The intertemporal relation between money and prices: Evidence from Argentina

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Abstract

The objective of this paper is to describe in a simple way the historical transmission process in Argentina for changes in the stock of money to changes in the price level. Following the basic idea of Lucas (1980), we analyze graphically (and additionally, econometrically) the correlations for the period 1976 to 1989. We find that although there does not seem to exist a short term relationship between these variables, there is one in the longer term. Our results suggest that the correlations between money and prices increase with the term considered and that the leads (if any) go from changes in prices to changes in money.

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Key words: Quantitative theory, inflation, money, exchange rate, lags, long run, empirical evidence.

[♣] Central Bank of Argentina, Economic Research Department. The ideas and errors in this paper are the responsibility of the authors and not the Central Bank.
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Introduction

In December 2002, the monetary base in Argentina grew approximately $3,000 M. Some people thought this increase was going to translate rapidly into prices. Neither monetary theory nor empirical evidence in other countries seems to go in this direction. Most economists in this area agree that, although the relationship between changes in money and changes in prices shows a high correlation in the long term, in the short term results are not conclusive.

The long-term relationship seems clear. Lucas emphasized the long-term relationship between money and prices in his Nobel Prize lecture by mentioning McCandless and Weber (1995). They show that, for a 188-country sample and using M1 as money measure, when the long run is characterized as 20 years, this correlation between money and prices is almost 1.

For the short-term relationship, no clear evidence arises, and for countries with relatively low inflation rates and periods below six months, the relationship between money growth and inflation is very weak. A variety of studies on money demand yield very dissimilar results. Consequently, it is rather difficult to establish a straight relationship between these two variables in the short term.

The objective of this paper is to describe in a simple way the historical process of transmission from changes in money to changes in prices in Argentina. Lucas´ (1980) basic idea is used. Lucas studied changes in prices and M1 in the United States. He showed graphically that as moving averages enlarge, the points indicating the correlation of the growth rates of money and prices tend to concentrate near the 45º line (i.e. the relationship tends to be approximately of 1).

This paper expands Lucas´ idea. In the first place, in addition to graphical analysis, simple OLS regressions are calculated. While qualitative results from graphics and regressions do not differ, the latter enable us to quantify the relationships. Secondly, different moving averages are calculated to study the intertemporal nature of the interaction between changes in money and prices. Finally, we do Granger causality tests, to see if changes in one variable helps predict future changes in the other.

Data description

We use circulation plus sight deposits (that include demand deposits + saving deposits) in millions of pesos as a measure of money (like M2), and the Consumer Price Index (base 1995=100) from the IFS for prices. We take monthly percentage change for each series.

The period included in the paper goes from January 1976 through March 1989. Data before that period seems not to be reliable, as no changes are reported in prices while in fact we know that they were changing. On the contrary, the period after March 1989 may distort the analysis due to the hyperinflation. We concentrate on a middle level inflation period.

The years under study are characterized by relatively high inflation and a period when Argentines were particularly sensitive to changes in the stock of money and prices (compared to the second half of the 1990´s, for example).

Although it might have been desirable to use more recent information to study this phenomenon, the 90´s have experienced a very low inflation, or even deflation, and the period after January 2002 -when a change in regime was implemented- is too short to be useful for empiric studies.

We think that, broadly speaking, Argentines´ response to changes in the stock of money has not changed substantially and that the results of the period chosen for the analysis should shed light on what could happen in the future near and medium term. In fact, the average monthly inflation rate during the period under treatment (0.47%) is very similar to the one observed during the last months of 2002, when the overshooting of the crisis had passed.

Methodology

In order to study the relationship between money and prices, and expanding Lucas´ idea, results from simple OLS regressions and Granger tests are added to graphic analysis.

After calculating monthly percentage changes in CPI and money, 2, 4, 6 and 12 months (centered)[1] moving averages were computed. In parallel, we compute the relationship between changes in money with changes in prices 1 to 6 periods ahead (using 0, 1, 2, 4 and 6 *leads* in price changes), and in a second stage with lagged changes (using 0, 1, 2, 4 and 6 *lags* in price changes).

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

Taking the alternative combinations between number of leads and months included in the moving averages, we are able to construct 25 scatter graphs. In ANNEX V, they are numbered from 1 to 5 (depending on the *lead*) and lettered (a to e) to differentiate the moving averages. The graphs corresponding to MA (0) are the ones that do not compute averages, consisting only on original changes in the variables.

In addition, we estimate simple OLS regression corresponding to each graphic, to quantify these pair relationships. Using the resulting coefficient and R^2, among each group of leads, we try to find the model that best fit the data.

Finally, we did a causality Granger test for each pair of variables. This test indicates whether one 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.

Results

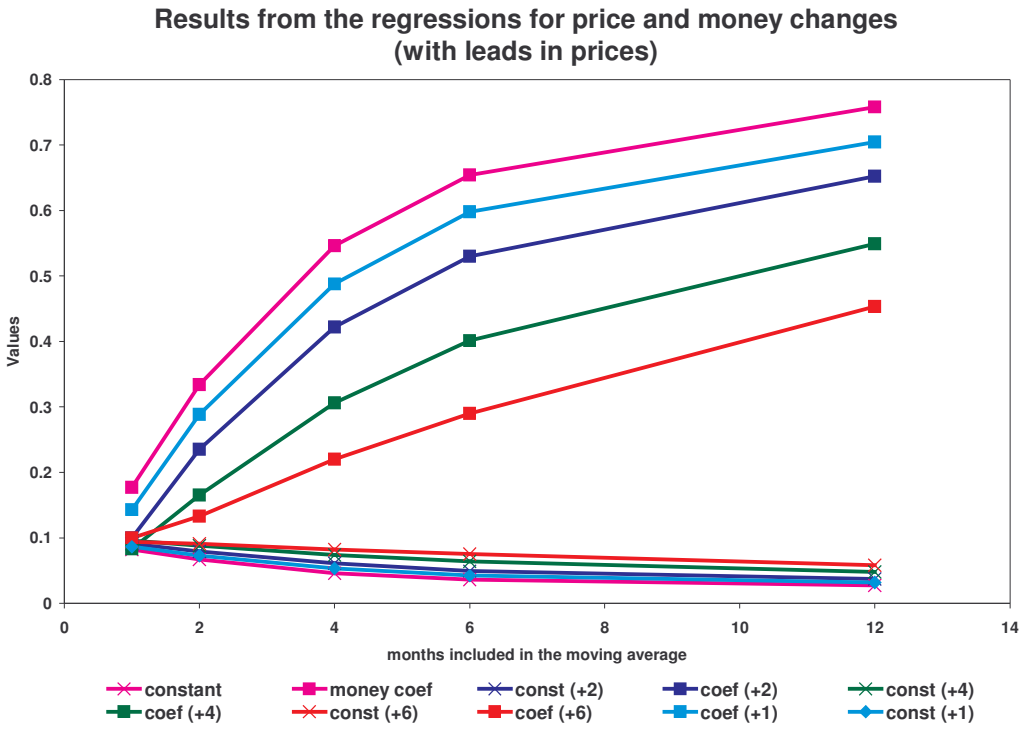
It is interesting to notice that, even though an undefined cloud of points represents the relationship of monthly contemporary changes, as the period included in the moving averages enlarges, a more specific relationship is found. See ANNEX V.a. for the sets of graphs. In the long term, points tend to concentrate around the 45º line indicating that changes in the quantity of money result in similar changes in the price level.

Specifically, in going from graph 1.a to graph 1.e -that refer to contemporary changes in variables, with higher letters corresponding to greater number of months included in the moving averages- points tend to locate nearer the 45º line. Similarly, and independently of which lead of price changes is taken into account, in all sets of graphs this evolution is observed.

Moreover, OLS regression results confirm that, for all cases, correlation between variables (measured by the R^2) improves when more periods are included in the moving averages. In parallel, the coefficients found become bigger.

Nevertheless, when we compare models with different leads for the CPI changes, the structure that best fit the data –with R^2 equal to 0.76- is the one considering 12 months moving averages of contemporary changes. This model structure prevails for all moving averages calculated.

The following graph summarizes these results. We use the same colors for the coefficient and constant resulting from the same lead structure regression. It must be noted that the structures that lead to lower values in constants correspond the higher coefficients. As the model becomes weaker, the constant are bigger and the coefficients smaller. The regression considering 6 leads is the weakest one and its constants and coefficients are located in the middle of the graph.



Another interesting result, is that Granger tests between changes in money and inflation, at a 95% confidence level, indicate that the null hypothesis that changes in prices do not help predict future changes in money, can be rejected. On the contrary, the null hypothesis that changes in money do not help predict future changes in prices cannot. We repeat this procedure for 2, 4, 6 and 12 lags and the results are consistent.

These results, shown in ANNEX I, were not the ones expected ex ante. In theory, it is expected that changes in money will result in changes in prices. However, with the data available, we found that changes in prices cause (from a Granger point of view) changes in prices.

One possible explanation is that during this period monetary authorities were subject to fiscal authorities decisions. As a consequence, if prices increased leading for example to a public sector salaries adjustment, a higher money emission would be necessary to finance this higher expenditure. In the end, this can result in a dynamic where changes in money are originated in changes in prices.

The Granger tests might also be considered as indirect evidence for the fiscal theory of the price level. If projections on fiscal expenditures imply that there will be future increases in the money supply, the inflation might adjust in anticipation of these increases in money issue (See Woodford (1995)). If these were the case, one would note that price changes preceded changes in the money stock. Cochrane (2001) finds also that the maturity structure of the debt matters for the effect on prices, with longer maturities associated with more future inflation instead of current inflation.

Evidence for other countries

Batini and Nelson (2002) present evidence for the United States and for England on the relationship between changes in the money stock and inflation (using six month or annual money growth and inflation rates). For the United States, changes in the money stock lead inflation by between 12 and 31 months from 1953 to 1979 and a longer and weaker (statistically) lead from 1980 on (up to 49 months). For England, changes in the money stock lead inflation by six months in the 1953 to 1979 period and by two years for 1980 to 2000 and for 1995-2000 alone. In all cases the evidence is that six month or one year averages in the changes in the money stock lead similarly average changes in prices. Using long series of annual data (1871 to 2000 for the US and 1835 to 2000 for England), they find one to two year lags from changes in money to inflation.

For Argentina, the evidence is completely different from that of Batini and Nelson. As we extend the lag on changes in money that we use with prices, the correlation worsens. This can be seen from the scatter plots (ANNEX V.b) and from the results of the regressions (Exercise nº 3 in ANNEX II). Changes in money lagged two years show very little correlation with prices, this is true whether we use six or twelve month moving averages.

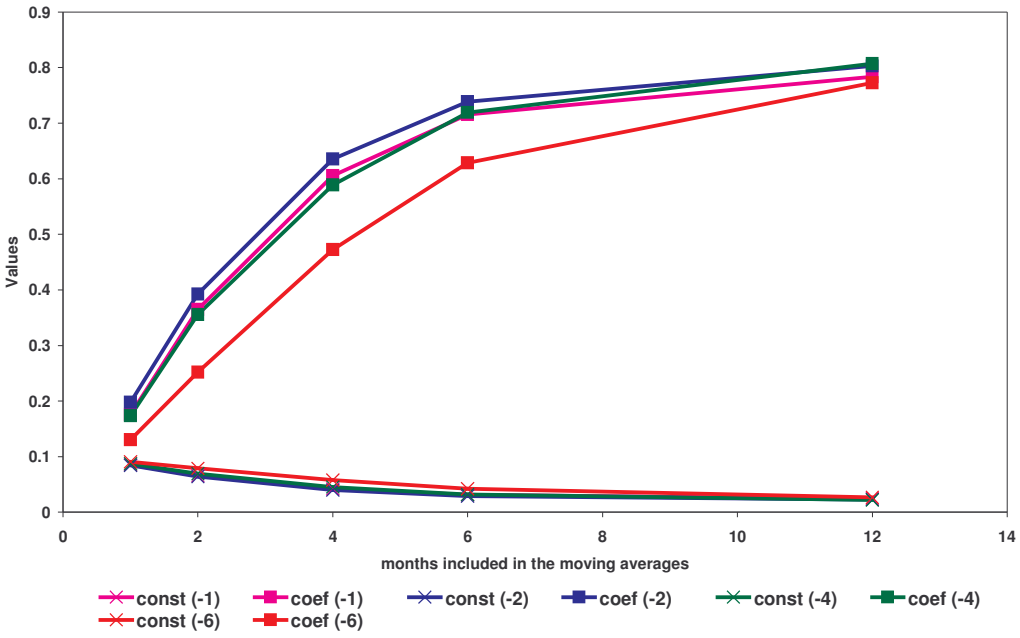
An additional exercise

This section's objective is to analyze in more detail the result found with the Granger tests, which indicate that change in prices precede changes in money. The same exercise as before was performed but using lags instead of leads for price changes. If Granger test are right, the inclusion of lags should improve the relationship between variables.

