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DISCUSSION PAPER

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Brasília, January 2015

LATENT INDEXATION AND EXCHANGE RATE PASSTHROUGH[1]

Antonio Fiorencio[2]
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DISCUSSION PAPER

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RESUMO

Este artigo utiliza modelos auto-regressivos vetoriais para discutir duas questões principais: *a*) os mecanismos de indexação que caracterizaram a economia brasileira por décadas são fatos do passado ou podem ser facilmente reativados no caso de um importante choque de preços?; e *b*) dada as condições fiscais, quais as conseqüências de uma desvalorização nominal sobre as taxas de inflação, de juros e de desemprego? Um dos principais resultados deste artigo é que a medida proposta do grau de indexação do sistema de preços no Brasil reduziu-se fortemente depois do Plano Real.

ABSTRACT

This paper uses VAR models to discuss two main questions: *a*) are the indexing mechanisms that characterised the Brazilian economy for decades a thing of the past, or could they be easily reactivated in the event of some important price shock? *b*) given the fiscal stance, what would be the likely consequences of a nominal devaluation on inflation, the real exchange rate, real interest rates and unemployment? One of the main results of the paper is tha a possible measure of the degree of indexation of the Brazilian price system was sharply reduced after the Real Plan.

1 - INTRODUCTION

There is now a widespread agreement that no stabilization program can succeed if it is not backed by a consistent fiscal policy. Fiscal policy, however, is not the whole story. Choices have to be made concerning monetary and exchange-rate policies. Also, in countries with a long history of high inflation and widespread indexing mechanisms, an important component of the stabilization program is the elimination of these indexing mechanisms, both formal and informal.

In this paper we analyse some of the choices confronting a country that has chosen an exchange rate based stabilization program but has not adopted the fiscal policy necessary to give it full credibility and, thus, is persistently faced with the question of whether or not to devalue. And, if so, when, and by how much.

In countries with a tradition of high inflation and generalized indexation, the success of the stabilization plan largely depends on the elimination of the indexing mechanisms. Part of this elimination can be mandated, at least in the short run. But part of it is a consequence of the success of the stabilization program itself. Lower inflation leads to less indexation and further allows the inevitable changes in relative prices to happen with a lower impact on inflation.[1]

The trade-offs associated with the timing of devaluation are clear enough. If you take too long to devalue, financing the deficit on the current account may become a binding constraint, to be respected only at the cost of high unemployment, if at all. If you devalue early on the stabilization program, the inflationary impact may be enough to reintroduce indexing mechanisms too recently or incompletely deactivated. The nominal devaluation might be eroded by the rise in prices with little impact on the real exchange rate.

In Brazil, the Real Plan did not produce a consistent fiscal adjustment from its very beginning. As a result, the exchange rate anchor on which the Real Plan was based led, as expected, to a revaluation of the real exchange rate and to increasing current account deficits. Equilibrium of the balance of payments was obtained at the cost of high interest rates and rising unemployment. Discussions of economic policy frequently turned around the following questions:

a) Are the indexing mechanisms that characterized the Brazilian economy for decades a thing of the past, or could they be easily reactivated in the event of some important price shock?

b) Given the fiscal stance,[2] what would be the likely consequences of a nominal devaluation on inflation, the real exchange rate, real interest rates and unemployment?

[1]Indexation *per se* is not inflationary. It will be if prices are more flexible upwards than downwards.

[2]It was not always obvious in discussions whether the qualification “given the fiscal stance” applied.

This paper uses VAR models to address these two questions and is organized as follows. Section 2 discusses the mechanisms of propagation of shocks that can be associated with the underlying degree of indexation of the economy. This section corroborates the casual impression that these propagation mechanisms changed significantly with the Real Plan. Section 3 confronts the Impulse Response Functions (IRFs) typical of the period preceding the Real Plan with those that apply after the Real Plan. We analyse how the degree of exchange rate passthrough changed between the two periods.

2 - LATENT INDEXATION

In this section we present a summary measure of the degree of indexation of the economy and estimate its value. We assume that the price level (P) is determined by the nominal exchange rate (C) and the nominal interest rate (J),[3] and we estimate the relations between these variable using a VAR model: y=(P,C,J).[4]

Let:

$$y_t = B_1 y_{t-1} + B_2 y_{t-2} + B_3 y_{t-3} + e_t \qquad e_t \sim (0,\Sigma) \qquad (1)$$

if: $(x_t=y_{t-1})$, $(z_t=x_{t-1})$, $Y_t=(y_t, x_t, z_t)$, $E_t=(e_t,0,0)$ and $B=\begin{bmatrix} B_1 & B_2 & B_3 \\ I & 0 & 0 \\ 0 & I & 0 \end{bmatrix}$, then (1) can be written as: $Y(t) = B\,Y(t-1) + E(t)$.

Since a VAR is a system of difference equations, its dynamic behaviour depends on its characteristic roots.[5] We do not want to fully characterise this dynamics in this section. Instead, we analyse only whether the system is stationary. And we take the absolute value of the largest eigenvalue of the VAR is our proxy for the underlying degree of indexation of the economy.[6]

Indexation involves a myriad of practices both formal and informal, which are easy to recognise but difficult to measure. But, no matter what the indexing practices are, their effects show up on the dynamic behaviour of the price system. So, instead of searching for an observable *proxy* for the degree of indexation we look for an unobservable one.

[3]We tested whether unemployment or the level of activity affect the dynamics of (y) using Granger causality tests. The graphics of the sequential p-value for each test, in Annex 1, shows that these variables do not precede.

[4](P) is the logarithm of INPC (Consumer Price Index Level), (J) is the logarithm of one plus the overnight interest rate (Selic), (C) is the logarithm of the average of daily exchange rates during the month.

[5]If D, $\Lambda=\text{diag}(\lambda i)$ are, respectively, eigenvectors and eigenvalues of B, then: $Y_{t+k} = D\Lambda^k D' Y_t + D\Lambda^{k-1} D' E_t + \ldots E_{t+k}$.

[6]When the absolute value of the largest eigenvalue is smaller than one, the system is stationary; if it is equal to one, the shocks have permanent effects; it is greater than one, the system is explosive.

