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The Intertemporal Relation Between Money and Prices: Evidence from Argentina*

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We study the relationship between money and prices in Argentina for the periods 1976-1989 and 1991-2001, which represent different monetary, fiscal, exchange rate and political regimes. We perform structural unit root tests, apply a filter similar to Lucas (1980), calculate correlations, perform Granger causality tests and estimate VAR models. The results from the two periods are very different and differ from those found for developed countries. The reaction times we get are much shorter and the direction of causality (Granger) for the earlier period is the opposite of that normally encountered in the literature.

JEL: C10, E31
Keywords: Quantitative Theory, Inflation, Empirical Evidence, Structural Unit-Root Testing, VARs.

1. Introduction

The long term relationship between money and prices is reasonably well understood. At least since the writings of Nicholas Copernicus, Jean Bodin, and Martin de Azpilcuenta (Navarrus) in the 16th century, the idea that increases in the quantity of money result in increases in the price level has been a part of economic theory. A large number of empirical studies have confirmed the long term relationship. One of the more recent and more extensive of these studies is McCandless and Weber (1995) where, when the long run is characterized as at

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least 20 years, for a sample of 188 countries the correlation between changes in money (M1) and changes in the consumer price index is almost one.

The medium and short term relationship between money an prices is much less well understood. For countries with histories of relatively low inflation rates, the relationship between money and prices even at a six month time horizon is very weak. In his classic study in defense of the Quantity Theory, Lucas (1980) shows that, for the United States, a contemporaneous relationship between money and prices does not exist and that a clear relationship between these two variables only shows up when one applies a filter which suppresses the high frequency components of the data. The lack of a short term relationship between money and prices is further supported by the famous "instability" encountered in trying to estimate money demand functions.

The current interest in inflation targeting makes knowledge of the lags between changes in money and changes in prices ever more important. Monetary policy normally works through interest rate changes to prices via a number of channels. One of these channels is the money channel, so that changes in interest rates change the amount of money in the economy and this eventually results in changes in prices. Since inflation targeting combines announcements of future inflation aspirations with policy intended to make these aspirations real, an understanding of the money channel is crucial.

Some estimates of the direction and timing of the relationship between money and prices have been done for developed countries. Batini and Nelson (2002) studied the United States and England using six month or one year averages of rates of changes in money and prices. They find that for the United States, changes in money lead changes in prices by between 12 and 31 months in the period from 1953 to 1979 and with a longer and weaker lead (up to 49 months) in the period after 1980. For England, changes in money lead inflation by six months in the 1953 to 1979 period and by two years after 1980. Using very long data sets (from 1871 to 2000 for the US and from 1835 to 2000 for the UK), they find that changes in money lead inflation by one to two years.

In this paper we study the relationship between changes in money and prices in Argentina during the last quarter of the 20th century, concentrating on the short and medium term. This period is full of monetary and exchange rate innovations although it divides fairly naturally into three periods. The period from 1976 to 1989 is one of relatively high inflation rates and relatively flexible exchange rates.[1] The 1989 to 1990 period experienced two hyperinflations. The 1991 to 2001 period was one of a fixed convertibility with the dollar in the form of a currency board. We study the full period and the 1976 to 1989 and 1991 to 2001 periods

[1] Although there were many periods of fixed exchange rates, these rates were adjusted with sufficient frequency as to approximate a *de facto* floating or intermediate regime. In their *de facto* classification of exchange rate regimes, Levy Yeyati and Sturzenegger (2002, 2003) classify Argentina as having floating and intermediate exchange rate regimes during that period. Specifically, their classification goes as follows: 1976: intermediate, 1977-1980: floating, 1981-1985 intermediate, 1986: floating and 1987-1988 intermediate.

separately. The division of the data into two periods is confirmed by our statistical tests. The statistical relationships between changes in prices and money in these two periods are very different.

Our analysis questions the wisdom of applying the results of Batini and Nelson (2002) to emerging economies or to currency boards. The reaction times we get are much shorter. Maximum correlations between yearly averages of changes in money and prices occurred with lags of six months or less. The direction of causality (Granger) is also different. For the earlier period, we find that changes in prices lead changes in money. In the later period, changes in money leads inflation but the relationship is far from the Quantity Theory one to one: inflation was, on average, only 23 percent of changes in money. Impulse response functions show that, for the early period, a shock to inflation has a bigger and longer effect on changes in money than a shock to changes in money has on prices. In the later period, impulse response functions are not significantly different from zero.

In section 2, we describe the data. In section 3, we describe the methodology for the various tests we use. In section 4, we present our results and section 5 gives some conclusions.