The corresponding graphs are numbered from 6 to 9 using 1, 2, 4 y 6 *lags* respectively (graphs 6 for 1 *lag*, and then on to end with graph 10 for 6 *lags* in prices). Letters indicate the difference in the months included in the moving average.

As before, 12 months averages yield the best results. Additionally, considering the number of lags in prices, the model that shows the best fit is the one for 2 lags. OLS regressions confirm this result, as the R^2 corresponding to 2 lags in prices are the highest for 12 months moving averages (See ANNEX II).

Results from the regressions of changes in prices and money (with lags in prices)



Reviewing other relationships

As the nominal exchange rate (NER) is a variable that is closely related to what happens in prices and money, we decided to include it in the analysis. In this way, we review the relationship between prices and exchange rate and alternatively that between money and the

exchange rate using the same methodology (that is, taking lags and leads of one variable and also calculating the different moving averages).

Changes in Nominal Exchange Rate and changes in Money

In this case also, we found that as long as more months are included in the moving average, the relationship between variables is higher. ANNEX V.c. shows that points relating changes in the NER and changes in money converge to a 45º line.

Leads y *lags* were calculated for the changes in NER. OLS regressions indicate that the best model is found when 4 lags of the NER is considered (of course, always taking into account a 12-months moving average). However, with this pair of variables, no strictly superior model is found. As the moving averages are modified, the election for the best lag/lead structures changes. As a result, the best models are the following: data not averaged, models with 2 and 4 lags are elected, with 2 month moving average, 1 lag is chosen, with 4 and 6 months, 2 lags is the best model. Finally, as we mentioned, with 12-month moving average, 4 lags are the best fit. For this model structure, with 4 lags, the R^2 goes from 0.03 for MA 0 to 0.63 for MA 12.

Changes in Nominal Exchange Rate and price inflation

As expected, with this set of variables, the same result in terms of the long term relationship is found: as long as more months are included in the moving average, the correlation between variables increases.

The best model includes 1 lead in CPI with a R^2 equal to 0.59. No strictly superior model structure is found in this section either. The contemporaneous model (the model without leads or lags) is superior when considering 0, 2 and 4 months moving averages. For longer moving averages, 1 lead in CPI is superior, as can be seen in ANNEX V.

Conclusions

In order to study the relationship between money, prices and NER a comprehensive analysis following Lucas was done. In the first place, taking Lucas´ graphical analysis, each pair of variables was intertemporaly revised. Enlarging the months included in the moving average,

it is graphically demonstrated that for the period 1976-1989, the longer the period, the stronger the relationship between variables. With the larger averages points tend to concentrate around a 45º line, implying a 1 to 1 relationship. This procedure was also done with different leads and lags of the variables. In a second stage of analysis, we estimate simple OLS regressions and Granger test in order to quantify the relationship between variables.

Even though the three pair of variables considered show the same kind of dynamic behavior (as longer the period considered, higher the correlation), the relationship between changes in money and changes in prices is stronger than the other two pairs studied.

The results suggest that in the short term, the response of prices to changes in the quantity of money is almost impossible to predict. What happens to prices depends on the performance of the money stock in the medium term. If money keeps growing, as it did at the end of 2002, the results show a high correlation with prices in a quite predictable way six months to one year from now. If, on the contrary, future growth in money is stopped or reversed, changes in prices over the medium term would be almost imperceptible.

References

- Cochrane, John H. (2001), **"Long term debt and optimal policy in the fiscal theory of the price level"**, *Econometrica*, vol.69 No. 1.
- McCandless Jr., G. T. & Weber W. E. (1995), **"Some Monetary Facts"**, *Quarterly Review*, Federal Reserve Bank of Minneapolis, vol.19 No. 3.
- Lucas, R. E., Jr. (1980), "**Two illustrations of the quantity theory of money"**, American Economic Review.
- Batini, N. y E. Nelson (2002), "**The Lag from Monetary Policy Actions to Inflation: Friedman Revisited**", Bank of England.
- Woodford, Michael (1995), **"Price level determinacy without control of a monetary aggregate"**, Carnegie-Rochester Conference Series on Public Policy 43.

ANNEX I

Pairwise Granger Causality Tests
Sample: 1976:01 1989:03

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability	
MONEYCH does not Granger Cause IPCCH		0.14814	0.86244	No rechazo H0
IPCCH does not Granger Cause MONEYCH		18.2302	8.1E-08	Rechazo H0

Lags: 4

Null Hypothesis:	Obs	F-Statistic	Probability	
MONEYCH does not Granger Cause IPCCH		0.63573	0.63782	No rechazo H0
IPCCH does not Granger Cause MONEYCH		10.7282	1.2E-07	Rechazo H0

Lags: 6

Null Hypothesis:	Obs	F-Statistic	Probability	
MONEYCH does not Granger Cause IPCCH		1.47645	0.19054	No rechazo H0
IPCCH does not Granger Cause MONEYCH		7.52486	5.4E-07	Rechazo H0

Lags: 12

Null Hypothesis:	Obs	F-Statistic	Probability	
MONEYCH does not Granger Cause IPCCH		1.46930	0.14493	No rechazo H0
IPCCH does not Granger Cause MONEYCH		3.89665	4.7E-05	Rechazo H0

ANNEX II: Relationship between prices and money

Exercise Nº 1: Leads in prices

	0 Lead	1 Lead	2 Leads	4 Leads	6 Leads
MA0	0.14	0.09	0.05	0.03	0.04
MA2	0.28	0.21	0.13	0.06	0.04
MA4	0.50	0.39	0.28	0.14	0.07
MA6	0.63	0.51	0.40	0.22	0.12
MA12	0.76	0.67	0.57	0.40	0.27

Exercise Nº 2: Lags in prices

	1 Lag	2 Lags	4 Lags	6 Lags
MA0	0.13	0.15	0.11	0.06
MA2	0.31	0.34	0.25	0.13
MA4	0.58	0.62	0.49	0.30
MA6	0.73	0.76	0.68	0.46
MA12	0.82	0.86	0.86	0.76

Exercise Nº 3: Long term

	12 Leads	18 Leads	24 Leads	30 Leads
MA6	0.02	0.00	0.04	0.02
MA12	0.04	0.00	0.03	0.03

ANNEX III: Relationship between NER and money

Exercise Nº 1: Leads in NER

	0 Lead	1 Lead	2 Leads	4 Leads	6 Leads
MA0	0.14	0.01	0.00	0.00	0.01
MA2	0.23	0.08	0.01	0.01	0.01
MA4	0.32	0.20	0.10	0.01	0.02
MA6	0.40	0.27	0.18	0.07	0.03
MA12	0.51	0.41	0.32	0.03	0.08

Exercise Nº 2: Lags in NER

	1 Lag	2 Lags	4 Lags	6 Lags
MA0	0.00	0.03	0.03	0.02
MA2	0.15	0.09	0.11	0.09
MA4	0.33	0.34	0.26	0.19
MA6	0.46	0.51	0.45	0.32
MA12	0.58	0.61	0.63	0.59

ANNEX IV: Relationship between NER and prices

Exercise Nº 1: Leads in CPI

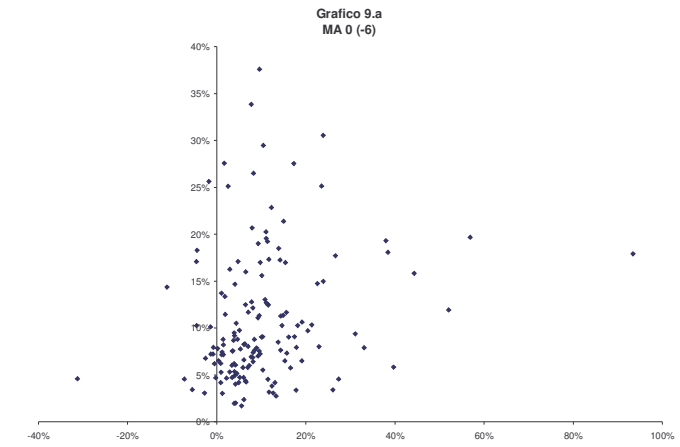
	0 Lead	1 Lead	2 Leads	4 Leads	6 Leads
MA0	0.25	0.14	0.11	0.20	0.05
MA2	0.35	0.31	0.20	0.07	0.08
MA4	0.46	0.44	0.36	0.18	0.13
MA6	0.51	0.52	0.48	0.33	0.21
MA12	0.57	0.59	0.58	0.50	0.42

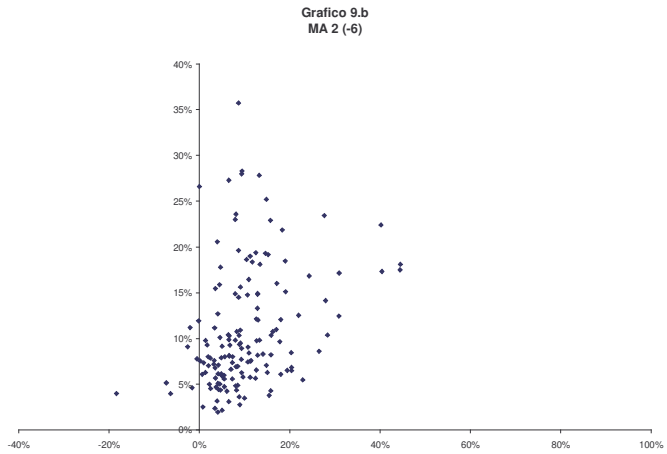
Exercise Nº 2: Lags in CPI

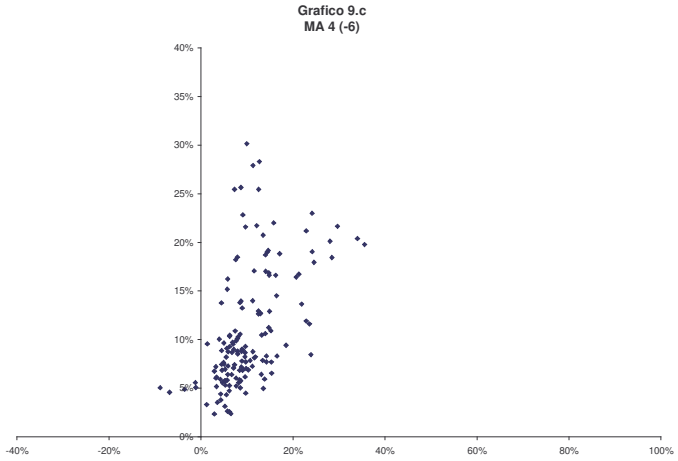
	1 Lag	2 Lags	4 Lags	6 Lags
MA0	0.10	0.04	0.01	0.01
MA2	0.24	0.11	0.02	0.01
MA4	0.37	0.24	0.06	0.03
MA6	0.44	0.34	0.16	0.07
MA12	0.57	0.51	0.39	0.26

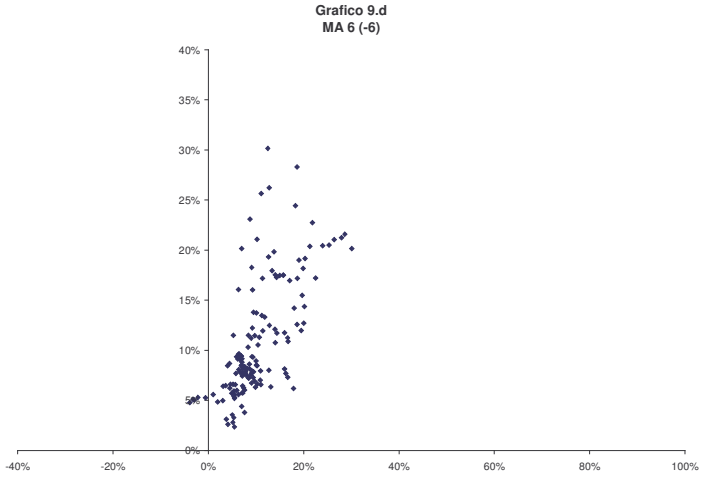
Note: For ANNEX III and IV, no strictly superior model prevails, considering R^2. It is observed that, when the number of months included in the moving averages is enlarged, the election of the best *leads/lags structures* for the model varies. For example, in ANNEX IV, although the contemporary model is superior when using 0, 2 and 4 months moving averages, when longer moving averages are considered, the model that best fits the data is the one with 1 *lead* in IPC.

