV	rejected	16.20
DF F max	4.93	1991.II	not rejected		5.22	1990.IV	not rejected	-4.52
Min DF	-1.94	1996.IV	not rejected		-1.36	1996.I	not rejected	-4.54
Ho: no changes in trend								
<i>Secuencial trend shift</i>								
Max F	72.18	1990.II	rejected		59.29	1990.III	rejected	13.64
DF F max	-4.42	1990.II	rejected		-4.60	1990.III	rejected	-4.19
Min DF	-4.78	1991.III	rejected		-4.70	1991.I	rejected	-4.20