A VAR with three lags[7] was estimated with monthly data from March 1973 to March 1999.[8]

The VAR described in (1) has fixed coefficients, which might be a bad assumption for our sample. The continuous evolution of indexing practices and successive stabilization plans affected the dynamic interaction between nominal variables. So we should consider the possibility that the parameters of the model change as the economic system adapts to a changing environment. Model (1) can be re-parameterized as:

$$(y_t=\pi r_t+e_t) \text{ where: } \pi=(B_1,B_2,B_3) \text{ and } r_t=(y_{t-1},y_{t-2},y_{t-3}) \qquad (2)$$

To allow (π) to be a function of time and still have an estimable model, we must introduce restrictions. We assume[9] that each element of (π) is equal to its value in the previous period plus a random shock.[10]

$$y_t=\pi_t r_t+e_t \quad , \quad \pi_t = \pi_{t-1}+ \xi_t \ ^{11} \quad \xi_t \sim N(0,IW_t) \qquad (3)^{12}$$

The scalar (W_t) determines how fast the parameters adjust to new information. This specification includes different situations as special cases.

If ($W_t=0$) we have the classical recursive estimation. If ($W_t=w^*$), we have a standard varying parameters model. Regime changes in selected periods (M) can be accommodated letting: $W_t=w \ \forall t\in M$,[13] and zero otherwise. If ($w=0$) we are back to the first situation and if (w) is "big" we are ignoring information prior to each regime change. Table 1 presents the predictive log-likelihood for some alternatives of (w), for the standard varying parameter with ($w^*=0.005$), and for the classical case.

---

[7]The choice is arbitrary, but the reflects the fact that nominal variables usually adjust quickly in Brazil.

[8]Numerical computation considerations led us to estimate the model in the equivalent form:
$\Delta y_t = b_1\Delta y_{t-1}+b_2\Delta y_{t-2}+ b_3y_{t-1}+ e_t$

[9]This a version of the Dynamic Bayesian Model [see West and Harrison (1997)].

[10]All shocks have the same variance.

[11]The notation means that each element (ij) in π equals its predecessor plus a specific random shock.

[12]This identity matrix has dimension (n^2p).

[13]We consider that regime changes occurred on the Cruzado Plan (1986.2), the Collor Plan (1990.3) and the Real Plan (1994.6). Since we estimate a VAR with three lags, we disregard observations on the three months following each regime change to avoid introducing possibly spurious data. So, it is the fourth month after each of these stabilization plans that enters the set M.

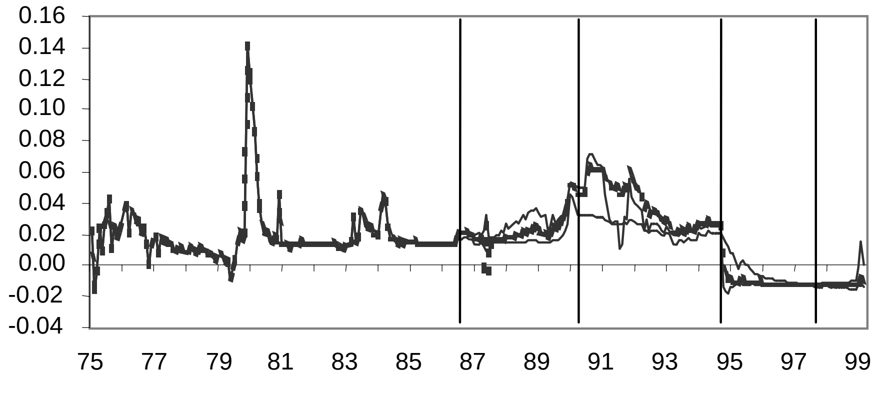
Table 1
Log-likelihood

Model	w	Log-likelihood
Intervention	.00	1391.1
Intervention**	.05	1392.8
Intervention	.1	1393.2
Intervention*	.3	1394.2
Intervention	.5	1393.7
Intervention**	.65	1392.7
Intervention	.7	1392.3
Varying Param.	0	1390.1
OLS	0	1391.1

Uncertainty about the value of (w) shows up on the similarity of the values of the log-likelihood. We took account of it by estimating three models: the most probable one (*) and two other ones which are statistically equivalent (**) but are less (0.05) and more (0.65) adaptive than the most probable model.

We estimate (π_t) for these values of (w), calculate the eigenvalues (Λ_t) for each period and select the one with the largest absolute value (λ^*_t), which is our measure of the degree of indexation of the economy on each month of the sample.[14] Estimated values are close to unity and we present our measure as (λ^*_t-1).[15]

Figure 1
Degree of Indexation (λ^*-1): 1975.1 to 1999.3



Several significant episodes of the Brazilian inflationary experience are clearly discernible in the figure.

a) The move from once a year to twice a year wage readjustments in 1979.
b) The large exchange rate devaluation in 1981 and in 1983.

[14]Our approach is a preliminary assessment of uncertainty about the estimation of this eigenvalue.
[15]Actually, this is the graphic of unity less the absolute value of the largest eigenvalue. The three lines correspond to models (*) and (**) explained in the last paragraph.

c) The Cruzado Plan in February 1986.
d) The quasi-hyperinflation that accompanied the presidential election of late 1989, when the public feared financial assets may be confiscated after the election.
e) The Real Plan of July 1994.

One striking feature of the picture is that before the Real Plan, the system is almost always explosive, in spite of numerous stabilization plans. The figure also indicates that the system is stationary from late 1995 until the January 1999 devaluation.[16] Figure 2 shows a zoom of the preceding picture from February 1993 until March 1999.