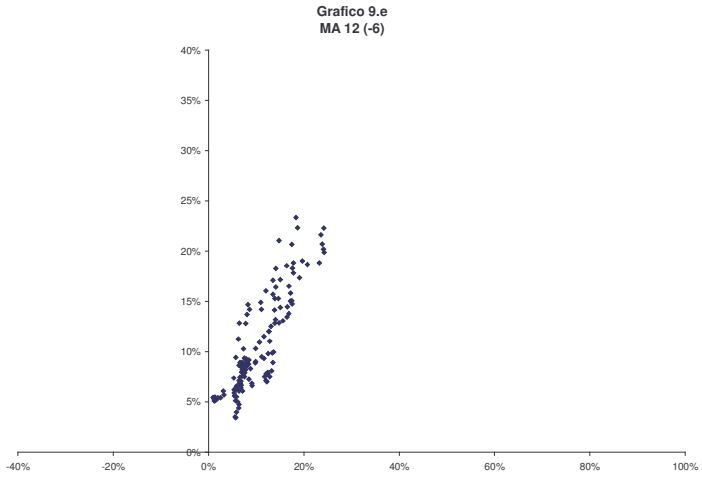
ANNEX V.a. **Relationship Money ch. – CPI ch.: Subset with 6 lags**











Relationship Money ch. – CPI ch.:
Subset with 4 lags

Gráfico 8.a
MA 0 (-4)

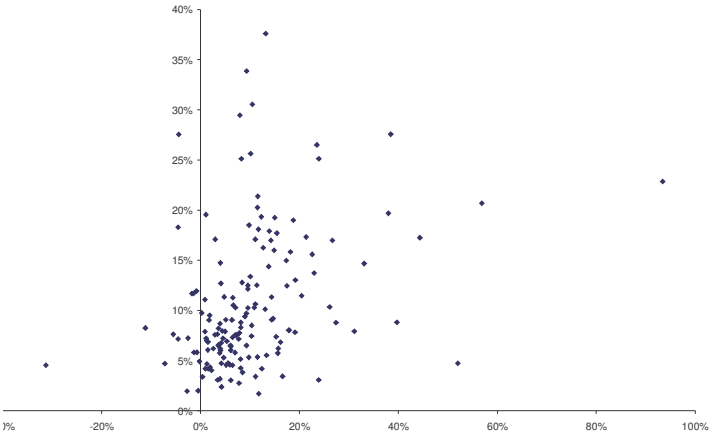


Gráfico 8.b
MA 2 (-4)

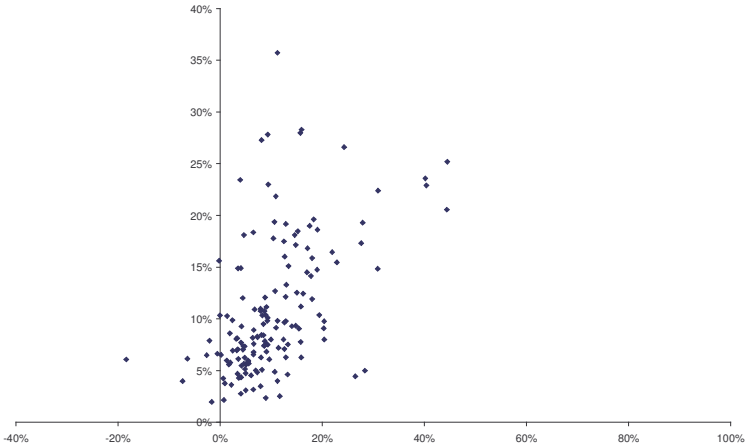


Gráfico 8.c
MA 4 (-4)

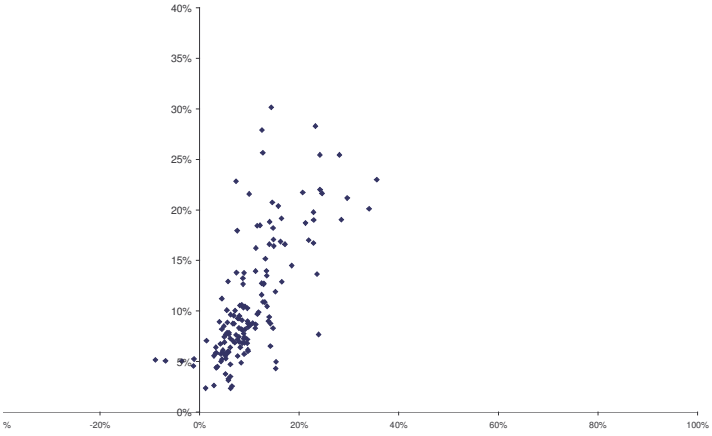


Gráfico 8.d
MA 6 (-4)

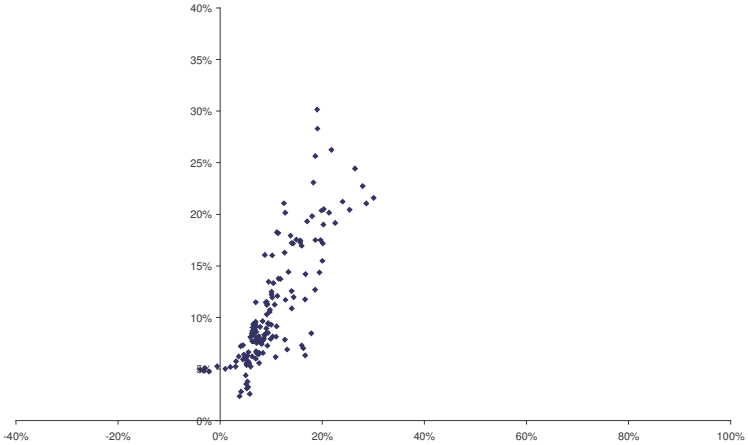
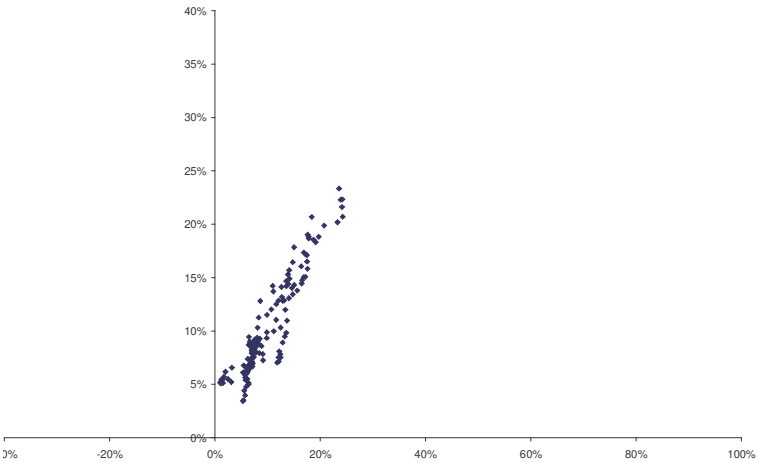


Gráfico 8.e
MA 12 (-4)



Relationship Money ch. – CPI ch.:
Subset with 2 lags

Gráfico 7.a
MA 0 (-2)

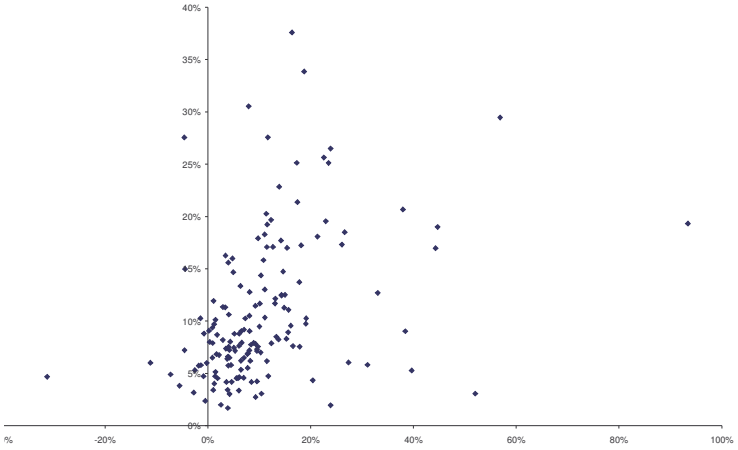


Gráfico 7.b
MA 2 (-2)

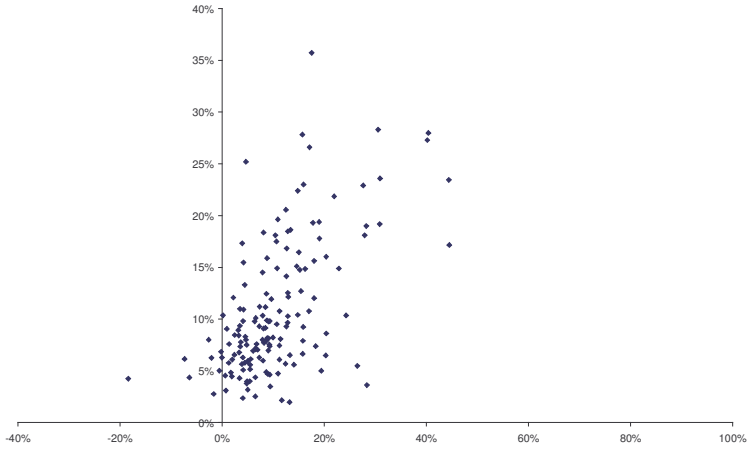


Gráfico 7.c
MA 4 (-2)

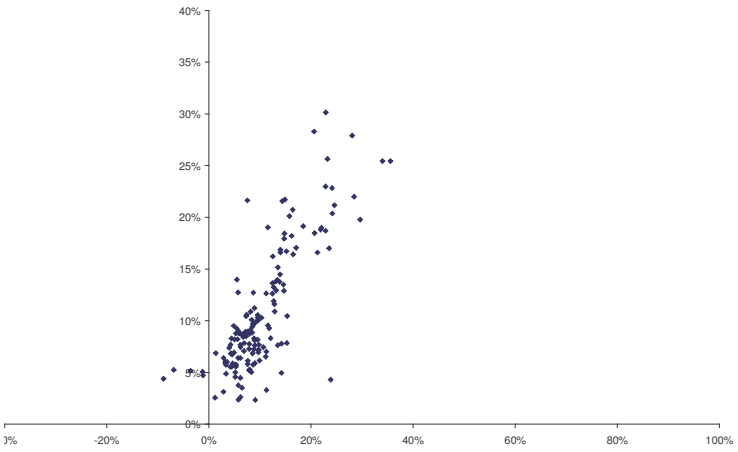


Gráfico 7.d
MA 6 (-2)