2. DATA AND PERIOD DESCRIPTION

We use the logarithm of money plus quasi-money[2] (in millions of pesos) as a measure of money and the logarithm of the Consumer Price Index (base 1995=100) for prices, both from the International Financial Statistics (IFS). See Figure 1; we used monthly data.

The period included for the analysis runs from January 1976 through March 2003. Data before that period seems not to be precise. Given the long history of inflation in Argentina, the number of significant digits declines as we one further back in time and by 1975 the IFS is reporting only one significant digit.

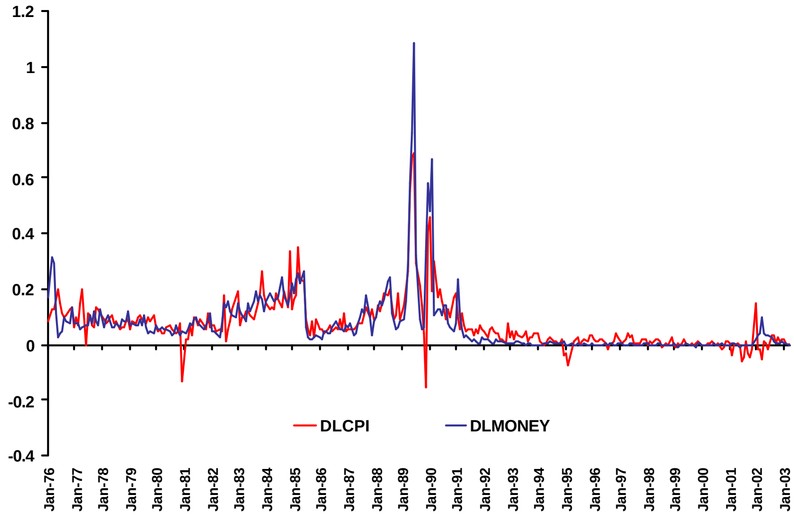
As we mentioned before, we study this relationship for two periods separately: January 1976 to April 1989 and April 1991 to December 2001 (the period under a Currency Board, called the Convertibility). We exclude the hyperinflation[3] that took place between 1989 and 1990 and also the period since Convertibility was abandoned, as insufficient observations for this new regime are available.[4]

[2] Money equals the sum of currency outside deposit money banks and demand deposits other than those of the Central Government. Quasi-money equals the sum of time, saving and foreign currency deposits in Deposit Money Banks of residence sectors other than the Central Government.

[3] We define hyperinflation as a monthly change in prices higher than 50%.

[4] It is worth mentioning that although it might have been desirable to include the latest data to study the relationship between money and prices, the period after January 2002 -when Exchange Convertibility was abandoned- is too short to be trustworthy for empiric studies.

FIGURE 1
LOG DIFFERENCES OF MONEY AND PRICES



The decision to divide the sample is based on both economic and statistical grounds. The full period includes a large number of very different monetary, fiscal, exchange rate and political regimes. In particular, the dynamics of the series change significantly after the introduction of the Currency Board. If the changes in the stochastic processes of the series are sufficiently large, one would expect the relationship between the series to change as well. One important characteristic of a dynamic process is its order of integration. Unit root tests on each of the series over the whole sample period are inconclusive as to the order of integration.

We examine each series divided into two periods separately. The first period (1976-1989) is characterized by changing exchange rate regimes and relatively high inflation and growth in the money stock.[5] Not only were growth rates of money and prices high, but also the variances in the rates were high. The Convertibility period (1991-2001), with a fixed exchange rate ($1 for US$1) throughout the whole period and a stable macroeconomic environment, resulted in a very different behavior in money and prices. Rates of changes in money and prices were much lower and the variance of each series was reduced markedly.

When we did unit root tests on the sub-samples, the results were significant. The earlier period is integrated and the second is not. Including the hyperinflation period with either of the sub-samples results in non-significant results for the unit root tests. Consequently, we limit the other analysis to the sub-sample periods.

[5] For a good description of this period see Gerchunoff and Llach (2003).

3. METHODOLOGY

We begin by studying the statistical properties of the series, to check for stationarity, as this determines the correct model specification. In the case where both variables are integrated of order one, we check for cointegration. Later, we perform graphical intertemporal analysis, Granger causality tests and VARs estimations to determine the relationship between money and prices for Argentina. This was done for the two sub-sample periods (1976-1989 and 1991-2001) separately.

3.1. Unitroot Testing

We begin with traditional Dickey-Fuller and Phillips-Perron tests. These two tests do not control endogenously for the possibility of structural breaks in the series.[6] Sometimes the tests may present a bias towards not rejecting the null hypothesis of a unit root, as the presence of structural breaks can lower the power of the these tests. Thus, they may confuse structural breaks with non-stationarity in the series.