Figure 2
Degree of Indexation (λ*-1): 1993.1 to 1999.3

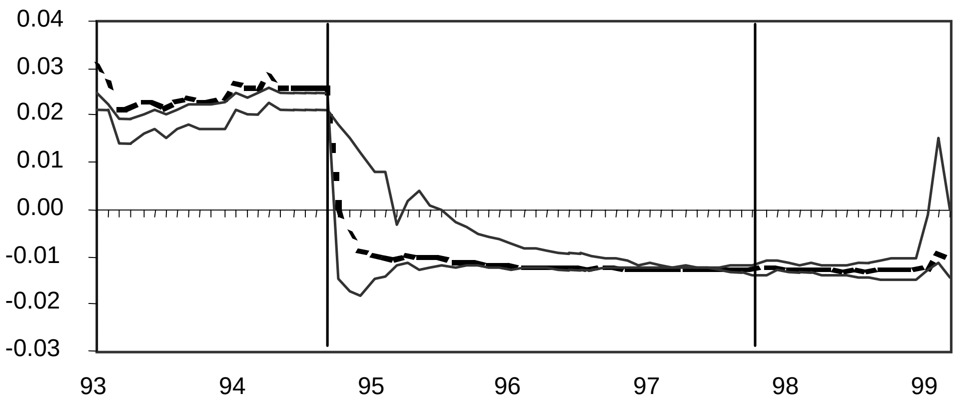


Figure 2 suggests that indexation decreases sharply, immediately following the Real Plan in July 1994 and the system becomes stationary no later than 1996. The Mexican crisis of December 1994 promotes a temporary increase in indexation. Indexation then decreases gently and consistently until the large devaluation of January 1999. The Asian crisis in the second half of 1997 is barely discernible in the graphic.

Assume Brazil had decided to devalue somewhere after the launching of the Real Plan. From the point of view of minimizing inflationary risks, when should it have been done?

The answer depends on many factors. The current phase of the business cycle. How devaluation is managed by policy makers. The degree of indexation of the price system. International conditions. Domestic policy conditions. *Etc.* Figure 2 suggests there were two favourable moments for devaluation after the Real Plan.

[16]In reality, we can not test this affirmative since software limitations prevent us from calculating the uncertainty associated with our measure of indexation.

The first favourable moment seems to have been the first half of 1997. Earlier, (our measure of) indexation was still too high. Later, we had the Asian crisis in the second half of 1997 and its repercussions on emerging markets well into 1998. And, in the second half of 1998, the Russian crisis and the Brazilian general elections.

Apparently, early 1999 was another favourable moment. In January, our measure of indexation was as low as ever; the president had just been comfortably re-elected and no new elections were shortly due; the economy was depressed; and leading industrial countries and international agencies were clearly willing to support the Brazilian stabilization program.

If this is true, why was the initial turmoil so big?[17] And why did prospects change so fast?

The way economic policy was handled is part of the answer to the first question. It is possible that much of the trouble was policy induced and not the reflex of a still high degree of indexation.

Reversal of policy is part of the answer to the second question. But there is more to it. It seems to have taken a major crisis to convince Congress to advance on fiscal adjustment. As an example, in the middle of the crisis, Congress got so worried that it approved changes on retirement legislation, which it had previously rejected on four different occasions. Apparently, besides the well-known expenditure reducing and expenditure switching effects, the Brazilian devaluation also included a (temporary) responsibility enhancing effect.

3 - EXCHANGE RATE PASSTHROUGH IN TWO DIFFERENT REGIMES

One of the messages of the previous section is that the Real Plan is a watershed for the degree of indexation of the Brazilian economy. But even if Figure 1 is not accepted as a *proxy* for the degree of indexation of the economy, it does indicate that the Real Plan changed the dynamic behaviour of the Brazilian price system. In this section, we evaluate the effects of monetary and exchange rate policies on prices and unemployment before the Real Plan and after it.

Identifying changes in monetary and exchange rate policies is a difficult problem. The decisions of policy makers depend on a myriad of variables, many of them unobservable. Moreover, the exchange rate and the interest rate are only partially controlled by policy makers and instruments vary with time. In spite of these limitations, VAR models have been frequently used to identify these changes in policy [see Bernanke (1986), Sims (1995), Blanchard and Watson (1993), Bernanke and Blinder (1992), Christiano, Eichenbaum and Evans (1994), Sims and Zha (1996), Eichenbaum (1998) and Eichenbaum and Evans (1993)].

We will assume that the structural VAR model adequately summarizes the relations among the variables and that some of the identified structural shocks can

[17] The effects of the devaluation appear clearly in Figure 2.

be interpreted as policy changes. Specifically, we estimate two identical structural VAR models over two independent samples: before the Real Plan and after it.[18] The models in this section differ from the previous one in three respects. First, parameters are constant. Second, we include unemployment (U) in the list of variables.[19] Third, these models include contemporaneous relations that are estimated imposing identifying restrictions to calculate IRFs.[20]

Let y=(P,C,J,U)[21] and:

$$Ay_t = A_1 y_{t-1} + A_2 y_{t-2} + A_3 y_{t-3} + u_t \qquad u_t \sim (0, \mathrm{diag}(\sigma_i^2)) \tag{4}$$

Model (4) includes two “market” variables — prices and unemployment — that we assume are partially determined by the innovations on monetary and exchange rate policies. Since the results depend on the identifying restrictions, one must look for “reasonable” restrictions.

Recursive identification is frequently used in the literature. The problems with this strategy are well known. First, it is not obvious how to interpret the IRFs. Second, the ordering of variables is not obvious either. Christiano, Eichenbaum and Evans (1998) argue there are situations where recursive ordering may be less restrictive than it appears. They consider a situation where *a*) market variables are not contemporaneously affected by policy variables, and *b*) the analyst is only interested in characterizing the policy shocks. In this case, the ordering of the market variables is irrelevant.

If their strategy is applied to our case, there are only two relevant orderings: (P,U,C,J) or (P,U,J,C). Annex 2 shows the IRFs for both orderings in the post-Real period. We do not analyse them in detail, since the results were unsatisfactory. For instance, there is a “price puzzle” and an “exchange rate puzzle”: when the interest rate rises, the price level rises and the nominal exchange rate is devalued. In the following, all our identifying hypothesis will involve simultaneous models.

We would like to impose identifying restrictions suggested by some non-controversial monetary model, of course. But it is not obvious where we would find them. Instead, we did some educated fishing, which led to following set of restrictions directly on the IRF, that is, on the inverse of the A matrix.

a) We want to focus on the behaviour of the nominal variables and we want to make as few assumptions as possible about the relation between them and

[18]1982.10 1994.06 and 1994.10 to 1998.12.

[19]Data on unemployment begins in February 1982. The interest rate used is the one on working capital (Capital de Giro). The three months following the Real Plan were disregarded, as explained above.

[20]The identifying restrictions are the same for both samples.