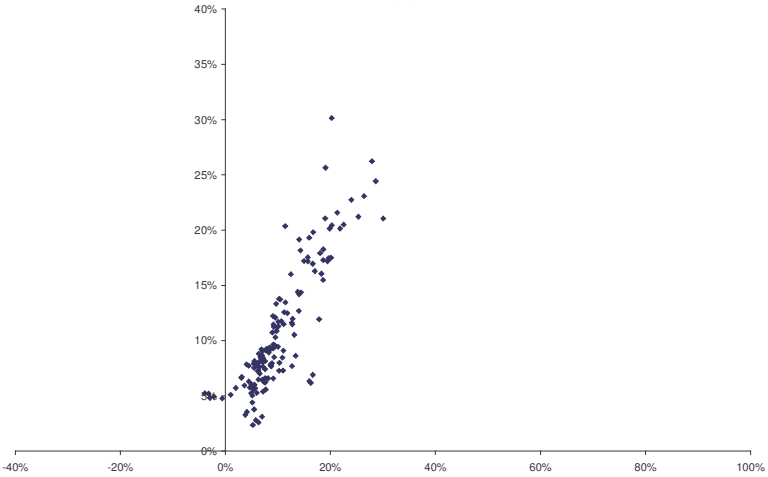
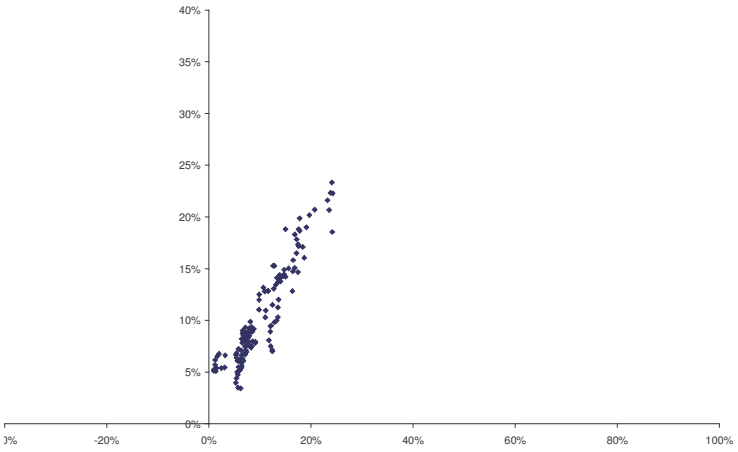


Gráfico 7.e
MA 12 (-2)



Relationship Money ch. – CPI ch.:
Subset with 1 lag

Gráfico 6.a
MA 0 (-1)

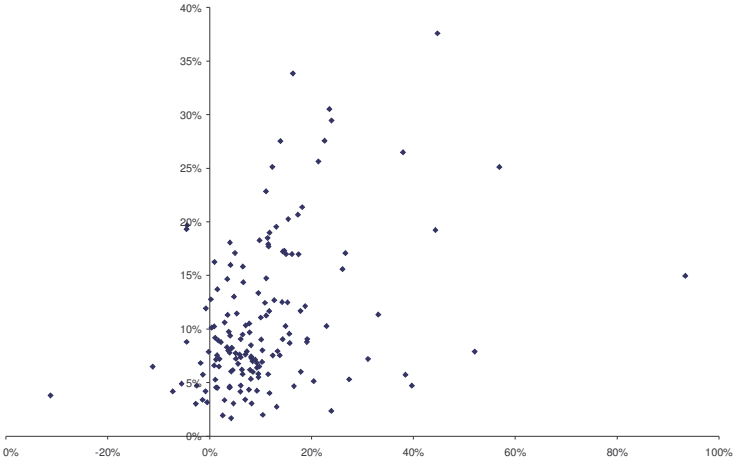


Gráfico 6.b
MA 2 (-1)

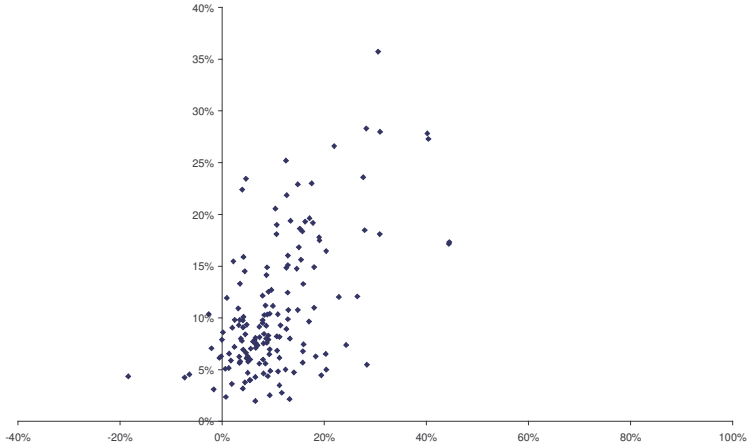


Gráfico 6.c
MA 4 (-1)

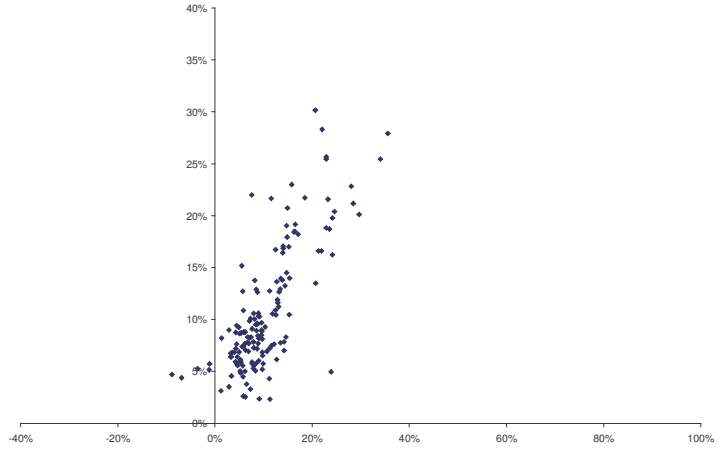


Gráfico 6.d
MA 6 (-1)

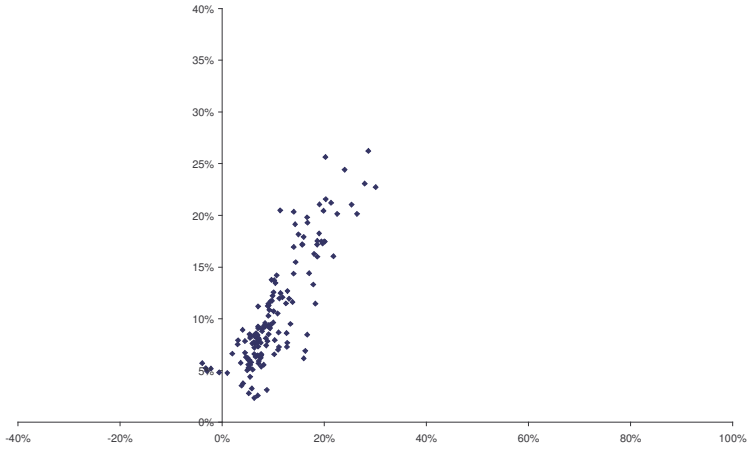


Gráfico 6.e
MA 12 (-1)