As these two tests tend not to reject the null of a unit-root, we decided to carry out a set of Dickey-Fuller tests that control endogenously for structural breaks. These are known as recursive, rolling and sequential Dickey-Fuller tests.[7] We base our conclusions on these more powerful tests.

Following Banerjee *et al*. (1992), who tabulated these tests, a traditional Augmented Dickey- Fuller regression is estimated taking subsamples $t = 1; ... ; k$ where $k = k_0; k_{0+1}; ... ; T$ and using as criteria the maximum and minimum values of these ADF tests. k_0 is the starting value of the recursive estimation and T is the size of the full sample. This is known as the recursive DF test. The rolling DF test is based on subsample of fixed size T_s, rolling through the sample. The maximum and minimum DF t-statistics are the criteria for this test.

To perform the sequential test, which allows for a possible single shift or break at every point in the sample for the mean or the slope of the trend, the following equation is estimated using the whole sample:

$$y_t = a + b\,t + g\,d_t + m\,y_{t-1} + e_t \qquad (1)$$

where $d_t = \begin{cases} 1 & \text{if } t > k, 0 \text{ otherwise (shift trend mean)} \\ t-k & \text{if } t > k, 0 \text{ otherwise (shift trend slope).} \end{cases}$

In order to test for the existence of structural breaks, an F-test evaluating $g = 0$ is used, while for the order of integration of the series the minimum DF statistic evaluating $m = 1$ is considered.

[6] See Sosa Escudero (1997) for an explanation and application of these tests to Argentine GDP.
[7] See Banerjee *et al.* (1992).

As will be shown in detail in the results section, these tests suggest that the two periods are very different for both series, and consequently, we study them separately.

3.2. Correlation and Graphical Analysis

Now that we have decided to analyze the two sub-samples separately, we want to determine the nature of the intertemporal relationship between money and prices. One direct and simple way to do this is via a sequential graphical exercise and a correlation analysis.

For the graphical exercise, Lucas´ (1980) basic idea is used. Lucas studied changes in prices and M1 in the United States. He showed graphically that as the filter used shifted to lower frequency data, the points indicating the correlation of the growth rates of money and prices tended to concentrate near the 45º line (i.e. the relationship tends to be approximately of 1). For a filter with properties similar to that of Lucas but which we believe is easier to interpret, we calculate different length moving averages to study the intertemporal nature of the interaction between changes in money and prices. Scattered diagrams are presented.

Using the log differences of prices and money, 2, 4, 6 and 12 months (centered)[8] moving averages were computed. We study the dynamics of the relationship by calculating the correlations of contemporary, 1, 2, 4 and 6 lags and 1, 2, 4 and 6 leads in log differences of prices against the log differences in money.

3.3. Granger Causality Test and VARS

The results of the lagged correlations suggest that, at least for the early period, there is a direction of causality from prices to money. This direction is different from that observed in many other countries, from that of the later period, and different from that normally expected from theory. Given that this result is unusual, we use other standard tests to examine the direction of causality. We do Granger causality tests and structural VARS to see if they support the results from the lagged correlations.

Granger causality test are performed to see if changes in one variable help to predict future changes in the another. The results of a Granger test indicate whether you can reject or not the hypothesis that variable A (and its past) does not help predict variable B in a better way than only using variable B´s past. Granger causality tests test for temporal precedence.

In addition, we built VAR models in differences and calculate the impulse-response functions. Impulse response functions show the dynamic response of the system to a one period shock in one variable and give more dynamic detail than the Granger tests.

[8] For example, for the 12 months moving average, the previous 5 months and the following 6 months were considered.

4. RESULTS

4.1. Unit Root Testing

The results for the unit-root tests are shown in Tables 1 and 2. As expected for the early (1976 to 1989) period, traditional tests do not reject the null of a unit-root for the logarithm of money and of prices. In the tests that control for structural breaks, we cannot reject the hypothesis of unit roots. While the sequential DF test suggests the presence of changes both in the mean and slope of the trend in the two series, it does not reject the hypothesis of a unit root either. In sum, we find strong evidence supporting the hypothesis that both money and prices are non-stationary processes. This result suggests that for this period the time series should be modeled as difference stationary processes where a random shock has a permanent effect on the economy.[9]

TABLE 1
UNIT ROOTS TESTS
(JANUARY 1976 - APRIL 1989)

	Log CPI			Log M2		
Tests	Statistic	Critical value*	Results	Statistic	Critical value*	Results
Dickey-Fuller	2.10(a)	-2.58	I(1)	1.36(b)	-2.58	I(1)
Phillips-Perron	0.87	-2.58	I(1)	1.01	-2.58	I(1)
Recursive						
Min DF	-2.08	-3.91	I(1)	-3.13(b)	-3.91	I(1)
Max DF	3.78(a)	-1.69	I(1)	2.07(b)	-1.69	I(1)
Rolling						
Min DF	-2.80(a)	-4.59	I(1)	-2.72(b)	-4.59	I(1)
Max DF	2.10(a)	-1.27	I(1)	1.45(b)	-1.27	I(1)
Sequential Trend shift						
Max F	20.10	13.32	Break	21.20	13.32	Break
Min DF	-2.92	-4.12	I(1)	-2.91	-4.12	I(1)
Mean shift						
Max F	72.90	16.72	Break	46.77	16.72	Break
Min DF	-3.52	-4.51	I(1)	-2.84	-4.51	I(1)

*10% confidence level. (a) Considering 1 lag.