[21](P) is the logarithm of INPC (Consumer Price Index), (J) is the logarithm of one plus the interest rate on working capital (Capital de Giro), (C) is the logarithm of the average of daily exchange rates during the month, and (U) is the logarithm of one plus the seasonally adjusted unemployment rate.

unemployment. So, we assume that the structural shock of unemployment affects none of the nominal variable innovations but is affected by all of them.

b) The price level innovation is almost unrestricted. It is affected by all structural shocks except the unemployment one.

c) We assume that innovations in the exchange rate are completely exogenous for the following reasons. The Brazilian Central Bank has always closely managed the exchange rate on a daily basis and, probably, does not have contemporaneous information about unemployment shocks when it decides the exchange rate innovation. We will also assume that interest rate shocks do not affect exchange rate innovations. This is more debatable and we examine the consequences of changing this assumption bellow. Finally, we also assume that shocks to the price level do not affect exchange rate innovations. In the post-Real period this simply reflects the way the Central Bank managed policy. In the pre-Real period this reflects inevitable informational lags.

d) The interest rate innovation is affected by the exchange rate shock, since the Central Bank tends to adjust the interest rate in line with the exchange rate to avoid undesirable international capital flows. We also assume that the interest rate innovation is affected on a one-for-one basis by price shocks.

Given these restrictions, we can estimate[22] matrix (A) for both samples: the pre- and the post-Real Plan periods. We will consider imposing different restrictions for each sample bellow. But it is useful to start from a situation where all differences in the IRFs come from the estimated reduced forms and not from the identifying restrictions.

Table 2 summarizes these restrictions and presents the estimated values of the parameters of the point estimation of (A^{-1}); innovations (U) are determined by the shocks (E) according to $U=A^{-1}E$.

Table 2
Point Estimation of A^{-1} for Three Alternatives[23]

Pre-Real

$$\begin{bmatrix} \mathbf{Up} \\ \mathbf{Uc} \\ \mathbf{Uj} \\ \mathbf{Uu} \end{bmatrix} = \begin{bmatrix} 1 & 1.03 & -.59 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & .99 & 1 & 0 \\ -.01 & -.00 & .01 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{Ep} \\ \mathbf{Ec} \\ \mathbf{Ej} \\ \mathbf{Eu} \end{bmatrix}$$

Post-Real

$$\begin{bmatrix} \mathbf{Up} \\ \mathbf{Uc} \\ \mathbf{Uj} \\ \mathbf{Uu} \end{bmatrix} = \begin{bmatrix} 1 & .13 & -.96 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & .60 & 1 & 0 \\ .04 & -.00 & -.07 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{Ep} \\ \mathbf{Ec} \\ \mathbf{Ej} \\ \mathbf{Eu} \end{bmatrix}$$

Post-Real*

$$\begin{bmatrix} \mathbf{Up} \\ \mathbf{Uc} \\ \mathbf{Uj} \\ \mathbf{Uu} \end{bmatrix} = \begin{bmatrix} 1 & .02 & -.97 & 0 \\ 0 & 1 & -.63 & 0 \\ 1 & .99 & 1 & 0 \\ 0 & 0 & -.13 & 1 \end{bmatrix} \begin{bmatrix} \mathbf{Ep} \\ \mathbf{Ec} \\ \mathbf{Ej} \\ \mathbf{Eu} \end{bmatrix}$$

[22]The structural VAR is a non-linear model that was estimated by maximum likelihood and by Monte Carlo Markov Chain (MCMC). (The latter allows uncertainty about the estimate of (A) to be taken into account more rigorously.) The point estimates of the IRFs were similar and we only present the results for the MCMC estimator. Details about the estimation procedure are in Annex 3.
[23]The third column represents a different identification that will be discussed later.

Most of the results are as expected. For instance, an unexpected devaluation increases prices contemporaneously, both in the post-Real and, much more so, in the pre-Real periods.[24] Figures 3.A and 3.B present the IRFs[25] for both samples, over a 12 months horizon.

Figure 3.A shows that, before the Real Plan, an unexpected *nominal* devaluation has a long-lasting effect on prices and almost no effect on the *real* exchange rate. The impact on unemployment is, if anything, positive (unemployment increases). The IRF for the interest rate innovation shows that monetary policy is almost powerless to affect any other variable.

The picture changes completely after the Real Plan.[26] A nominal devaluation has a smaller and more rapidly absorbed impact on the price level than it had in the pre-Real. The real exchange rate undergoes a long-lasting devaluation. The unemployment rate, however, increases: the devaluation raises prices and a rise in price increases unemployment. Monetary policy now affects the economy. An increase in the interest rate reduces prices and promotes a *real* devaluation. Unemployment is marginally reduced in the first months after the shock but remains above trend for the rest of the period.

Three results of the post-Real Plan period deserve comment.

The first result is that a nominal devaluation promotes a long-lasting real devaluation and a long-lasting increase in unemployment. Even if these effects are long lasting, they are still temporary, since this model is stationary. Variables may not revert to trend within the simulation horizon but on a longer horizon they will. This model only captures propagation around some exogenously given trend. Permanent effects depend either on the existence of a unity root or on the inclusion of some set of exogenous regressors.

The second result is the fact that a nominal devaluation increases unemployment. This is a short run result. In the long run, a devaluation may reduce unemployment if it switch expenditure and allows the country to equilibrate the balance of payments with lower interest rates.

The third result is the most troubling one. A rise in the interest rate promotes a nominal devaluation. We do not thing that this is a sensible result, and we are going to experiment with a slightly different identification.

We make one important change in our original identification.[27] We recognize that market forces might have an impact on the contemporaneous exchange rate that our previous identification excluded by hypothesis. Thus, we let the exchange rate be affected by the interest rate.

[24]Notice that there is no price puzzle, even though we have included no leading indicator for inflation.

[25]IRF: $y_t = (I - A^{-1}A_1L - A^{-1}A_2L^2 - A^{-1}A_3L^3)^{-1} A^{-1}e_t = C(L)e_t$, always for 12 months ahead.

[26]Figure A4 in the Annex shows the difference between both sets of IRF.

[27]There is also a minor change. Since the impacts of the price level and exchange rate shocks on the unemployment innovation are not statistically significant, we assume that they are zero.