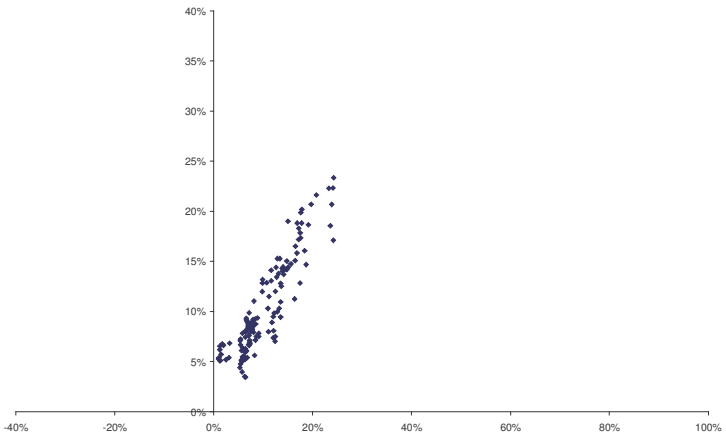


Gráfico 1 a.
MA 0

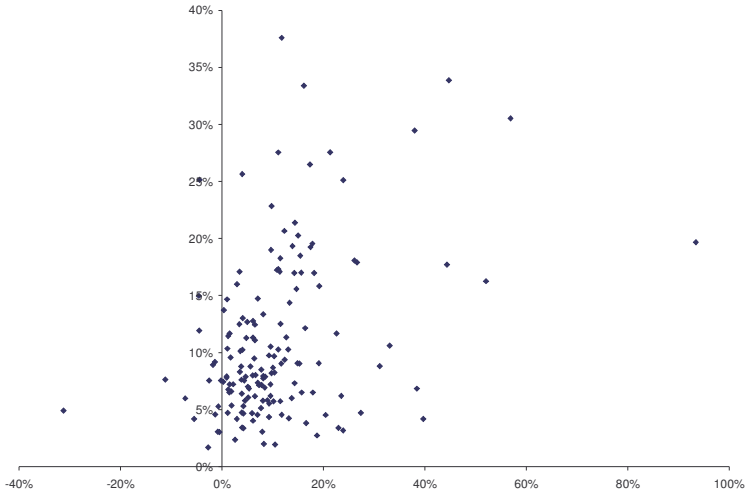


Gráfico 1.b.
MA 2

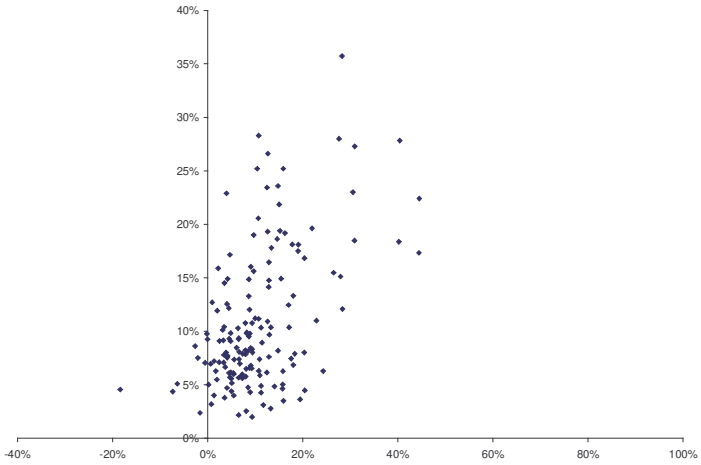


Gráfico 1.c.
MA 4

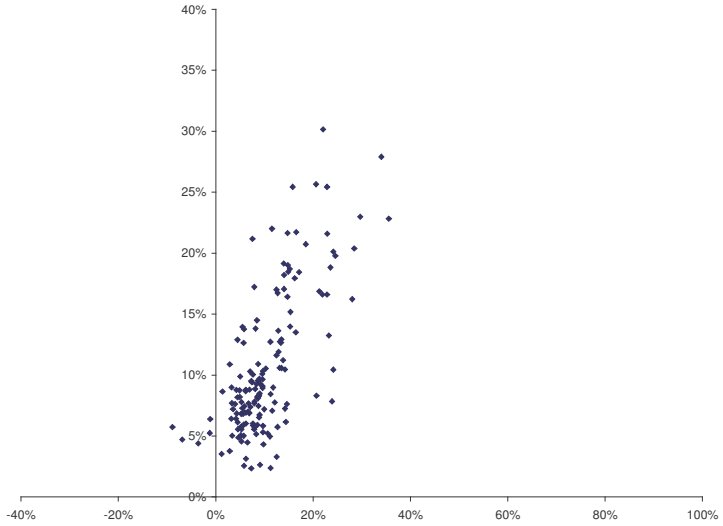


Gráfico 1.d.
MA 6

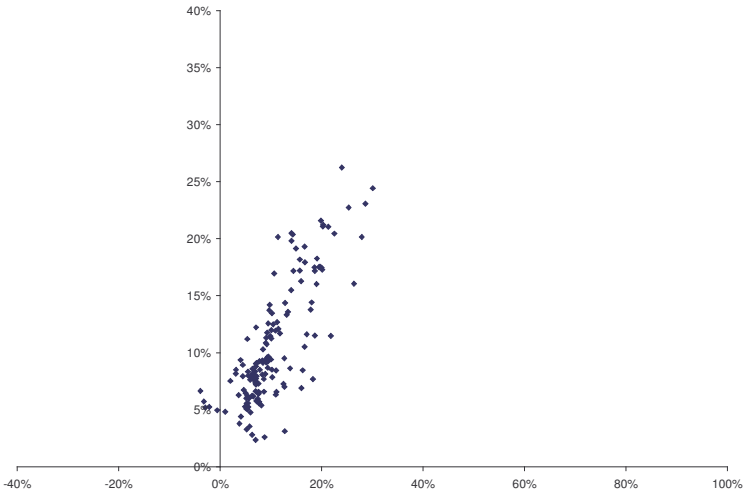


Gráfico 1.e.
MA 12

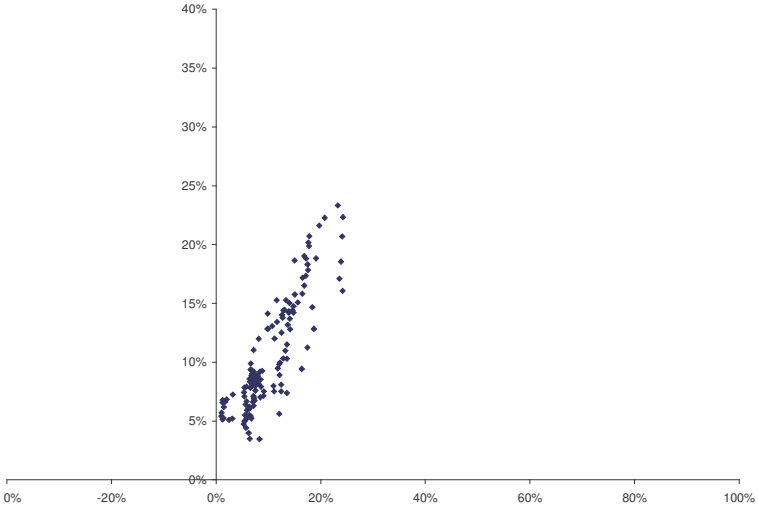


Gráfico 2.a.
MA 0 (+1)

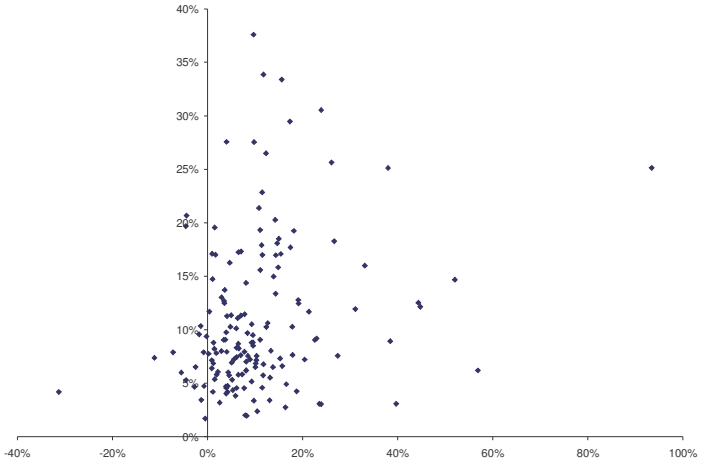


Gráfico 2.b.
MA 2 (+1)

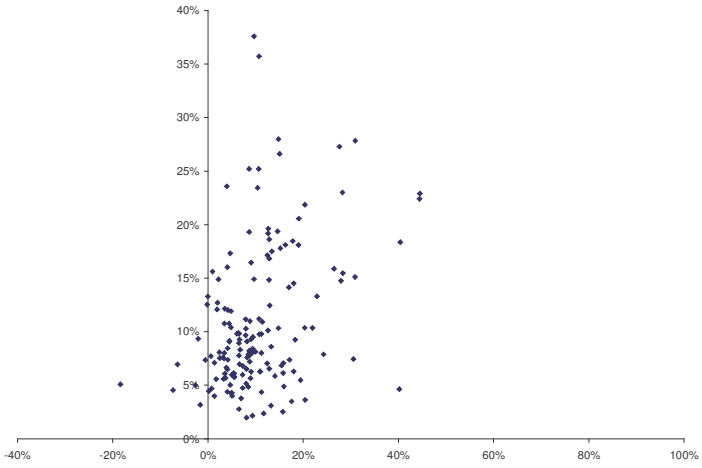


Gráfico 2.c.
MA 4 (+1)

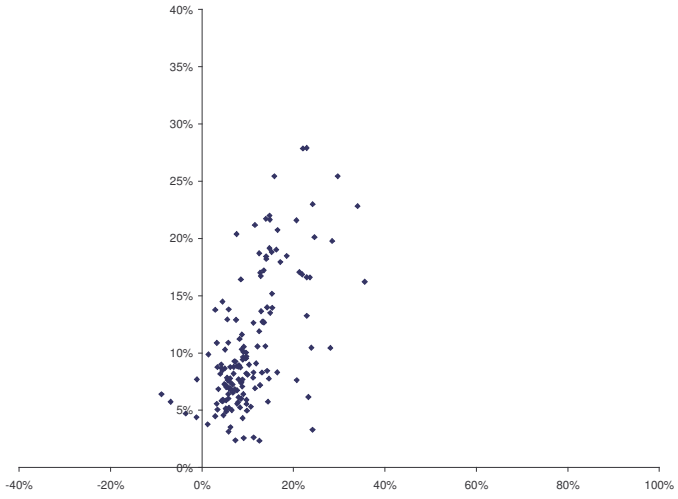


Gráfico 2.d.
MA 6 (+1)

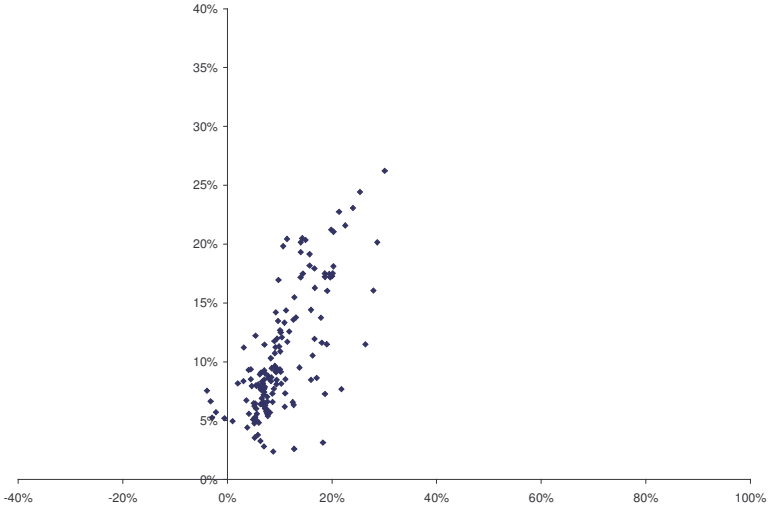
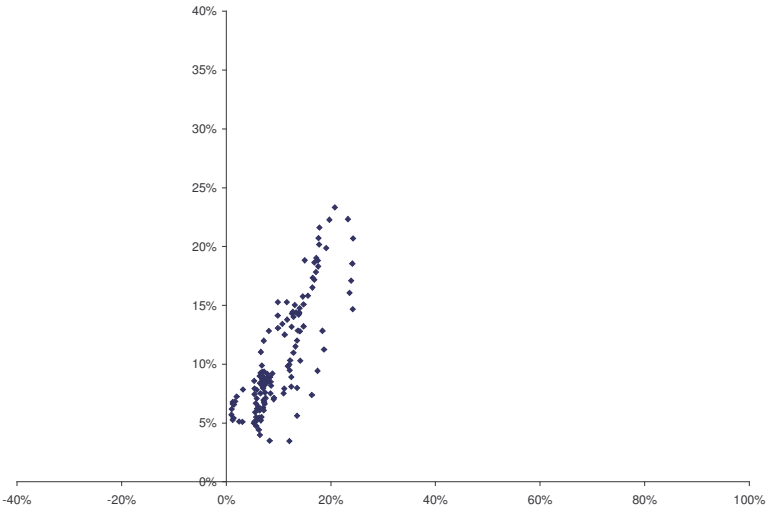


Gráfico 2.e.
MA 12 (+1)



Relationship Money ch. – CPI ch.:
Subset with 2 leads

Gráfico 3.a.
MA 0 (+2)

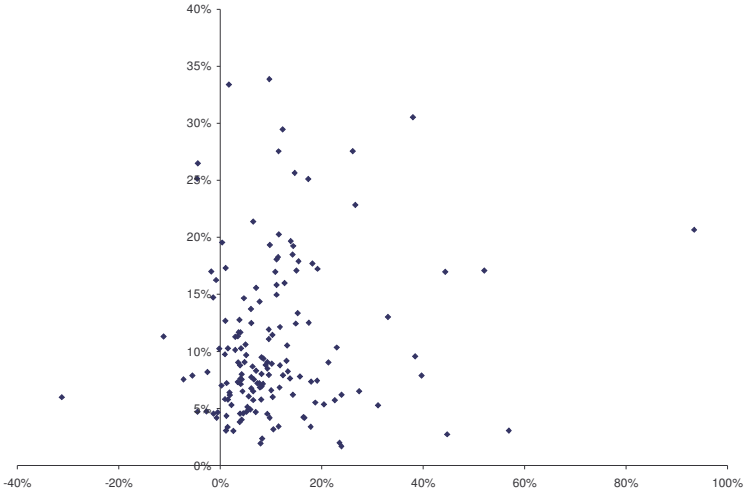


Gráfico 3.b.
MA 2 (+2)

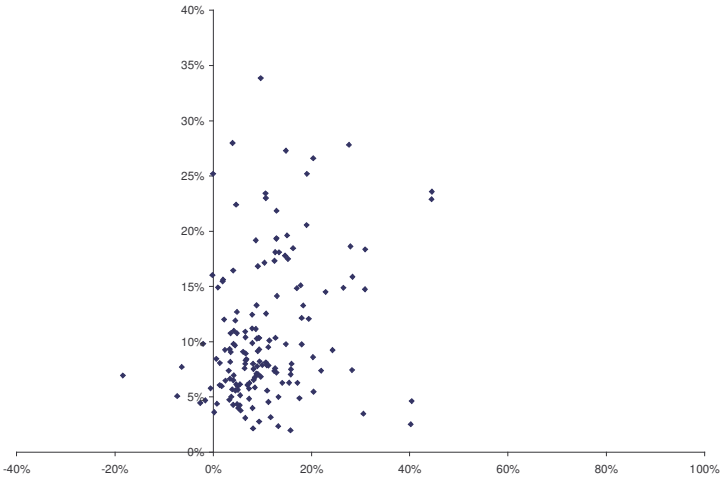


Gráfico 3.c.
MA 4 (+2)