In the 10-year period under a Currency Board, the behavior of money and prices is significantly different compared to the earlier one. The results are shown in Table 2. For prices, there is strong evidence in all tests for rejecting the null hypothesis of a unit root and for not rejecting the hypothesis of no break. This result does not surprise us and reflects the fact that during Convertibility prices

[9] Although both series are I(1) in the 1976-1989 period they are not co-integrated. We tested for co-integration with both the Engle-Granger Approach and with the Johansen Approach.

stabilized and exhibited very low volatility. For money, the results among tests are not conclusive but two reasons lead us to think that money in this period might have followed a stationary process. In the first place, traditional test are powerful and reliable when rejecting the null hypothesis. Secondly, when choosing among the tests that control for structural breaks, the sequential DF is to be more reliable. Using this last test, we find evidence of breaks both in the mean and the slope of the trend of the logarithm of money and we can reject the hypothesis of a unit root.

TABLE 2
UNIT ROOTS TESTS
(APRIL 1991 - DECEMBER 2001)

	Log CPI			Log M2		
	Statistic	Critical value*	Results	Statistic	Critical value*	Results
Dickey-Fuller	-6.38(a)	-3.15	I(0)	-4.71(b)	-2.58	I(0)
Phillips-Perron	-14.81	-3.15	I(0)	-6.21	-2.58	I(0)
Recursive						
Min DF	-6.42(a)	-4.00	I(0)	-3.16(b)	-4.00	I(1)
Max DF	-2.41(a)	-1.73	I(0)	-1.53(b)	-1.73	I(1)
Rolling						
Min DF	-5.75(a)	-4.71	I(0)	-3.38(b)	-4.71	I(1)
Max DF	-0.48(a)	-1.31	I(1)	0.68(b)	-1.31	I(1)
Sequential Trend shift						
Max F	3.25	13.64	No break	20.85	13.64	Break
Min DF	-9.79	-4.2	I(0)	-4.83	-4.2	I(0)
Mean shift						
Max F	12.67	16. 2	No break	23.17	16.2	Break
Min DF	-9.99	-4.54	I(0)	-4.58	-4.54	I(0)

*10% confidence level. (a) Considering 2 lags, (b) Considering 1 lag.

4.2. Correlations and Graphical Analysis

Table 3 shows the results of calculating simple pair wise correlations of log differences in money and log differences in prices. The correlation of current log differences in money with current log differences in prices, with lagged log differences in prices, and with leads of log differences in prices are given. For any order of leads and lags, the highest correlations are encountered when we use twelve month moving averages. For the earlier period, the highest correlations of the twelve month moving averages are found when the log differences in prices lag log differences in money by two periods. For moving averages between 2 and 6 months, the highest correlations occur with one month lag in log differences in prices. For the period of the currency board, the highest correlations of the twelve month moving averages are found when prices lead money by six periods. For some of the shorter moving averages, the highest correlations are found at shorter leads in prices and, in general, the number of leads increases with the number of periods included in the moving average.

TABLE 3
SIMPLE PAIRWISE CORRELATIONS OF MONEY AND PRICES: 1976-1989

	Lags in prices				Contemporary	Leads in prices			
	-6	-4	**-2**	-1		1	2	4	6
MA(0)	0.352	0.493	**0.619**	0.588	0.633	0.556	0.465	0.326	0.280
MA(2)	0.450	0.593	**0.731**	0.740	0.714	0.628	0.548	0.386	0.315
MA(4)	0.594	0.725	**0.838**	0.843	0.819	0.773	0.697	0.499	0.382
MA(6)	0.680	0.808	**0.896**	0.918	0.898	0.853	0.774	0.601	0.457
MA(12)	**0.841**	**0.924**	**0.959**	**0.957**	**0.943**	**0.913**	**0.868**	**0.756**	**0.635**