Figure 3.A

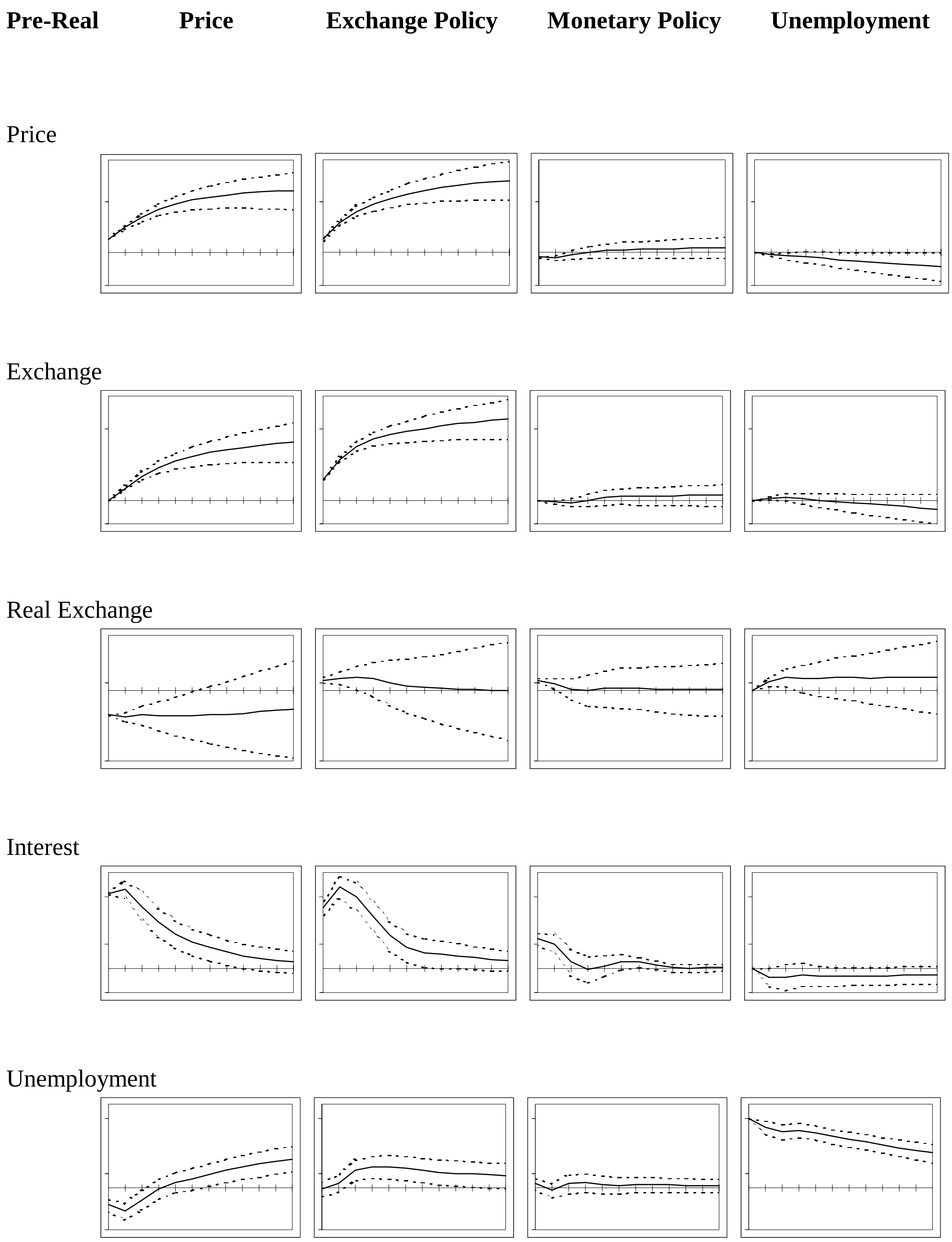
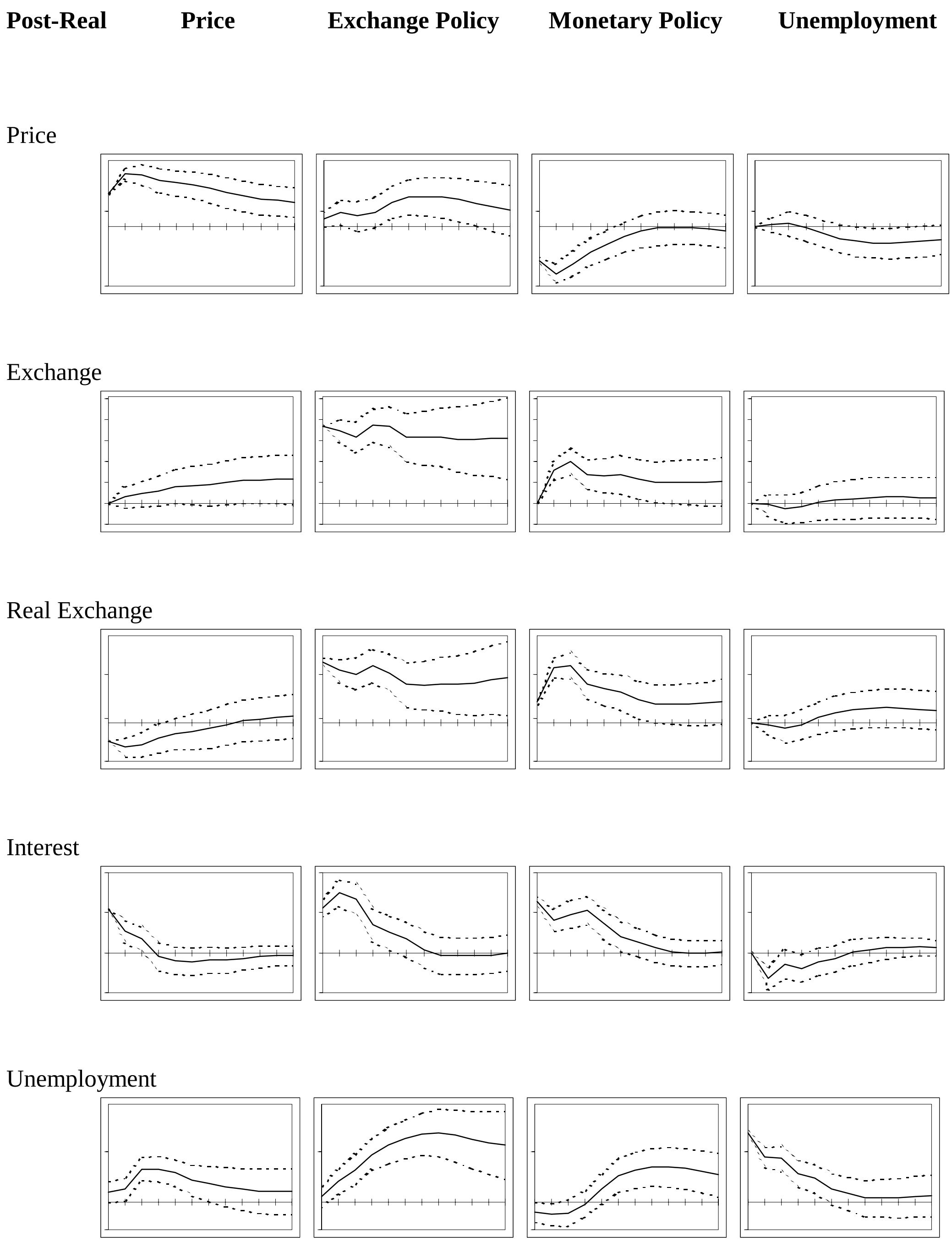