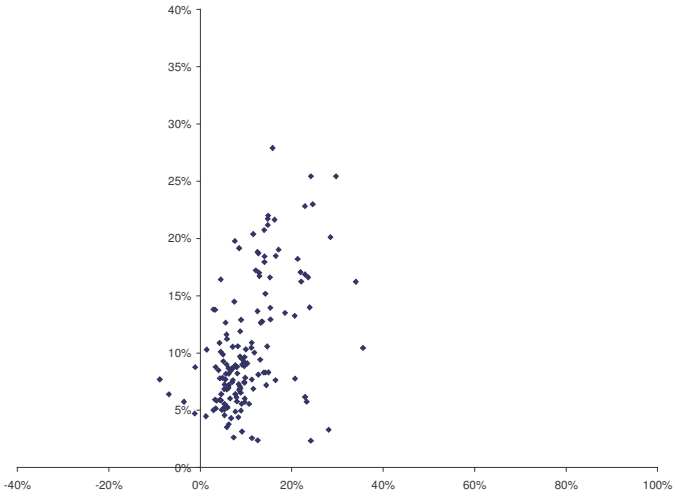


Gráfico 3.d.
MA 6 (+2)

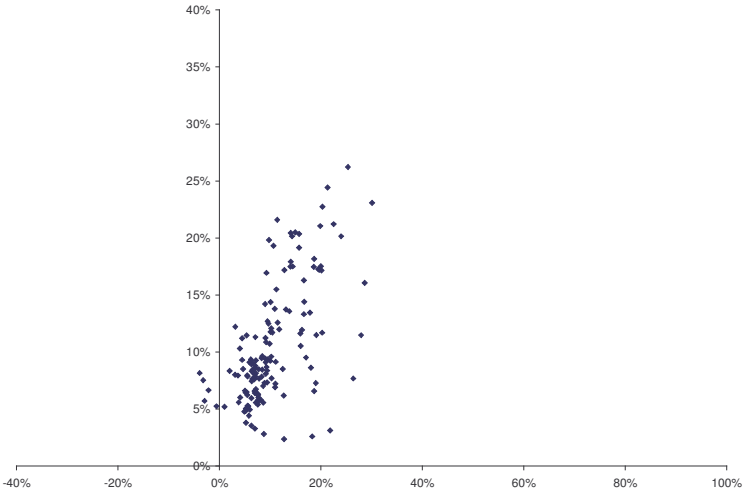
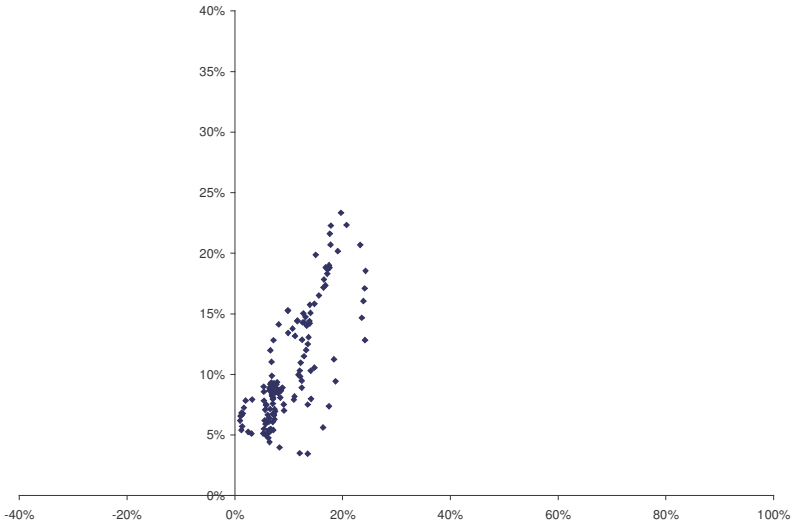


Gráfico 3.e
.MA 12 (+2)



Relationship Money ch. – CPI ch.:
Subset with 4 leads

Gráfico 4.a.
MA 0 (+4)

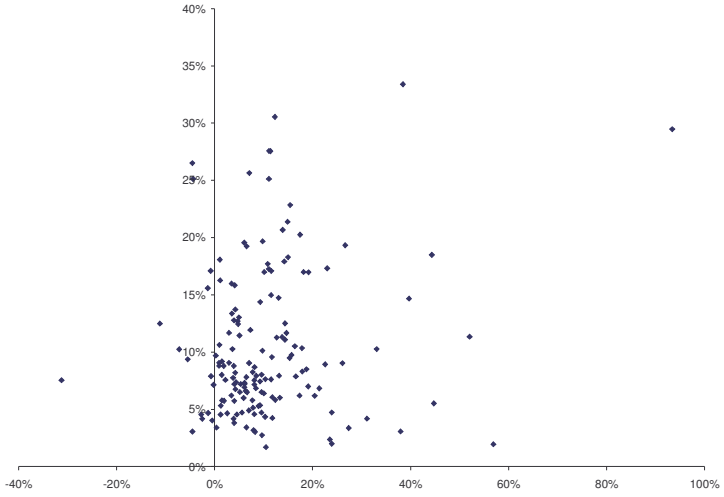


Gráfico 4.b.
MA 2 (+4)

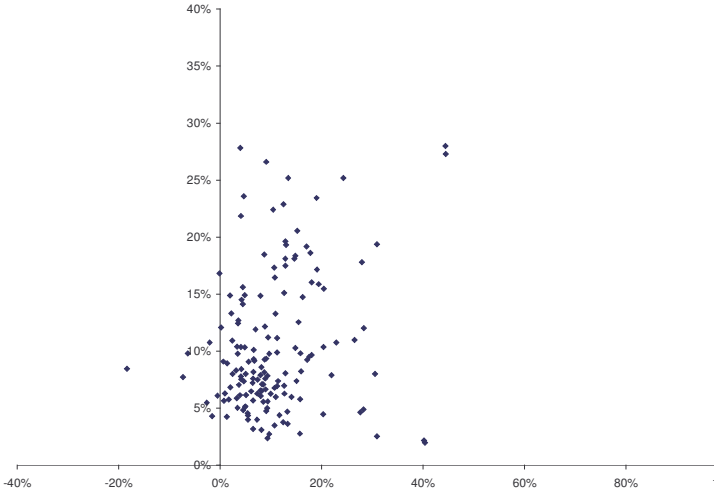


Gráfico 4.c.
MA 4 (+4)

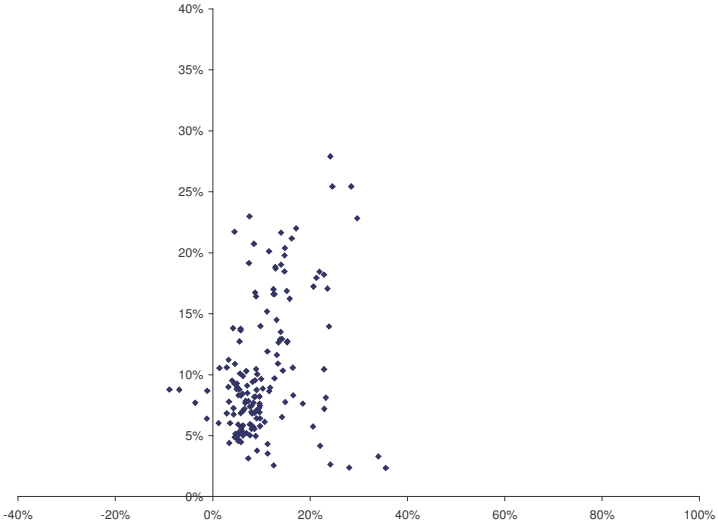


Gráfico 4.d.
MA 6 (+4)

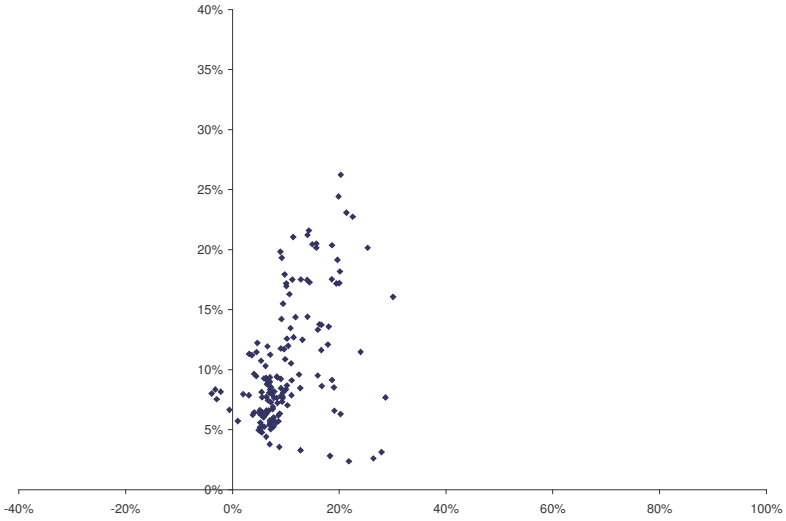
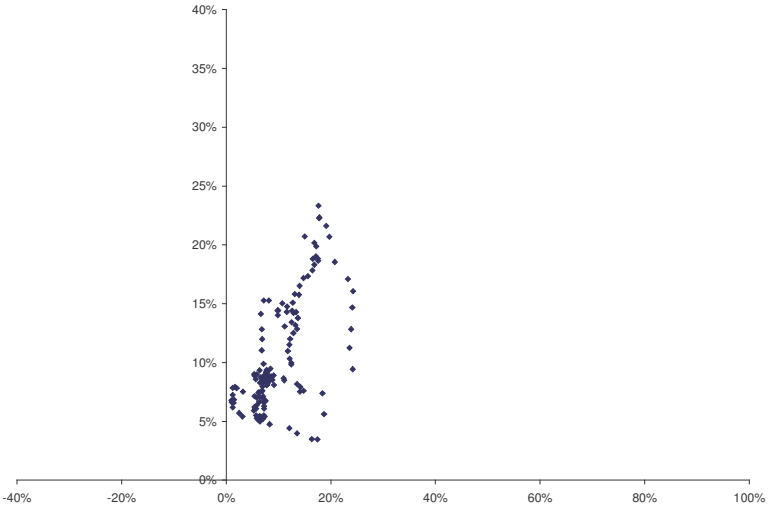


Gráfico 4.e.
MA 12 (+4)



Relationship Money ch. – CPI ch.:
Subset with 6 leads

Gráfico 5.a.
MA 0 (+6)

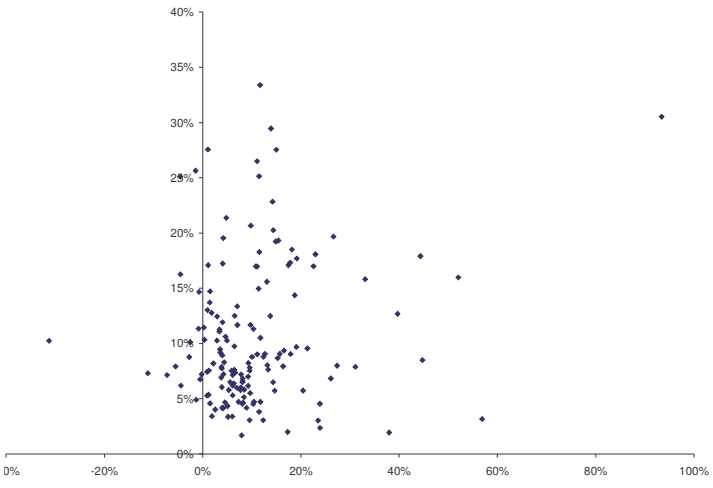


Gráfico 5.b.
MA 2 (+6)