SIMPLE PAIRWISE CORRELATIONS OF MONEY AND PRICES: 1991-2001

	Lags in prices				Contemporary	Leads in prices			
	-6	-4	-2	-1		1	2	4	**6**
MA(0)	0.457	0.496	0.448	0.456	0.522	0.594	0.553	0.469	**0.469**
MA(2)	0.568	0.613	0.555	0.569	0.635	0.680	0.682	0.593	**0.584**
MA(4)	0.672	0.703	0.704	0.708	0.726	0.747	0.752	0.716	**0.740**
MA(6)	0.728	0.752	0.762	0.775	0.777	0.777	0.776	0.773	**0.812**
MA(12)	**0.818**	**0.818**	**0.815**	**0.818**	**0.822**	**0.830**	**0.840**	**0.862**	**0.879**

We construct a sequence of scatter plots for the leads or lags and the moving averages circled in Table 3. This is our version of Lucas's filter. As can be seen Figures 2 and 3, for both periods, as more months were included in the moving averages, the cloud in the graphs tends to concentrate on a line. It is clear from the figures that the relationship between log differences in prices and log differences in money is not the same for the two periods under analysis: for 1976-1989, points tend to concentrate around the 45º lines (giving a one to one correspondence), while in the case of years 1991-2001, the relationship is much weaker. It is worth mentioning that independent of which lag or lead in the log difference in price is used with the log differences in money, in all pairs the scatter diagram approaches a line as the number of moving averages is increased, the line has a 45 degrees for the earlier period and the line has a much smaller slope for the currency board period.

FIGURE 2
RELATIONSHIP BETWEEN MONEY AND PRICES FOR 1976-1989
(MONEY IN X-AXIS AND PRICES IN Y-AXIS)

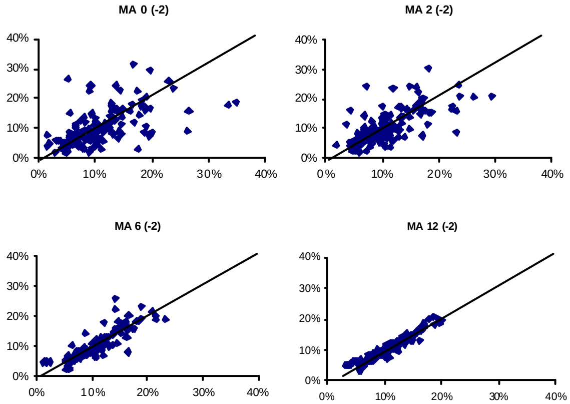
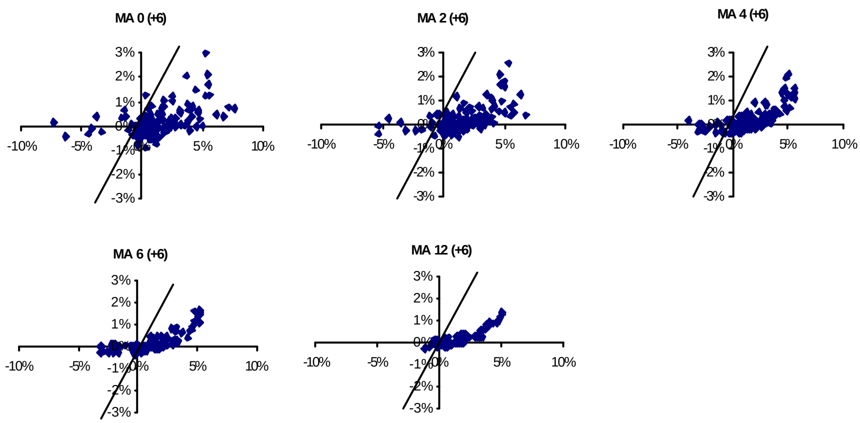


FIGURE 3
RELATIONSHIP BETWEEN MONEY AND PRICES FOR 1991-2001
(MONEY IN X-AXIS AND PRICES IN Y-AXIS)



As mentioned earlier, the interesting result is that the intertemporal structure is very different for the two periods. In the first one, it seems that prices move before money (as the best fit is the one taking two *lags* in prices), while in the second one, money seems to precede prices (as in this case the best fit is considering 6 *leads* in prices). In order to provide additional evidence as to whether the intertemporal relationship is as described, Granger causality tests are conducted.

4.3. Granger Causality Tests

In line with the results found in the previous section with graph and correlation analysis, Granger causality tests between changes in money and prices show different conclusions for the two periods.

At a 95% confidence level, for the period 1976-1989, the null hypothesis that changes in prices do not help predict future changes in money can be rejected when considering models with either 2, 4 and 12 lags for both variables. In this period, prices Granger cause (i.e. temporally precedes) money. On the other hand, the null hypothesis that changes in money do not help predict future changes in prices is only rejected for models with 2 and 4 lags and is not rejected at the 95% level in the model with 12 lags. The detailed results are given in Annex 1.