Pre-Real
Price
Exchange Policy
Monetary Policy
Unemployment
Price
Exchange
Real Exchange
Interest
Unemployment

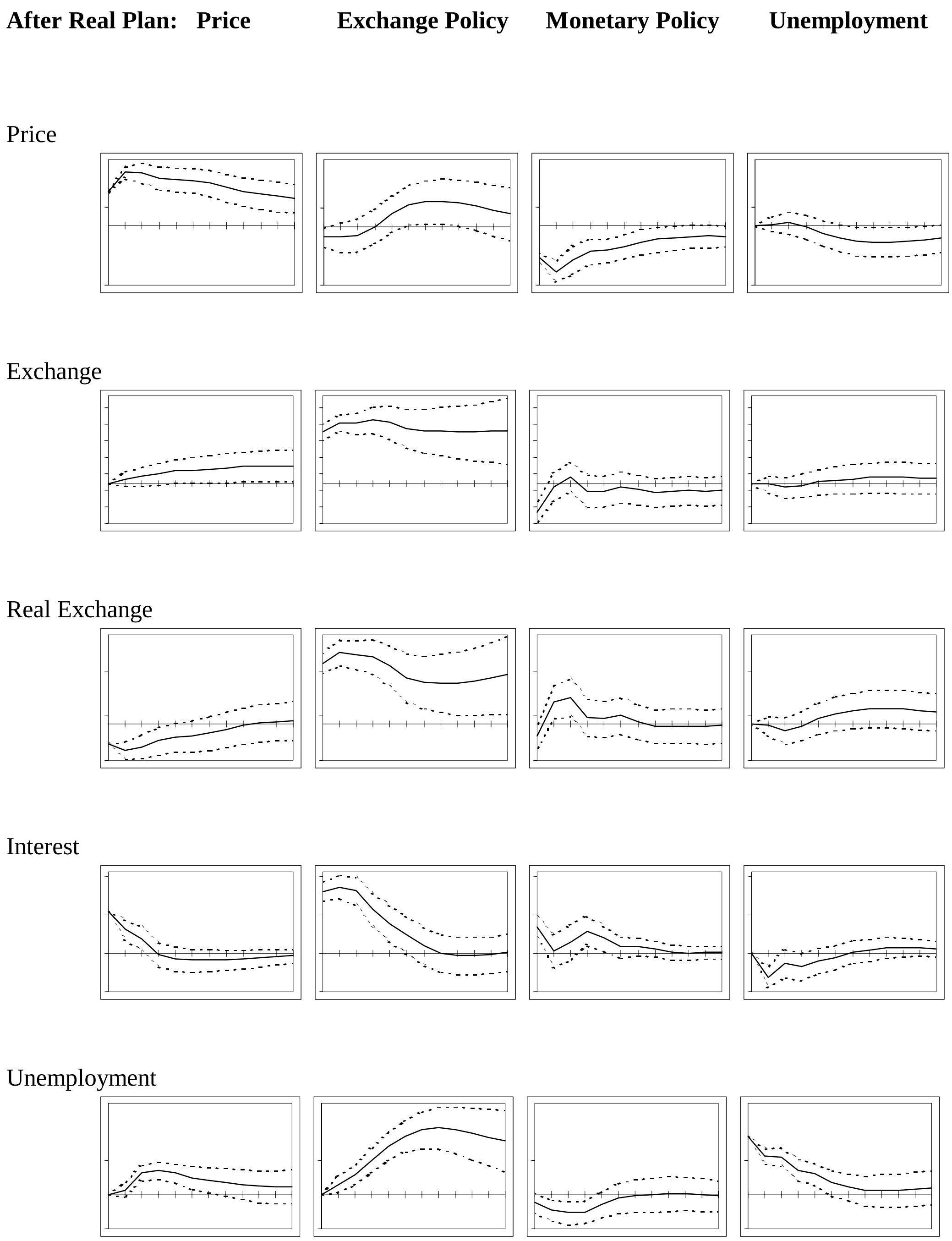
Figure 3.B



When we apply this identification to the pre-Real Plan period, we are not capable of reproducing the estimated correlation in the data. In other words, this new identification is rejected by the data of the pre-Real Plan period. It is not rejected by the data of the post-Real Plan period, however.

The IRFs for the post-Real Plan period calculated with this new identification — Figure 4 — are similar to the previous ones, with one remarkable difference: a rise in interest rates now appreciates the nominal exchange rate.

Figure 4



One last comment to close this section. We have, of course, experimented with alternative identifications and results do change. Since our identifying assumptions are somewhat arbitrary, results must be viewed with caution.[28]

[28]Uncertainty concerning estimation of (A) is briefly discussed in Annex 3.