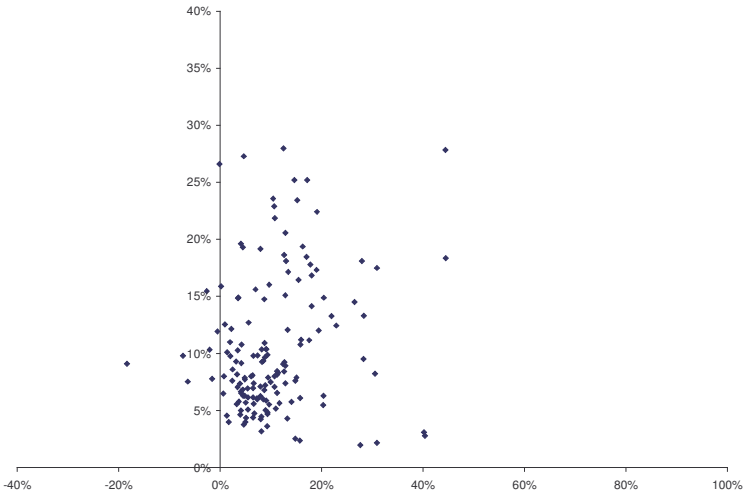


Gráfico 5.c.
MA 4 (+6)

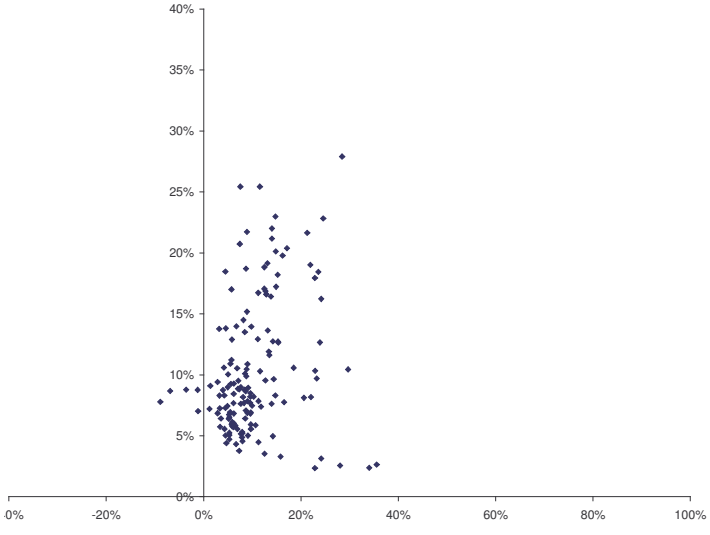


Gráfico 5.d.
MA 6 (+6)

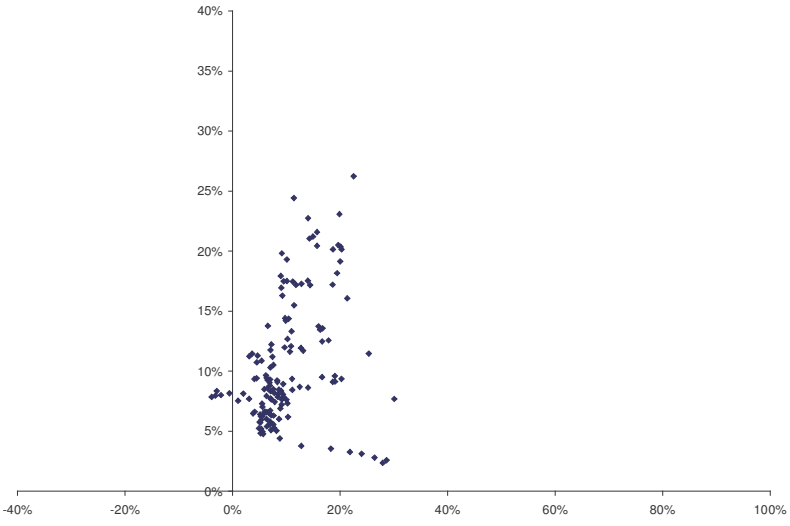
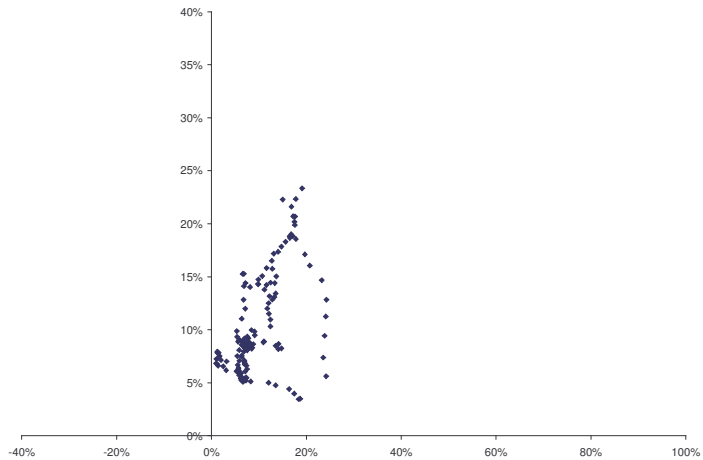
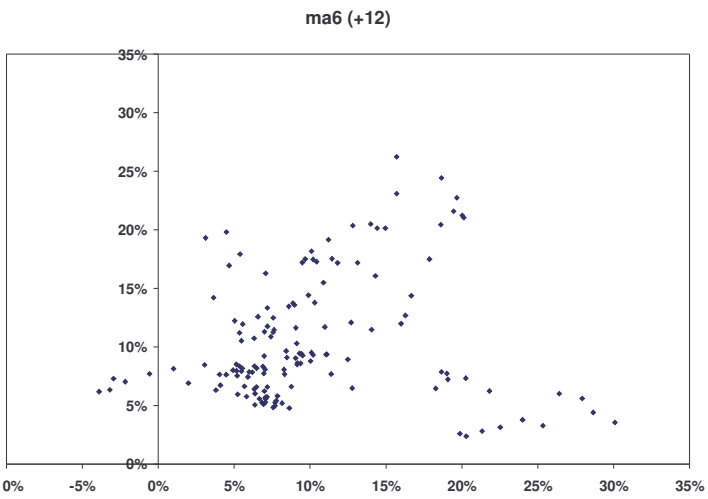


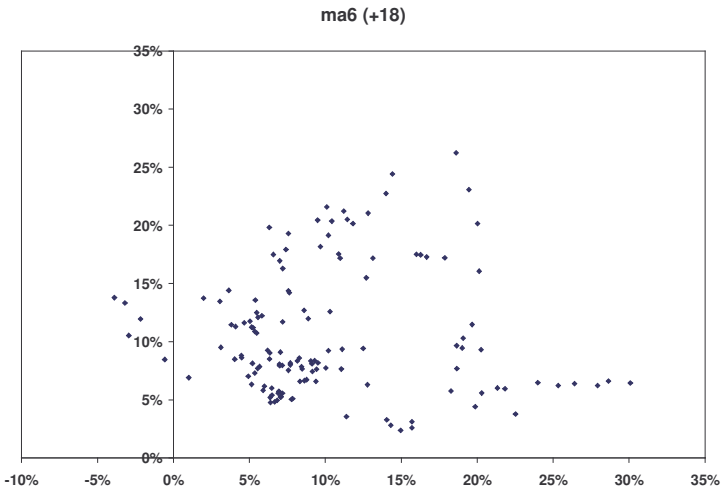
Gráfico 5.e.
MA 12 (+6)

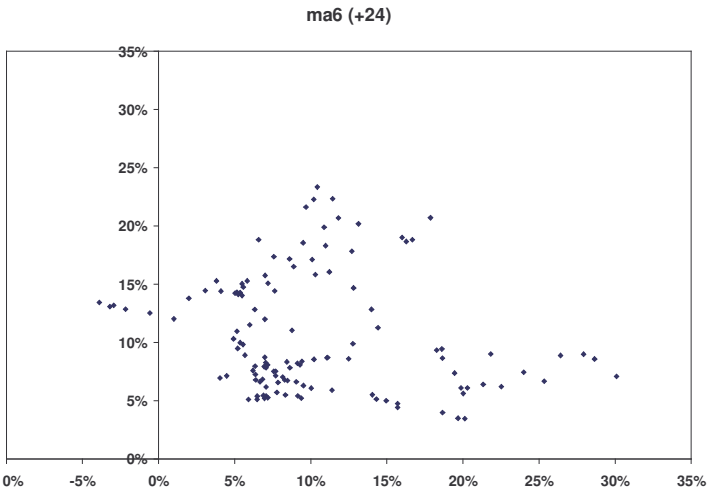


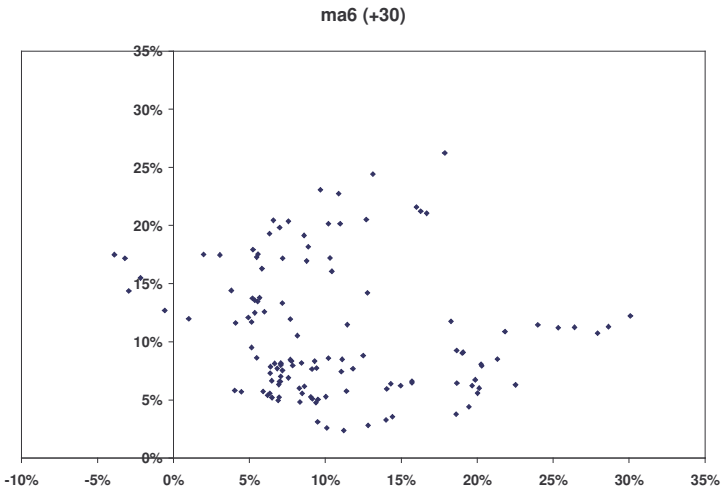
ANNEX V.b.

Relationship Money ch. – CPI ch.: Subset with 6 months MA



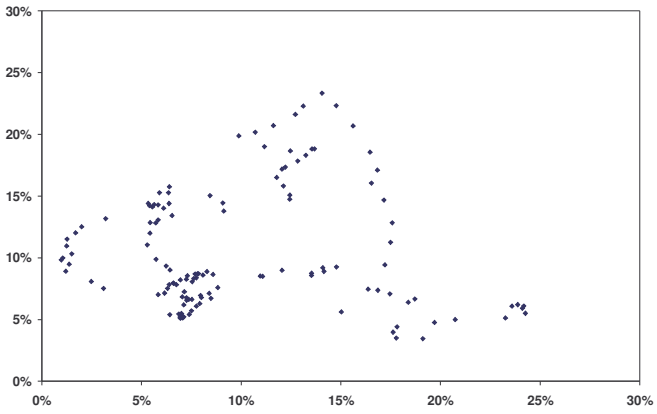




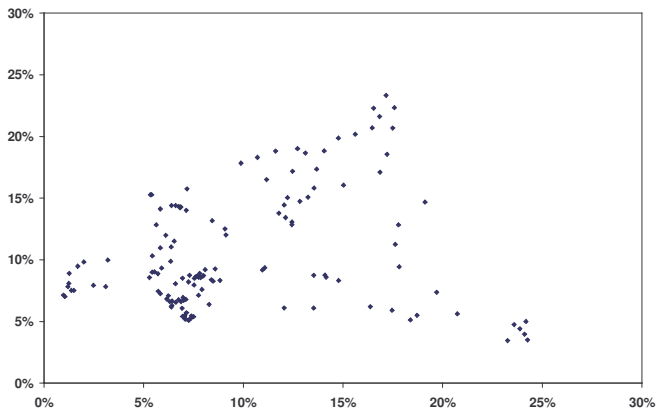


Relationship Money ch. – CPI ch.:
Subset with 12 months MA

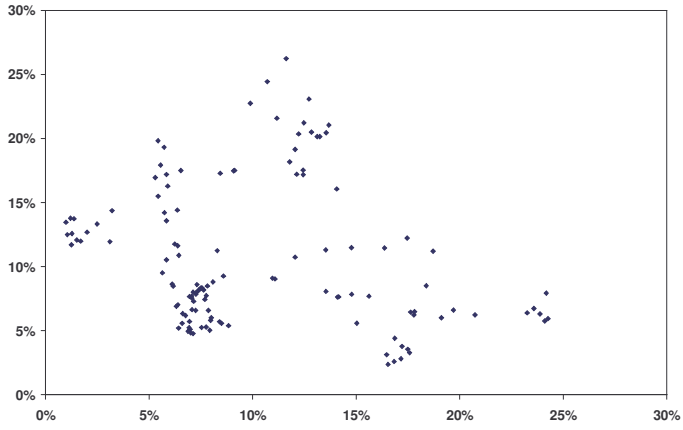
ma12 (+12)