These results are not the ones expected from traditional quantitative monetary theory nor from the empirical evidence of industrialized economies. The more standard result is that changes in money will result in changes in prices. However, during the early period, we found that changes in prices cause (both from a Granger point of view and from the correlations) changes in money.

We can think of two possible explanations, one based on rational expectations and forward looking behavior and the other based on fiscal dominance. In developed countries, where money and prices exhibit low volatility, public expectations change slower than in the more volatile, developing economies. When changes in money and prices are smaller, the costs of monitoring become relatively more important and less monitoring is done. On the other hand, in more volatile economies, the substantial changes in macroeconomic variables make monitoring worth the cost. This monitoring results in better predictions of future path of money and, under a rational expectations framework, these predictions should result in the appropriate adjustments of prices. In a simple model of money in the utility function, the solution for current prices is a geometric sum of expected future values of the money stock.[10] From a statistical point of view, this model could produce changes in prices that anticipate changes in money.

On the theme of fiscal dominance, there is strong evidence that during much of the 1976-1989 period the monetary authority was obedient to fiscal authority decisions.[11] As a consequence, an increase in the price of government of goods and services or an adjustment public sector salaries[12] would result in higher future money emission to finance the higher expenditure. In the end, this process can result in a dynamic where changes in prices result in later changes in government

[10] See Sargent (1987), chapter 4. There, when considering money in the utility function, the solution found is $\left[\frac{1}{p_t}\right] = g c_t \sum_{j=0}^{\infty} b^j E_t\left[\frac{1}{m_{t+j+1}}\right]$.

[11] See Auernheimer (1982). For passive money theory see Olivera (1970).

[12] During this period salary indexation was law.

expenditures that are covered by similar changes in the amount of new money that the government must issue. In a simple statistical analysis of this process, changes in prices would precede changes in money.

For the Convertibility period, at a 95% confidence level, the null hypothesis that money does not Granger cause prices can be rejected (the exercise was also done using models with 2, 4 and 12 lags). In this case, changes in money help predict changes in prices. The hypothesis that changes in prices do not cause changes in money cannot be rejected. During this period, the behavior of money and prices differ considerably from the one observed during 1976-1989. Under the Currency Board, the 90´s were characterized as years with a very "passive" monetary policy that followed the Currency Board rules. The economic environment of these years was influenced by several years of GDP growth, which implied growing money demand and velocity, a recovery of the banking system and a fixed exchange rate that kept tradable prices relatively stable. In terms of the relationship between money and prices, Argentina looked more like a developed country during these years.

4.4. VAR Analysis

From the unit root tests for the period 1976-1989 it cannot be rejected that money and prices follow a non-stationary process (i.e. they are I(1)), so they must be modeled in first differences in order to get a stationary process. In order to get comparable results, we also modeled the series for 1991-2001 in first differences (although it was not strictly necessary as the series were already stationary).

The best lag structures (based on log-likelihood ratio tests) for the two periods are reported in Annex 2. For the chosen structures the residuals are well behaved and have a normal distribution and no serial correlation. Dummies were included for the 1982 debt crisis and dates related to changes in exchange rate regimes for the 1976 to 1989 period; and for the tequila crisis effect (in January and March, 1995) as well as the bank runs in March and July, 2001 for the Convertibility period. The impulse response functions for these two models are calculated considering a one-unit shock in prices using the Cholesky decomposition and similar one-unit shock in money and are shown in Figures 4 and 5.

FIGURE 4
IMPULSE-RESPONSE FUNCTIONS FOR THE 1976-1989 PERIOD

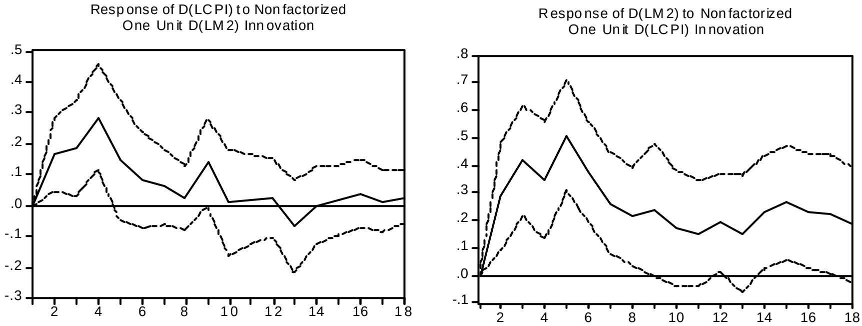
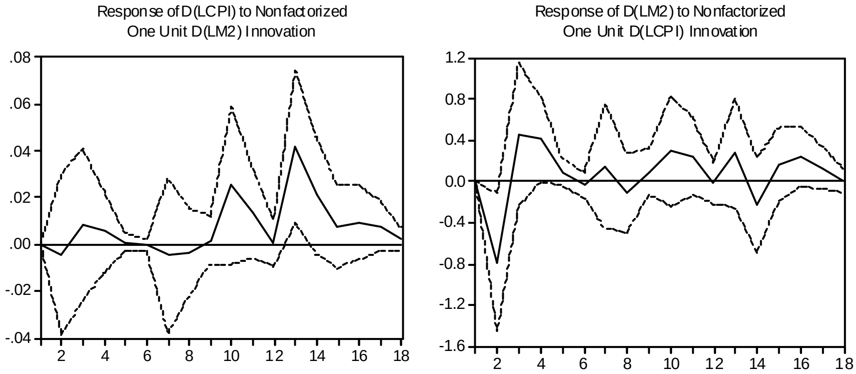