4 - CONCLUSIONS

In this paper we argue that a possible measure of the degree of indexation of the Brazilian price system was sharply reduced after the Real Plan. How fast it was reduced depends on how adaptive is the model used to estimate it. But, this measure of indexation suggests that, from the point of view of a risk-averting policy maker with a strong concern for inflation, the best moments for devaluation were probably the first half of 1997 and early 1999.

The large devaluation of January 1999 may have increased the degree of indexation of the price system. It might be useful to keep track of this indicator, as new data become available, and to calculate a more rigorous measure of its uncertainty.

We also tried to obtain summary measures of policy actions and of their effects. Our results here are more fragile.

Monetary theory does not suggest a set of fully convincing identifying restrictions. Recursive identification did not produce sensible results, and parameters estimated by simultaneous identification may not be robust. In the latter case, the problem is that fully characterizing economic behaviour may involve estimating more parameters than the available information really allows us to. For instance, it may be the case that, in our sample, the Central Bank did not pursue an exchange rate policy independent from its monetary policy.

ANNEX 1

Figure A2 shows the sequential p-values for the tests of exclusion of unemployment, GDP or the price level from the system. We expected the results we got for real variables. But we were surprised by the result for the price level on the equation of footnote 7, where the model is specified as a VEC without co-integrating restrictions. When we started this paper, we expected that the price level would be uninformative for the pre-Real Plan only, since very high inflation might mean that the absolute price level was irrelevant. The graphic shows that prices may be excluded from the system even after the Real Plan when inflation is low.

Figure A2
P-Value for the Exclusion of Either Unemployment, or Prices or GNP from the VAR

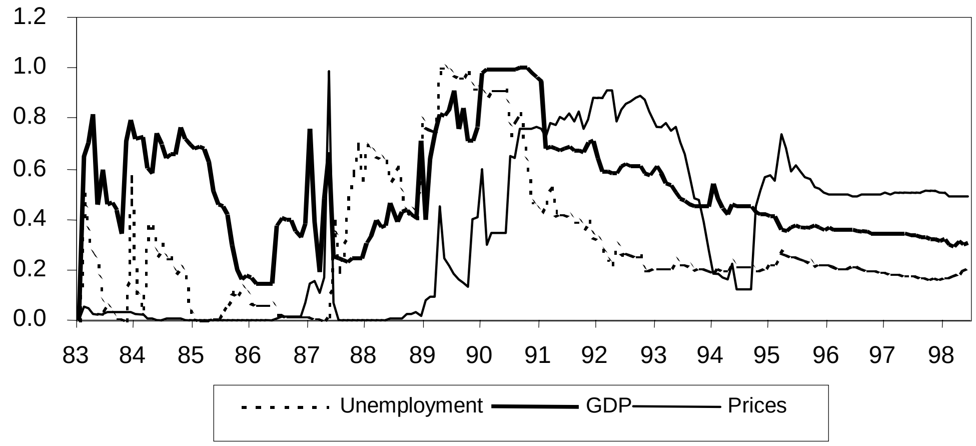


Figure A3
Unity Less the Largest Eigenvalue of the Dynamic System (λ*-1) under Different Hypothesis of Estimation

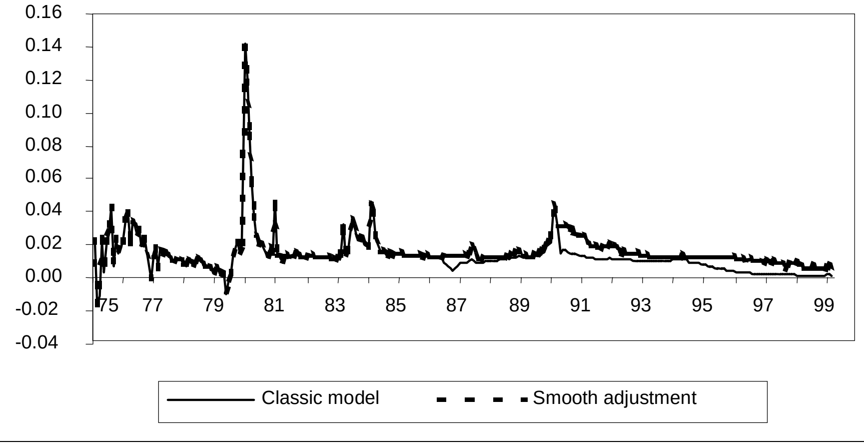
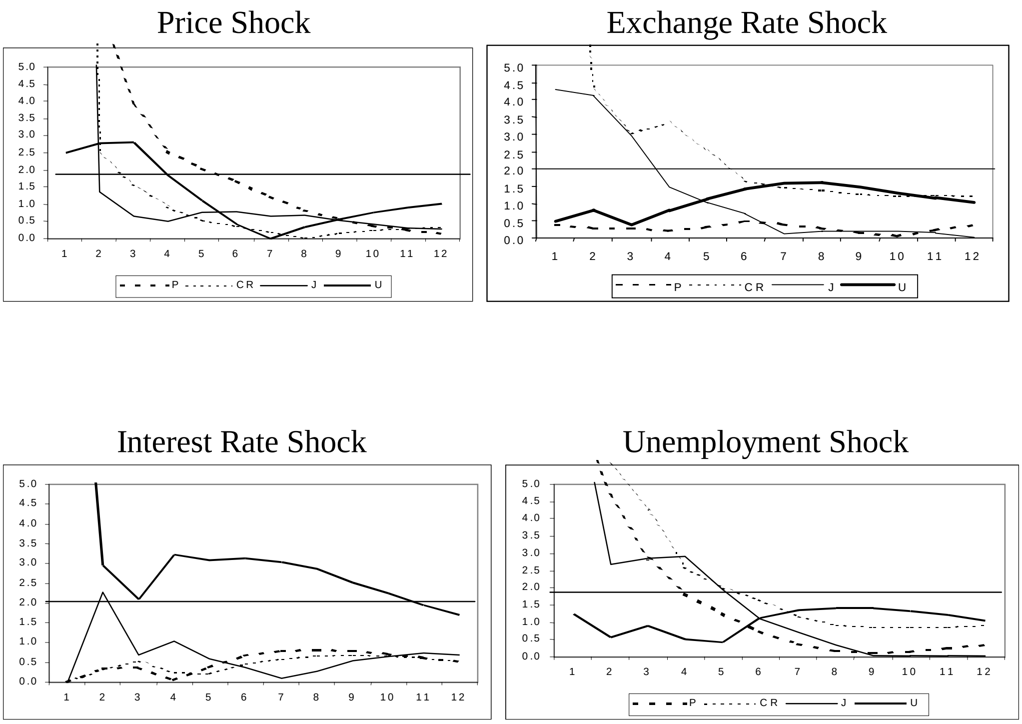