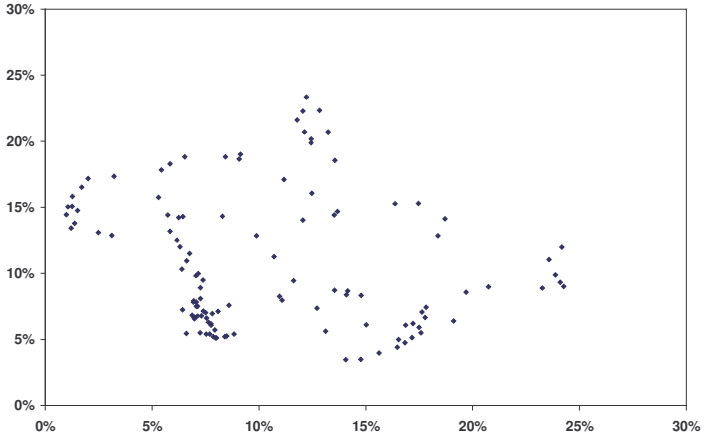
ma12 (+18)



ma12 (+24)



ma12 (+30)



ANNEX V.c.

Relationship NER ch. – Money ch.: Subset with 4 *lags* in NER

Gráfico 8.a
MA 0 (-4)

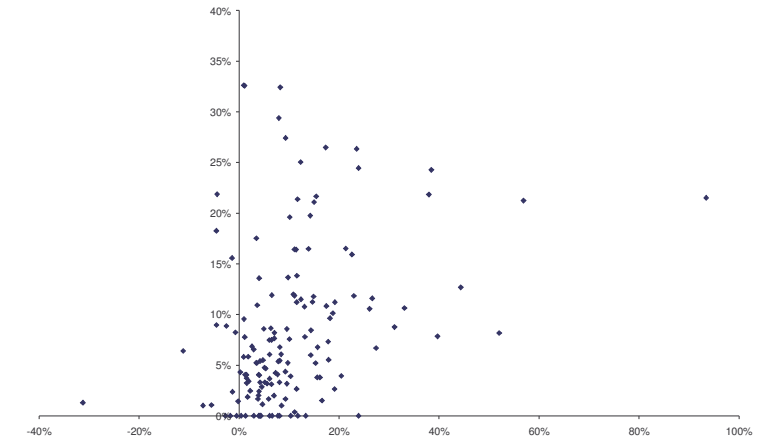


Gráfico 8.b
MA 2 (-4)

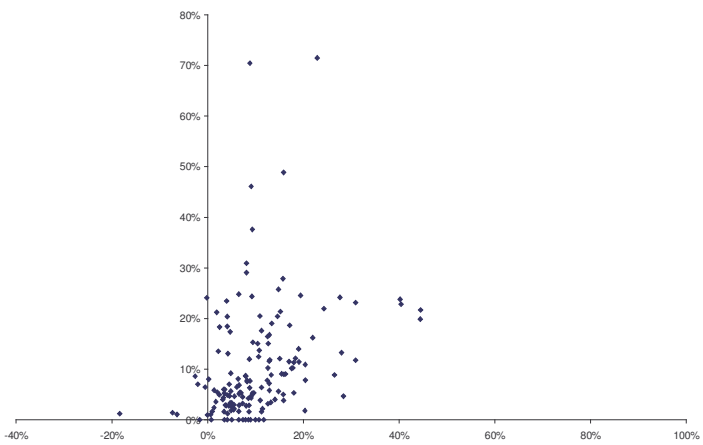


Gráfico 8.c
MA 4 (-4)

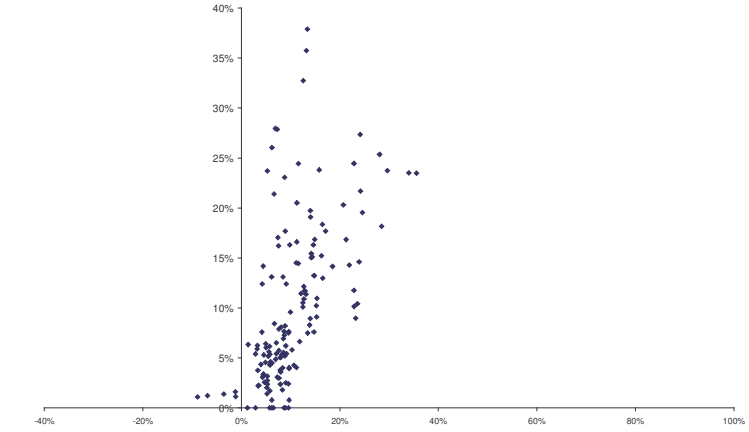


Gráfico 8.d
MA 6 (-4)

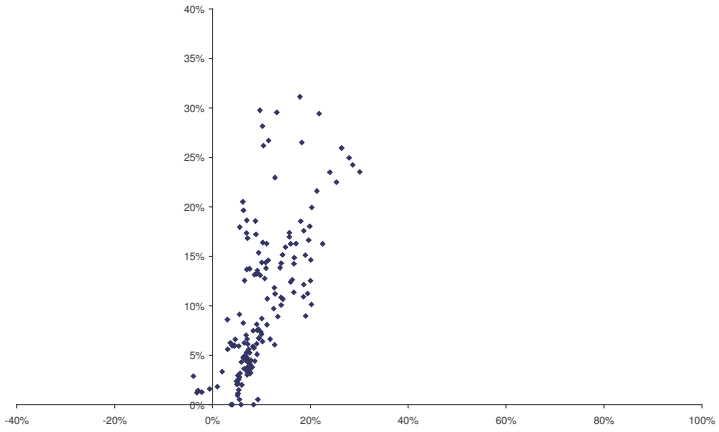
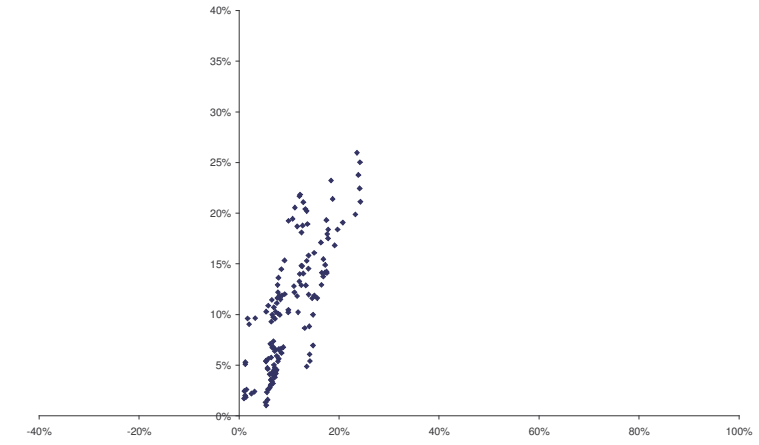


Gráfico 8.e
MA 12 (-4)



Relationship CPI ch. – NER ch.:
Subset with 1 *lead* in CPI

Gráfico 2.a.
MA 0 (+1)

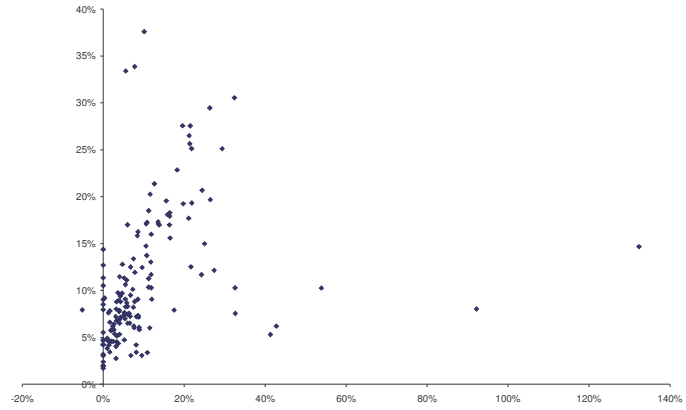


Gráfico 2.b.
MA 2 (+1)

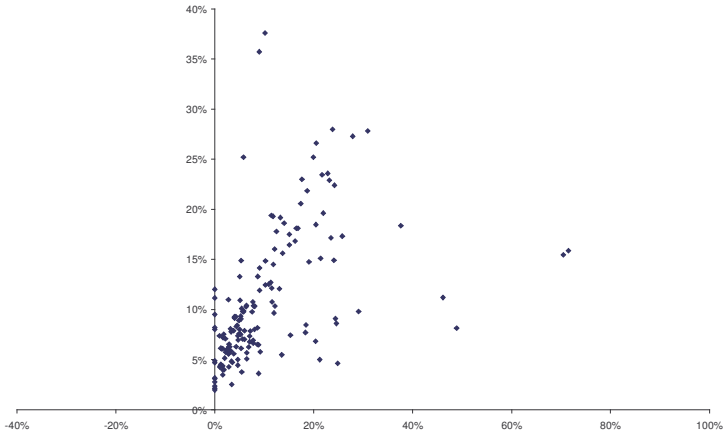


Gráfico 2.c.
MA 4 (+1)

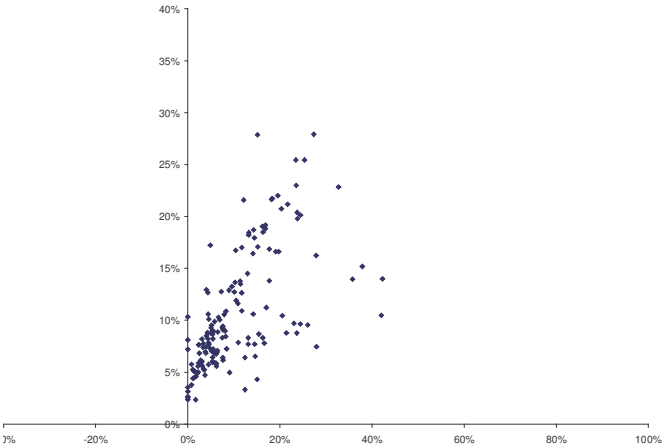


Gráfico 2.d.
MA 6 (+1)

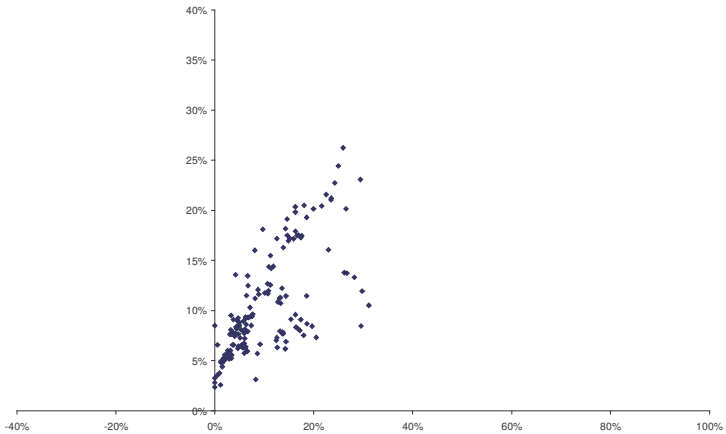


Gráfico 2.e.
MA 12 (+1)