FIGURE 5
IMPULSE-RESPONSE FUNCTIONS FOR THE 1991-2001 PERIOD



The impulse-response functions imply different dynamic behaviour. For 1976-1989 the reaction of prices to money is weaker than the reaction of money to prices (this result is consistent with the Granger tests). For the stronger relationship, from prices to money, the response is significant for approximately 9 months. In the case of the Convertibility period, no significant response is found to either shock.

5. CONCLUSIONS

In this paper, we study the statistical relationship between money and prices in Argentina during the last quarter of the 20th century. We first look at the unit root characteristics of the series and these suggest dividing the whole sample into two sub-samples: 1976 to 1989 and 1991 to 2001. These sub-samples represent different monetary, fiscal, political and exchange rate regimes (the first a mix of movable fixed floating regimes and the second the currency board fixed exchange rate regime).

We then apply a filter similar to that of Lucas (1980) and find that correlations between changes in money and prices are highest when 12 month moving averages are used. In the early period, the correlation is almost one to one and the scatter diagram of changes in prices against changes in money fall on the 45 degree line. For the later period, the correlation is somewhat less and the relationship implies much smaller changes in prices for a given change in the money stock. Taking lags and leads in the moving averages of prices, we find very different results for the two periods. In the earlier period, two-month lags in changes in prices are the highest correlated with current changes in money. In the latter period, six-month leads in moving averages of changes in prices are highest correlated with current moving averages of changes in money.

The result of changes in prices preceding changes in money for the earlier period are confirmed by Granger causality tests and impulse response function calculations from VARs models. In the later period, while money precedes prices, the period of maximum correlation is quite short: only six months.

The main results of this paper are quite different from those found for developed countries. The time frame for the highest correlations of prices and money is much shorter in Argentina than for either the US or Britain. Temporal causality is also different. During the movable fixed or floating exchange rate period of 1976 to 1989, we find that prices precede money. While this result is consistent with a number of theoretical models in which expectations are important, it is also consistent with a model in which the fiscal deficit that must be financed by future money issues is a function of the changes in today's prices. Either could give the correlation that we found.

In the period of the currency board, the relationship between changes in money and changes in prices was much weaker than in the earlier period. These results are not inconsistent with a free banking model where money supply is determined by demand and where the banking system is recovering from a period of substantial restrictions. However, although we do not wish to make too much of this point, the dramatic end of the currency board period with substantial inflation and depreciation of the exchange rate suggest that it may be that currency boards only postpone the realization of price changes to money stock changes. This last would be more consistent with the observed long run relationship between changes in money and changes in prices.

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ANNEX I
PAIR WISE GRANGER CAUSALITY TESTS

Sample: 1976:01 1989:04

Null hypothesis:	Obs	F-statistic	Probability
Lags: 2			
DLM2 does not Granger cause DLCPI	157	5.67722	0.00419
DLCPI does not Granger cause DLM2		9.82263	9.7E-05
Lags: 4			
DLM2 does not Granger cause DLCPI	155	3.16972	0.01565
DLCPI does not Granger cause DLM2		5.79521	0.00023
Lags: 12			
DLM2 does not Granger cause DLCPI	147	1.64358	0.08816
DLCPI does not Granger cause DLM2		2.34590	0.00960

Sample: 1991:04 2001:12

Null hypothesis:	Obs	F-statistic	Probability
Lags: 2			
DLM2 does not Granger cause DLCPI	126	9.48657	0.00015
DLCPI does not Granger cause DLM2		2.01398	0.13791
Lags: 4			
DLM2 does not Granger cause DLCPI	124	4.54900	0.00190
DLCPI does not Granger Cause DLM2		1.15053	0.33650
Lags: 12			
DLM2 does not Granger cause DLCPI	116	1.87574	0.04775
DLCPI does not Granger cause DLM2		1.51715	0.13231

ANNEX II
VARS

Sample (adjusted): 1992:05 201:12
Included observations: 116 after adjusting endpoints
Standard errors in parenthesis