Figure A4

Mean Difference Between the IRFs for the Pre-Real and the Post-Real
(Normalized by its Standard Deviation)

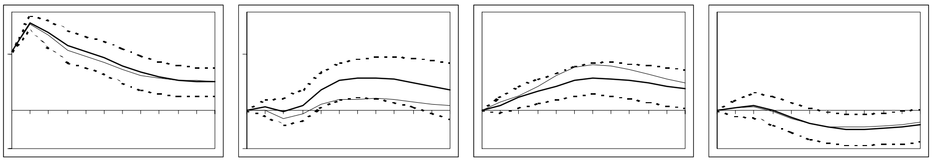


ANNEX 2: IRF of Two Recursive Models

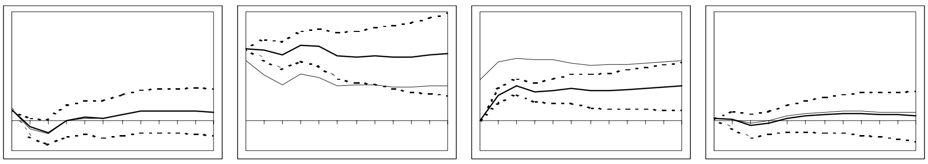
Heavy Line: expected value for model (P,U,C,J)
Dotted Line: confidence interval (one standard deviation) for model (P,U,C,J)
Light Line: expected value for model (P,U,J,C)

After Real Plan: Price Exchange Policy Monetary Policy Unemployment

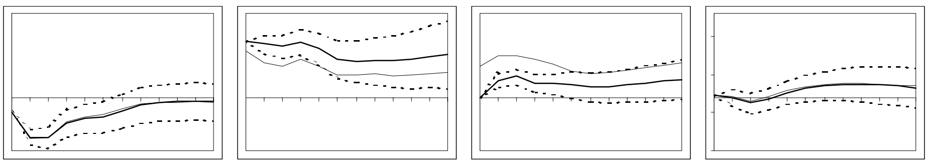
Price



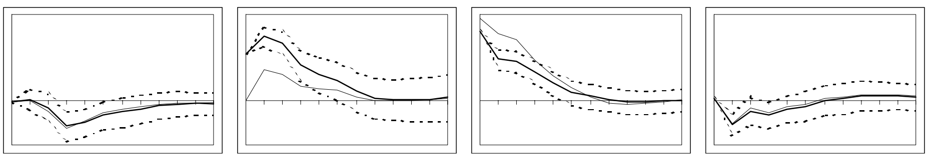
Exchange



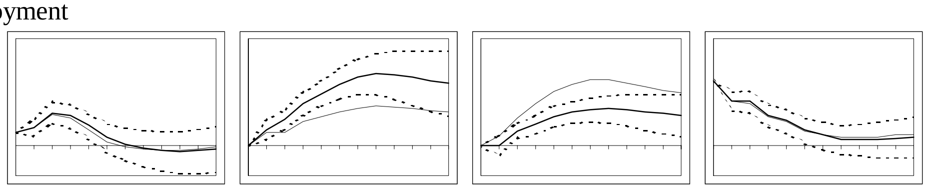
Real Exchange



Interest



Unemployment



ANNEX 3: Estimation of Simultaneous Models

Let: $Ay_t = A_1y_{t-1}+A_2y_{t-2} + A_3y_{t-3} + u_t$ $\quad u_t \sim(0,\text{diag}(\sigma_i^2))$

One can show that the posterior density of A is [see Gamerman and Moreira (1998)]:

$$p(A|D_T)\propto|A|^n\exp\{-.5.tr(nS_1A'A)\}f_A(A) \qquad \text{where:}$$

$nS_1= (m-m_0)'C^{-1}(m-m_0)+ \sum(y_t-m.r_t)' (y_t-m.r_t)$
$C = (C_0^{-1}+\sum r_t r_t')^{-1}$
$m = C(C_0^{-1}m_0+\sum r_t y_t')$

Priors:
$f_A(A)$: $\Pi\ g(A_{ij})$, where $g(.) \sim N(0,10)$
$\pi \sim MN(m_0,C_0)$, where $m_0=0$, e $C_0=\text{diag}(c_{0i})$, $c_0=1000$

A sample with 17000 elements of the posterior $p(A|D_T)$ was obtained by the MCMC method — Monte Carlo Markov Chain with the chains formed by the Metropolis-Hastings algorithm [see Gamerman (1997)].

In the case of the second identification for the post-Real period, we obtained the following results, which are qualitatively similar to the other cases.

Characteristics of the Estimators of A^{-1}

	Mode	Mean	Std. error	Min (65%)	Max (65%)	Min (95%)	Max (95%)
1*	0.015	-0.129	0.112	-0.327	0.138	-0.526	0.138
2	-0.974	-1.905	0.629	-3.389	-0.564	-4.114	-0.482
3*	-0.632	-3.468	1.740	-7.042	0.085	-7.825	0.085
4	0.358	0.535	0.138	0.216	0.762	0.187	0.976
5*	-0.126	-0.216	0.248	-0.798	0.180	-0.990	0.509

Correlation between the Estimators of A^{-1}

1	1.000	0.193	0.629	-0.649	0.017
2	0.193	1.000	0.576	-0.159	0.128
3	0.629	0.576	1.000	-0.636	0.146
4	-0.649	-0.159	-0.636	1.000	-0.003
5	0.017	0.128	0.146	-0.003	1.000

Since we have a non-informative prior, the column labelled “mode” is the maximum likelihood estimator. The other columns give other indicators of the uncertainty associated with this estimator. Many parameters are not statistically different from zero. Excluding them, however, completely changes the identification.

Even though this is an over-identified model, the fragility of the results suggests that we might need still more restrictions. But this would impair the interpretability of the results. One possible reason for that is that we may be trying to identify more independent shocks that the data support.

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