	D(LCPI)	D(LM2)
D(LCPI(-1))	0.212045	-0.791024
	(-0.07743)	(-0.33653)
D(LCPI(-2))	-0.206628	0.886967
	(-0.07988)	(-0.34716)
D(LCPI(-6))	0.200446	0.164178
	(-0.07011)	(-0.30471)
D(LCPI(-9)	0.058495	0.137267
	(-0.0633)	(-0.27511)
D(LCPI(-12))	0.18659	0.3147
	(-0.0633)	(-0.27513)
D(LM2(-1))	-0.004287	0.327366
	(-0.01721)	(-0.07482)
D(LM2(-2))	0.010459	0.058831
	(-0.01693)	(-0.07357)
D(LM2(-6))	-0.004815	0.072383
	(-0.01656)	(-0.07199)
D(LM2(-9))	0.022746	-0.199811
	(-0.01674)	(-0.07276)
D(LM2(-12))	0.045166	0.251307
	(-0.01649)	(-0.07166)
C	-0.001013	0.003686
	(-0.0004)	(-0.00175)
D951	0.009688	-0.061882
	(-0.00308)	(-0.01337)
D953	-0.00312	-0.075893
	(-0.00331)	(-0.01439)
D013	0.004621	-0.045345
	(-0.00302)	(-0.01312)
D017	-0.001533	-0.080269
	(-0.00308)	(-0.0134)
R-squared	0.653955	0.711645
Adj. R-squared	0.605988	0.671675
Sum sq. resids	0.00089	0.016815
S.E. equation	0.002969	0.012903
F-statistic	13.63353	17.8045
Log likelihood	518.5108	348.0689
Akaike AIC	-8.681221	-5.742567
Schwarz SC	-8.325153	-5.386499
Mean dependent	0.001473	0.010018
S.D. dependent	0.004729	0.022518

Determinant residual covariance	1.47E-09
Log likelihood (d.f. adjusted)	850.5417
Akaike information criteria	-14.14727
Schwarz criteria	-13.43513

Sample (adjusted): 1977:02 1989:04
Included observations: 147 after adjusting endpoints
Standard errors in parenthesis

	Equation D(LCPI)	Equation D(LM2)
D(LCPI(-1))	0.73119	0.287457
	(0.08139)	(-0.09809)
D(LCPI(-2))	-0.076925	0.167041
	(-0.09458)	(-0.11399)
D(LCPI(-3))	0.054615	0.007709
	(-0.09414)	(-0.11346)
D(LCPI(-4)	-0.112027	0.233495
	(-0.08114)	(-0.09778)
D(LCPI(-8))	-0.133929	0.o96364
	(-0.083)	(-0.10004)
D(LCPI(-9))	0.234608	0.010948
	(-0.08062)	(-0.09716)
D(LCPI(-12))	0.031877	0.004114
	(-0.06317)	(-0.07613)
D(LM2(-1))	0.165272	0.135558
	(-0.05996)	(-0.07226)
D(LM2(-2))	0.041137	0.04561
	(-0.06066)	(-0.0731)
D(LM2(-3))	0.140649	-0.033402
	(-0.06324)	(-0.07622)
D(LM2(-4))	-0-091043	-0.140301
	(-0.06641)	(-0.08004)
D(LM2(-8))	0.099069	-0.030593
	(-0.06146)	(-0.07408)
D(LM2(-9))	-0.088443	-0.028299
	(-0.06424)	(-0.07743)
D(LM2(-12))	-0.118287	0.084243
	(-0.05365)	(-0.06466)
C	0.012252	0.017494
	(-0.00678)	(-0.00817)
D811	-0.004812	-0.193225
	(-0.02835)	(-0.03417)
D827	0.082357	0.11028
	(-0.02831)	(-0.03412)
D8412	0.055274	0.161647
	(0.03041))	(0.03665)
D854	0.072007	0.183703
	(0.03146)	(0.03791)
D857	-0.204329	-0.124359
	(0.03093)	(0.03727)
D894	0.120297	0.138840
	(0.03045)	(0.03670)

	Equation D(LCPI)	Equation D(LM2)
R-squared	0.799032	0.738962
Adj. R-squared	0.767132	0.697527
Sum sq. resids	0.097616	0.141789
S.E. equation	0.027834	0.033546
F-statistic	25.04825	17.83438
Log likelihood	329.2261	301.7886
Akaike AIC	-4.193552	-3820253
Schwarz SC	-3.766348	-3.393048
Mean dependent	0.098501	0.100727
S.D. dependent	0.057679	0.060995
Determinant residual covariance		7.89E-07
Log likelihood (d.f. adjusted)		615.6898
Akaike information criteria		-7.805303
Schwarz criteria		-6.950893